Staring EMI Straight in the Eye
— and Doing My Best Not to Flinch

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> *"Good artists borrow; great artists steal."*
> — Douglas Hofstadter*

How Young I Was, and How Naïve

I am not now, nor have I ever been, a card-carrying futurologist. I make no claims to be able to peer into the murky crystal ball and make out what lies far ahead. But one time, back in 1977, I did go a little bit out on a futurologist's limb. At the end of Chapter 19 ("Artificial Intelligence: Prospects") of my book *Gödel, Escher, Bach*, I had a section called "Ten Questions and Speculations", and in it I stuck my neck out, venturing a few predictions about how things would go in the development of AI. Though it is a little embarrassing to me now, let me nonetheless quote a few lines from that section here:

> *Question:* Will there be chess programs that can beat anyone?
> *Speculation:* No. There may be programs which can beat anyone at chess, but they will not be exclusively chess players. They will be programs of *general* intelligence, and they will be just as temperamental as people. "Do you want to play chess?" "No, I'm bored with chess. Let's talk about poetry." That may be the kind of dialogue you could have with a program that could beat everyone....

We all know today how very wrong that speculation was. What was it that so misled the author of *Gödel, Escher, Bach* back then?

Well, when I wrote those words, I was drawing some of my ideas from a fascinating article that I had read by my soon-to-be colleague at Indiana University, the psychologist and chess master Eliot Hearst (formerly Vice President of the United States Chess Federation, member of the U.S. Chess Olympics team, and once a frequent playing partner of Bobby Fischer). In his article, Hearst (who clearly knew infinitely more about chess than I ever could hope to) eloquently expressed the conviction that deep chess-playing ability depends in an intimate manner on such cognitive skills as the ability to sort the wheat from the chaff in an intuitive flash, the ability to make subtle analogies, and the ability to recall memories associatively. All of these elusive abilities seemed to lie so close to the core of human nature itself that I jumped to the conclusion that profoundly insightful chess-playing draws intrinsically on central facets of the human condition, and that mere brute-force searching of the rapidly branching lookahead tree, no matter how fast, broad, or deep, would not be able to circumvent or shortcut that fact.

I didn't realize — and perhaps no one did, at the time — that the USCF rankings of the best computer chess programs (all of which used brute-force search algorithms) were pretty much creeping up linearly with time, so that a simple-minded linear extrapolation on a plot of *chess prowess versus time* would, even back then, have suggested that computers would take over from humans somewhere around the year 2,000. The first time I actually

saw such a graph was in an article in *Scientific American* in the mid-1990's (written by the creators of Deep Blue, by the way), and I vividly remember thinking to myself, when I looked at it, "Uh-oh! The handwriting is on the wall!" And so it was.

Chess Tumbles to Computational Power...

We now know that world-class chess-playing ability can indeed be achieved by brute-force techniques — techniques that in no way attempt to replicate or emulate what goes on in the head of a chess grandmaster. Analogy-making is not needed, nor is associative memory, nor are intuitive flashes that sort wheat from chaff — just a tremendously wide and deep search, carried out by superfast, chess-specialized hardware using ungodly amounts of stored knowledge. And thus, thanks to the remarkable achievements of the past decade, one can no longer look at a subtle, elegant, and stunning midgame chess move and say with confidence, "Only a genius could have spotted that move!", because the move could just as well have emanated from a mindless, lightning-fast full-width search as from the silent machinations of an insightful human mind.

I cannot say what goes on in the brain of a Bobby Fischer or a Garry Kasparov when they play championship-level chess. I have no idea whether their phenomenal chess-playing ability draws in some subtle way on their entire human existence, on their prior struggles with life and death, on their striving for personal identity, on their coping with dashed romances, on their hopes and fears in domains apparently remote from chess — or, contrariwise, whether their chess-playing skill is in some sense totally isolated from the rest of their minds, fully contained in some little localized region of their brains that, at least in principle, could be neatly excised by a neurosurgeon, leaving the rest of their brains fully intact so that they could go on living normal lives while the little module, safely preserved and nourished in a vat, happily kept on playing world-level chess.

Eliot Hearst's article had led me to believe that the image of an isolated chess-playing module is wrong, and that, to the contrary, great chess-playing skill is of necessity deeply intertwined with all that being human is about. But as Deep Blue has taught us, that certainly need not be the case. Top-notch chess-playing does not necessarily depend on the full mental complexities that come from living life, facing death, and all those messy things that we experience. Top-notch chess playing *can* come from a pure chess engine, full stop. As for top-notch *human* chess-playing ability, one might still plausibly believe that it is necessarily tightly integrated with the rest of the brain and with the whole kit and caboodle of being human — but ever since Deep Blue's appearance on the scene, there is reason to doubt that romantic vision. Perhaps it is the case, but perhaps not.

I, in any case, have had to eat humble pie with respect to my 1977 speculation. But, I must say, having to swallow my words about chess doesn't upset me all that much, since, aside from writing that one speculation, I personally have never had any emotional stake in the notion that chess skill lies very near the pinnacle of that which is most truly human, and so I'm not crushed that my speculation was refuted. And even though people say that the game of Go is far less computer-tractable than chess is, I don't think I'd care to rewrite my speculation substituting Go for chess. I'll just admit my mistake.

So... chess-playing fell to computers? I don't feel particularly threatened or upset; after all, sheer computation had decades earlier fallen to computers as well. So a computer had outdone Daniel Shanks in the calculation of digits of pi — did it matter? Did that achievement in any way lower human dignity? Of course not! It simply taught us that calculation is more mechanical than we had realized. Likewise, Deep Blue taught us that chess is more mechanical than we had realized. These lessons serve as interesting

pieces of information about various domains of expertise, but to my mind, they hardly seem to threaten the notion, which I then cherished and which I still cherish, that human intelligence is extraordinarily profound and mysterious.

It is not, I hasten to add, that I am a mystic who thinks that intelligence intrinsically resists implantation in physical entities — to the contrary, I look upon brains themselves as very complex machines, and, unlike John Searle and Roger Penrose, I have always maintained that the precise nature of the physico-chemical substrate of thinking and consciousness is irrelevant. I can imagine silicon-based thought as easily as I can imagine carbon-based thought; I can imagine ideas and meanings and emotions and a first-person awareness of the world (an "inner light", a "ghost in the machine") emerging from electronic circuitry as easily as from proteins and nucleic acids. I simply have always run on faith that when "genuine artificial intelligence" (sorry for the oxymoron) finally arises, it will do so precisely because the same degree of complexity and the same overall kind of abstract mental architecture will have come to exist in a new kind of hardware. What I do *not* expect, however, is that full human intelligence will emerge from something far simpler, architecturally speaking, than a human brain.

...and so, Is Musical Beauty Next in Line?

My "Ten Questions and Speculations" section in *GEB* was an attempt to articulate just these kinds of pieces of faith, and at the time I wrote it, I was particularly proud of another one of them, which I now reproduce here in full:

> *Question:* Will a computer program ever write beautiful music?
> *Speculation:* Yes, but not soon. Music is a language of emotions, and until programs have emotions as complex as ours, there is no way a program will write anything beautiful. There can be "forgeries" — shallow imitations of the syntax of earlier music — but despite what one might think at first, there is much more to musical expression than can be captured in syntactical rules. There will be no new kinds of beauty turned up for a long time by computer music-composing programs. Let me carry this thought a little further. To think — and I have heard this suggested — that we might soon be able to command a preprogrammed mass-produced mail-order twenty-dollar desk-model "music box" to bring forth from its sterile [sic!] circuitry pieces which Chopin or Bach might have written had they lived longer is a grotesque and shameful misestimation of the depth of the human spirit. A "program" which could produce music as they did would have to wander around the world on its own, fighting its way through the maze of life and feeling every moment of it. It would have to understand the joy and loneliness of a chilly night wind, the longing for a cherished hand, the inaccessibility of a distant town, the heartbreak and regeneration after a human death. It would have to have known resignation and world-weariness, grief and despair, determination and victory, piety and awe. In it would have had to commingle such opposites as hope and fear, anguish and jubilation, serenity and suspense. Part and parcel of it would have to be a sense of grace, humor, rhythm, a sense of the unexpected — and of course an exquisite awareness of the magic of fresh creation. Therein, and therein only, lie the sources of meaning in music.

In recent years, when lecturing about Dave Cope's work, I have read this paragraph aloud so many times that I practically know it by heart. And what do I make of it now? Well, I am not quite sure. I have been grappling for several years now with these issues, and still there is no clear resolution. That, perhaps, is why I have been so fascinated by Cope's EMI and the issues raised thereby. Let me explain.

In the spring of 1995, I was conducting a cognitive-science seminar at Indiana

University called "AI: Hype versus Hope", whose purpose was for me and my students, working together, to try to sort the wheat from the chaff in this field so rife with brazen claims of human-level performance in one domain or another, most of which I knew were groundless, or nearly so. I was willing to concede, however, that even in a hopelessly hyped project, there might somewhere reside a nugget of value, and it was my idea that we would uncover those nuggets while at the same time chucking out the overblown claims. We discussed computer driving of cars, speech recognition, story understanding, machine translation, face recognition, and many other topics. One topic that particularly interested me was music, because I was convinced, *a priori*, that claims I'd heard here and there about high-quality music emanating from computers were hugely exaggerated, and I wanted to confirm this hunch. And so when a student in the seminar told me she had run across a book called *Computers and Musical Style* in the music library and wondered if she could present it to the seminar, I enthusiastically encouraged her to do so.

A couple of days later in class, this student described to us the ideas behind the program — EMI, to be specific — but I found myself not terribly interested. It sounded like EMI was dealing only with the surface level of music — with patterns, not with the deep emotional substrate — and I was pretty sure that little of interest could come of such an architecture. Then she said she could play for us some of EMI's compositions on the piano in my research center, so I said "Fine!" We went in and listened as she played, and my skeptical ears were somewhat jolted. Although the two pieces she played — very short Mozart-aping and Brahms-aping pieces — sounded amateurish and flawed, they were by no means totally incoherent or absurd. I wondered how in the world they could have come out of this architecture, and so I asked if I could borrow the book for a day or two. She said yes, and I took it home and plunged into it with great interest.

I noticed in its pages an EMI mazurka supposedly in the Chopin style, and this really drew my attention because, having revered Chopin my whole life long, I felt certain that no one could pull the wool over my eyes in this department. Moreover, I knew all fifty or sixty of the Chopin mazurkas very well, having played them dozens of times on the piano and heard them even more often on recordings. So I went straight to my own piano and sight-read through the EMI mazurka — once, twice, three times, and more — each time with mounting confusion and surprise. Though I felt there were a few little glitches here and there, I was impressed, for the piece seemed to *express* something. If I had been told it had been written by a human, I would have had no doubts about its expressiveness. I don't know that I would have accepted the claim that it was a newly-uncovered mazurka by Chopin himself, but I would easily have believed it was by a graduate student in music who loved Chopin. It was slightly nostalgic, had a bit of Polish feeling in it, and it did not seem in any way plagiarized. It was *new*, it was unmistakably *Chopin-like* in spirit, and it was *not emotionally empty*. I was truly shaken. How could emotional music be coming out of a program that had never heard a note, never lived a moment of life, never had any emotions whatsoever?

The more I grappled with this, the more disturbed I became — but also fascinated. There was a highly counterintuitive paradox here, something that obviously had caught me enormously off guard, and it was not my style to merely deny it and denounce EMI as "trivial" or "nonmusical". To do so would have been cowardly and dishonest. I was going to face this paradox straight on, and it seemed to me that the best thing to do was to look the monster right in the face. And thus I picked up my telephone and phoned the program's inventor, David Cope, in Santa Cruz. I reached him with ease, and as he was very friendly and open, I asked him about aspects of EMI's architecture that I had not been able to glean from his book. After a lengthy and very informative conversation, we

made a point of agreeing to get together next time I was in California. In the meantime, I continued to grapple with this strange program that was threatening to upset the apple cart that held many of my oldest and most deeply cherished beliefs about the sacredness of music, about music being the ultimate inner sanctum of the human spirit, the last thing that would tumble in AI's headlong rush towards thought, insight, and creativity.

The Proof of the Pudding Is in the Eating

Of all the projects examined in my "Hype versus Hope" seminar, EMI was the only one that made me reconsider deeply-held beliefs. I have to confess, though, that had I only read about its architecture and not heard any of its output, I would have paid little or no attention to it. Although Cope has put in far more work on EMI than most AI researchers ever do on any one project (he was worked on it for nearly 20 years now, and the program consists of some 20,000 lines of Lisp code that runs on his trusty Macintosh), the basic ideas in the design of EMI simply did not sound radically new to me, or even all that promising. What made all the difference in the world for me was *carefully listening to EMI's compositions*.

I don't think one can possibly judge EMI without hearing some of "her" pieces (Dave usually says "her", and, for fun, I sometimes go along with the anthropomorphism). Some people will approach them open-mindedly, while others — often musicians — will come to EMI's pieces with a strong preconceived idea that they will be weak or blatantly derivative, and so, however the pieces actually sound, such people will wind up putting them down, even pooh-poohing them, safe in their knowledge that they were done by a computer. For that reason, I think it best that one first hear a few of EMI's pieces without knowing their provenance — perhaps without even having ever heard of EMI. I don't like dishonesty, but perhaps it is best to misinform people about what they are about to hear, in order that they not listen with a pre-closed mind.

Lecturing on EMI in Many Different Venues

It was not too long after my first exposure to EMI that I decided that I had to organize my many complex reactions to this strange project in a coherent fashion, and that meant preparing a well-rounded lecture on it all. I pulled together a set of thoughts, made a bunch of transparencies, and was lucky enough to find several venues where I could give this lecture. My set of transparencies evolved in many ways as these lectures took place, which was good, but one strange thing I soon discovered was that almost no one in my various audiences shared my profound sense of bewilderment or alarm. Hardly anyone seemed upset at Cope's coup in the modeling of artistic creativity; hardly anyone seemed threatened or worried at all. I felt kinship with but a few souls in the world who also were bewildered by similar triumphs. One of them was none other than Garry Kasparov, who had said, a year before being trounced by Deep Blue:

> To some extent, this match is a defense of the whole human race. Computers play such a huge role in society. They are everywhere. But there is a frontier that they must not cross. They must not cross into the area of human creativity. It would threaten the existence of human control in such areas as art, literature, and music.

On one level, Kasparov's words sounded ridiculous to me. Saying "Computers *must not* cross into human creativity" seemed hopelessly naïve, almost like saying, "We must not

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let them do certain things, because they'll beat our pants off if we do, and won't that be dreadful!" And Kasparov's last sentence, even sillier, raises the specter of computers trying to wrest control away from human beings, as if on the surface of our planet there were already raging some terrible battle between alien species for control of culture. Such a weird scenario may possibly come to be in the next few decades or next few centuries — who can say for sure? — but certainly it is not happening already. Today we control computers, and that is beyond doubt or dispute.

And yet... and yet... something of Kasparov's worried tone resonated with me. It was as if he had felt, and I now felt, something about the profundity of the human mind's sublimity being taken away, being robbed, by the facile victories of programs that seemed totally out of touch with the essence of the domains in which they were operating so well. It seemed somehow humiliating, even nightmarish, to me.

But no matter how I tried, I could not get my own sense of confusion and worry across to my audience. One thing I learned fairly soon was that few people have a visceral feeling about the centrality and depth of music. Indeed, I discovered that there is a rough trichotomy of people. There are some who, like me, feel that music is the most powerful drug in the world, and that it reaches in and touches one's innermost core like almost nothing else — more powerfully than art, than literature, than cinema, and so on. But such people are few and far between. A much more common attitude is, "Sure I like music, but it doesn't touch me at my very core. It's just fun to listen to, to dance to, and so forth." And then another attitude that came up surprisingly often in question-and-answer sessions after my lectures was this: "I'm kind of tone-deaf, and music's okay but I can take it or leave it, so I don't really relate to your deep love of music, but..."

I soon realized that I was probably not going to reach the third group no matter what I said, and wondered if the "music enthusiasts" of the middle group were also beyond reach. But to my greater chagrin, even most people in the *first* group often couldn't relate to my worry! This I found utterly baffling.

In pondering how I might more effectively transmit my admittedly nonscientific, totally emotional concerns to a wide audience and gain their sympathy, I somehow came up with the idea of putting my ideas into rhyming quatrains. And so, before long, I had converted a great deal of the lecture into verse. As I tried it out on audiences, I found that the serious ideas in my message, now "leaner and meaner", seemed to reach more people. Perhaps part of the reason for this is that I put on a kind of artistic persona in my rhymes, which allowed me to express myself in a more personal manner than I would dare to do in prose.

The first time I gave my versified lecture was, amusingly, in a back-to-back pair of lectures with Dave Cope right on his home turf in Santa Cruz, and our complementary talks went over very well. I might add that Dave himself — as one might expect, since music is his profession — belongs to that first category (the most intense lovers of music), and he and I even share a great deal in musical taste. This makes the discrepancy in our attitudes towards EMI all the more striking, and, needless to say, thought-provoking.

Is Music Just Splicings of Licks, and No More?

Without further ado, let me now proceed to describing EMI a little bit, and then begin giving my reactions in verse form. The basic idea behind EMI is what Dave Cope terms "recombinant music" — the identification of recurrent structures of various sorts in a composer's output, and the reusing of those structures in new arrangements, so as to construct a new piece "in the same style". One can thus imagine feeding in Beethoven's

nine symphonies, and EMI coming out with Beethoven's Tenth (or Brahms' First, if you subscribe to the claims of some musicologists that in his First Symphony, Brahms carried on the Beethoven spirit beyond the grave).

Toward the beginning of *Computers and Musical Style*, his first book about EMI, Cope says this about his personal pathway of exploration:

> In 1981, during a moment of recklessness, I wrote the following in a daily journal:
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> > *I envision a time in which new works will be convincingly composed in the styles of composers long dead. These will be commonplace and, while never as good as the originals, they will be exciting, entertaining, and interesting. Musicians and non-musicians alike will interact with programs that allow them to endlessly tinker with the styles of the composing programs.... I see none of this as problematic. Machines, after all, only add and subtract. Programs that benefit from those operations are only as good as their creators.*
>
> This book describes many aspects of a program I have since devised for the replication of musical styles.... If there is a discovery here, it is that one way of defining style is through pattern recognition and that musical style can be imitated if one can find what constitutes musical patterns.

Here, then, is my opening salvo of quatrains in reaction to Cope's characterization of musical style as patterns.

Is music a craft,
Or is it an art?
Does it come from mere training,
Or spring from the heart?

Is music just notes,
Merely patterns combined
By a cocktail-bar pianist
With a wandering mind?

Though Fats Waller's ticklin'
Suggests profound joy,
Might it all be illusion
From a practiced riff-boy?

Does music, like poetry,
Cry from one's core,
Or is it just splicings
Of licks, and no more?

Do the études by Chopin
Reveal his soul's mood,
Or was Frédéric Chopin
Just some slick "pattern dude"?

Was Chopin a zombie with
The gift of piano gab?
Did he toss off mazurkas
Much as party bores blab?

Could he turn off his brain
And continue to sing
In true heart-rending fashion —
Or would one miss some zing?

Was Bach a musician
Or mere "Musikant"?
Did Johann his passion
Express — or just cant?

In the furnace of Bach,
Did there burn a pilot light,
Or did Joh. Seb. compose
On cool autopilot flight?

There's music that's trite,
And there's music that's deep —
Or is that the truth?
Does all music come cheap?

Can one bypass the soul,
Can one sidestep all strife,
And produce wondrous music
Without living life?

That's the crux of my talk;
The idea, I hope, 's clear.
And until recently, I
Myself had no fear.

A skeptic shot through,
But then one day I heard
Some not half-bad tunes
From a program. My word!

So can style by learned
By mechanical means?
Can Rodgers be churned
Out by Hart-less machines?

Soul-fire in Cole Porter
Began his Beguine;
Can we order more Porter
From a Cole-less machine?

Well, so begins my commentary — making no bones about setting forth an emotional point of view. But if one is to form an educated opinion of EMI, one's first duty is obviously to familiarize oneself with how the program works. Cope, naturally, has his own

ways of explaining EMI, but I have found it useful to rephrase what I have learned over these past few years, and I think that hearing it from an outsider's viewpoint may help to clarify certain difficult points. Moreover, I found more than once, in talking with Dave, that he would provide highly revelatory answers to key questions — questions that were not answered anywhere in his writings, and in fact in most cases were not even posed in his books. Such interchanges gave me a kind of personal insight into some aspects of EMI that I believe may be useful to share, and so, with that as my excuse, I now present my amateur's capsule portrait of EMI's innards.

A Personal View of How EMI Works

EMI's central *modus operandi*, given a set of input pieces (usually all by a single composer and belonging to the same general form, such as *mazurka*) is:

(1) chop up; (2) reassemble.

This, in three words, is what Cope means by the phrase "recombinant music". Caveat: The assembly phase, in contrast to Mozart's famous *Musikalisches Würfelspiel*, which produced waltzes by random shuffling of 3/4 measures, is anything but haphazard or willy-nilly (as if by throwing dice). There are significant principles constraining what can be tacked onto what, and these principles are formulated so as to guarantee coherence (at least to the extent that the input pieces themselves are coherent!). I summarize these two principles as follows:

(1) Make the *local flow-pattern* of each voice similar to that in source pieces;
(2) Make the *global positioning* of fragments similar to that in source pieces.

These could be likened to two types of constraints that a jigsaw-puzzle solver naturally exploits when putting together a jigsaw puzzle:

(1) The *shape* of each piece meshes tightly with those of neighboring pieces;
(2) The *stuff* shown on each piece makes sense in the context of the picture.

The former of these constraints might be characterized as *syntactic meshing*, or meshing based solely on *form*, while the latter could be characterized as *semantic meshing*, or meshing based solely on *content*. In isolation, perhaps neither of them would be too impressive, but when used together, they form a powerful pair of constraints. But how does my jigsaw-puzzle metaphor translate into specific musical terms?

Syntactic Meshing in EMI: Voice-hooking and Texture-matching

Let me first consider the the first of these constraints — that involving form, or what one might call "coherence of flow". This constraint in fact breaks down into two facets:

(1) voice-hooking; (2) texture-matching.

To understand these two distinct facets of syntactic meshing, one has to imagine that a new piece is being put together note by note, in sequence, and that to this end, short fragments of input pieces are being selected so as to mesh with the current context.

Imagine that we have just inserted a fragment f_1, and are considering whether to insert fragment f_2 right after it, drawn from somewhere in the input. *Voice-hooking* would be the requirement that *the initial note of the melodic line of fragment f_2 should coincide with the next melodic note to which fragment f_1 led in its original context.* In other words, a given fragment's melodic line should link up smoothly with the melodic line of its successor fragment. This is very much like saying that two puzzle pieces should fit together physically.

Of course, here I referred only to the melodic, or soprano, line of a piece. One can also insist on voice-hooking of the bass line, and of intermediate lines as well (tenor, alto, and so on). Ideally, voice-hooking can be carried out successfully on all voices at once, but if not, then the most logical voices to sacrifice are the inner ones, then the bass line, and last of all, the melodic line. Usually, provided there is a sufficient quantity of input pieces, it will be possible to achieve a good deal of satisfaction in voice-hooking.

In addition, there is *texture-matching*, which is basically the idea that *the notes in a chord can be moved up or down pitchwise by full octaves and can be spread out timewise so as to match some preexistent local pattern in the piece being composed.* Most typically, these two operations result in the "spinning-out" of a simple chord into an arpeggio that matches some pre-established arpeggiation pattern. Thus, a purely vertical C-E-G triad could be spun out, for instance, into a C-G-E-G figure to be incorporated into an Alberti-type bass line, or into a very wide E-C-G arpeggio to match the widely arpeggiated pattern of the bass line of a Chopin-like nocturne. It could even be turned into the very long sequence of notes "C-E-G-C-E-G-C-E; C-E-G-C-E-G-C-E", which you may recognize as the melody in the first measure of the C major prelude of Book I of Bach's Well-Tempered Clavier. Basically, the pattern of that piece is so regular that it is a mechanical act to spin out a triad into a whole sixteen-note sequence.

Semantic Meshing in EMI: Tension–Resolution Logic and SPEAC Labels

We now turn to the second constraint — that involving content, or what one might call "tension–resolution logic". This is where ideas devised by Cope as part of EMI may in fact constitute a significant new contribution to music theory. The basic idea is that one wishes to insert a fragment into a new piece only if *the "location" of the insertion is similar to the "location" of the fragment where it occurred in some input piece.* The word "location" is put in quotes here because it is not clear what it means. Indeed, the italicized phrase forces one to ask the puzzling question, "How can a given fragment be 'in the same location' with respect to two different pieces? How can one compare 'locations' inside totally different pieces? What, indeed, might 'location' inside a piece be taken to mean (since, self-evidently, using measure number would be a pathetic travesty of an answer)?"

Cope decided that "location" must be defined in a way that involves both global and local contexts — in fact, a series of nested contexts, ranging from very local (notes, measures) to medium-range (phrases) to large-scale (periods) to global (sections). To a fragment on any of these distinct hierarchical levels (and there can be any number of such structural levels), Cope attaches a label — one of the five letters *S, P, E, A, C* — which attempts to capture what I have chosen to call the *tension–resolution status* of that fragment. These letters stand for the following words: *statement, preparation, extension, antecedent, consequent.* The label-assignment process proceeds from most local to most global, with the labels of larger sections dependent upon the labels already assigned to their component pieces.

Unfortunately, the details of the label-assignment process are unclear to me, but in essence it starts at the most local level, where the presence of specific scale degrees in the

various voices is used as the main diagnostic for the labeling of a chord (co-presence of tonic and dominant, for instance, or tonic and mediant, suggests an "S" label at that level). From there on out, certain characteristic sequences of local labels are telltale cues that suggest specific higher-level labels, and so on, always moving upwards hierarchically. In the end one winds up with *SPEAC* labels attached to sections of many different sizes and, perforce, at many different structural levels.

The upshot of this many-leveled labeling process carried out by EMI is that any local fragment of an input piece winds up with a set of labels — its own label, that of the larger fragment inside which it sits, then that of the next-larger fragment in which that one sits, etc. etc. Thus hypothetically, a given chord in an input piece could have the following set of labels (proceeding from most local to most global): A-C-C-E-P-A-S, and another chord might have the hierarchical series of labels E-S-C-S, etc. In either case, such a series of letters basically tells you, on several different hierarchical levels, just what the tension–resolution status of the piece is at the chord concerned. And that — provided it really works well — would seem about as good a way of saying "where you are" in a piece as any I could imagine, since tension and resolution on many levels really do constitute the crux of musical meaning.

Now the trick is to use these labels to guide composition, and the basic idea is fairly straightforward. Suppose that in our piece-under-construction we find ourselves in a location whose tension–resolution status is PACSCS (moving from most local to most global). The letters "PACSCS" tell us "where we are", so to speak, inside our new piece. And so, in choosing a fragment to borrow from an input piece and to insert right here, our main criterion will naturally be that the chosen fragment's tension–resolution status inside its original piece was exactly PACSCS — in other words, that the fragment we are going to quote lies in "the same place" inside its original piece as in the new piece.

If in the input corpus we find several such "same-location" fragments, that is good, since it gives us a choice of how to continue, but we of course also want to satisfy the syntactic voice-hooking constraint. We thus throw away any fragments that don't match in this manner. If after this paring-down, there are still several potential fragments surviving and vying with each other for insertion, then we can choose one at random.

Suppose, on the other hand, that there is no input fragment that has exactly the desired multi-level tension–resolution status — how then to proceed? The only solution is to sacrifice something — but what? Cope decided that in such circumstances, global status is more sacrificeable than local, and so we lop off the final letter, leaving us with "PACSC", and now we try again to find an appropriate fragment in the input corpus. If this fails, we lop off one more letter (thus giving "PACS"), and we search again in the input corpus. Since through such lopping-off we are loosening ever further the constraint of matching tension–resolution status, we will eventually find one or more input fragments that match the labels that we seek, and then we can choose randomly among those fragments, provided that voice-hooking also works. And thus the piece gets extended a little bit. At this point, we restart the constrained search process and extend the growing composition a little bit more — and so forth and so on. Thus, like a crystal growing outwards, is built up a piece of music by EMI.

In summary, here, in my own words, is the core of EMI's composition process:

> Sequential assembly of fragments that have the highest possible degree of agreement of SPEAC-labels on all hierarchical levels;
> Stitching-together of fragments so as to respect voice-hooking constraints and so as to match local textures.

Signatures

The preceding is the true core of EMI, but in addition there are two other important mechanisms that should be described here as well. The first is what Cope calls *signatures*. A signature is a characteristic intervallic pattern that recurs throughout a composer's *œuvre*, the use of which lends a high degree of seeming authenticity to a freshly-composed piece. To find signatures, Cope has EMI scour all input pieces for pairs of short note-sequences (say, between four and twelve notes, although there is no strict cutoff) whose intervallic patterns match either exactly or approximately. Thus, for instance, C-B-C-G would *exactly* match F-E-F-C, and would be a *near* match for D-C-D-A (the difference being that the first and second intervals are semitones in C-B-C-G, and whole tones in D-C-D-A). EMI scours the input for exact matches, and then gradually loosens up the search (relaxing the criteria governing interval-matching), until a satisfactory number of recurrent patterns have been found.

The parameters that determine whether a potential match is judged satisfactory or not are called "controllers", and during a search for signatures, one must adjust the controllers until just the right number of signatures is found — not too few but not too many either. I know that in the past, Cope tended to do this adjustment of controllers himself in order to increase the effectiveness of EMI's search for signatures, but perhaps by now he has managed to automate that aspect of the process. In any case, among the subtlest of controllers are those that winnow "insignificant" notes out of a given passage, leaving just "significant" ones; thanks to such controllers, EMI can then match a highly embellished melodic fragment that contains, say, 20 very rapid notes with another melodic fragment that contains only four slow notes, and can discover the core signature that they share. Thus signatures found by EMI can be very subtle indeed.

An important point is that such matching of intervallic patterns must take place *across* pieces, rather than *within* a given piece — for the obvious reason that any given piece will re-use its own motifs many times, and Cope is not trying — indeed, he does not wish — to get EMI to reproduce the melodic lines of a given piece, but rather he wishes EMI to pick up on and to exploit the recurrent (but less obvious) melodic patterns that a composer tends to re-use from piece to piece, probably without even being aware of doing so.

It may not seem *a priori* evident, needless to say, that all composers do have signature motifs, but this has turned out to be the case. One might tend to think that the existence of many signatures would show that a composer is rut-bound, and perhaps it does, but in any case, it is a universal fact, revealed in undeniable fashion by Cope's work on EMI, that each composer does employ interval-pattern motifs that recur in piece after piece.

Once such signatures have been identified in the input, they are stored in a data base, with each diverse instance of a given signature being stored *together with its underlying harmonies*, thus all ready for insertion *as a whole* inside a new piece. You might suppose that the insertion of prepackaged, precisely quoted chunks would risk producing passages that sound like pure plagiarism, but surprisingly, these prepackaged chunks are usually so generic-seeming and so small that, even to a highly astute listener, they don't shout from the rooftops which precise piece they came from; they merely sound like the given composer in a nonspecific, non-pinpointable manner.

Templagiarism

The second mechanism that I wish to describe here is what I dub "templagiarism", short for "template plagiarism" — a fascinating, more abstract version of the signature

concept. If, in scanning a given input piece, EMI notes that a motif appears in quick succession two or more times (again with some liberty taken in the matching, thus allowing variants of a given motif, such as tonal entries of a fugue theme, to be counted as "equal" to each other), it records the following data for these entries: (1) the *pitch displacement* of the new occurrence relative to the previous occurrence, and (2) the *temporal displacement* of the new occurrence relative to the previous occurrence. In short, EMI records, for any repeated motif, the "where and when" pattern that characterizes the motif's repetitions. EMI then detaches this abstract pattern from the specific motif in question, and takes it to be characteristic of the composer's style. Note that this is a higher-order architectural stylistic feature than a mere signature, because it is concerned not with any motif itself, but with how that motif recurs within a piece.

Templagiarism can be an astonishingly effective style-evoking device, as I found out one day when listening, in Cope's living room, to "Prokofiev's tenth sonata for piano" (as Dave humorously, or perhaps hubristically, dubs one of EMI's pieces, about which more later). As the second movement started, I heard a very striking chromatically descending eight-note motif in mid-range, then moments later heard the same motif way up high on the keyboard, then once again a few notes lower, and then one last time very deep down in the bass line. These widely spread entries gave an amazing feeling of coherence to the music. Indeed, for me the passage reeked of Prokofievian impishness, and I thought, "Good God, how in the world did EMI do *that*?" It sounded so well calculated (not in the computer sense of the term!), so inventive, so full of musical intelligence.

Astonished, I asked Dave what was going on, and he replied, "Well, somewhere in one of the input movements on which this movement is drawing, there must be some motif — totally different from *this* motif, of course! — that occurs four times in rapid succession with exactly these same timing displacements and pitch displacements." Then he spelled out more explicitly the concept of templagiarism to me. It would have been pleasing if at that point we had scoured Prokofiev's scores until we found exactly such an episode, but we didn't take the trouble to do so. I'll take Dave's word for it that we would find it somewhere or other.

Cope's idea of templagiarism is itself brilliant and devilishly impish: it borrows a touch of genius from the composer at such a high level of abstraction that when the pattern is simply quoted lock, stock and barrel — plagiarized, no more, no less — it once again sounds like a touch of genius, but an utterly fresh and new one. The reason it sounds fresh and new is, of course, that in order to quote the template, you need to supplement it with a new "low-level" ingredient — a new motif — and so the quotation, though exact on the *template* level, sounds truly novel on the *note* level, even if one is intimately familiar with the input piece from which the template was drawn. New filler material has been spliced into an old template that bears the unmistakable stamp of a specific genius, and so the whole passage has a powerfully compelling feel to it — a deep musical mind seems to lie behind it.

It's a bit as if one were to use fancy speech-synthesis technology to make the very familiar voice and accent of, say, John Kennedy come out with utterances that Kennedy himself never made — perhaps nonsense statements, perhaps cheap rabble-rousing inanities that he would have despised, whatever. Despite their falsified content, they would still sound for all the world like Kennedy (at the voice level, at least), and such statements probably would seem genuine to most people.

I must admit that I don't have a clear understanding of how the very complex operation of templagiarism (or, for that matter, the somewhat simpler operation of insertion of signatures) is made to coexist harmoniously with the previously described

syntactic and semantic meshing-operations, because I can easily imagine them conflicting with each other. Nor do I understand how EMI composes a "motif" and deems it worthy of use as such in an extended movement. But of course, how could I? It would probably take many months of intense study of EMI in order to understand such matters. I remain an intrigued outsider, and hope and expect that over time, Dave will explain EMI's principles ever more lucidly.

The Acid Test: Hearing and Voting

The foregoing provides a summary of what I myself have absorbed about the workings of EMI, both from reading Cope's books and from a good number of one-on-one conversations with him. We now continue with a few more of my quatrains about EMI.

> *David Cope, a composer*
> *At UCSC,*
> *Has a program make music*
> *From S, P, E, A, C.*
>
> *Cope's "EMI" takes scores*
> *By, say, Bach — scores of scores!*
> *Then it scours these scores*
> *For Bach-style "signatures".*
>
> *From a "style-free" scaffolding*
> *(A pattern of "SPEAC"'s),*
> *The program hangs signatures,*
> *And lo! Old Bach speaks!*
>
> *So is music an art,*
> *Or is it merely a craft?*
> *Remember at whom it was*
> *That they all laughed.*
>
> *The proof's in the pudding*
> *(In this case, the ears);*
> *If you've not heard EMI,*
> *Don't prejudge it with sneers.*

At this juncture in my lecture, I have almost always had a live pianist — sometimes Dave's wife Mary Jane Cope, who is on the music faculty at UC Santa Cruz — perform a handful of small two-voice pieces for the audience. The listeners are forewarned that there is at least one piece by Johann Sebastian Bach in the group, and at least one by EMI in the style of Johann Sebastian Bach, and they should try to figure out which ones are by whom (or by what).

As a prelude and to set the proper tone, I first read aloud the following two short excerpts from Cope's *Computers and Music Style*, the first one describing a very simplified version of EMI which Cope devised solely for pedagogical purposes, and the second one ushering in the chapter in which the full-strength EMI — at least the EMI of that vintage — is carefully discussed (though it is certainly not described in full detail):

It will create small two-part inventions similar in nature (not in quality) to those created by Bach. (p. 98)

For the true inheritance of Bach's style to take place, a much more elaborate program would be necessary. This more elaborate program is presented in the description of EMI in the next chapter. (p. 136)

Make of that telling little phrase "the true inheritance" what you will...

After the pieces have been performed, I tell the audience that they are now going to vote (with the proviso that anyone who has recognized a piece from their knowledge of the classical repertoire is disenfranchised). The result has usually been that most of the audience picks the genuine Bach as genuine, but usually it is only about a 2/3 majority, with roughly 1/3 getting it wrong. And it is not by any means always the less sophisticated audience members who make the wrong classification. In any case, once people have made their vote, I then return to my verse, as follows:

Well, now you've heard EMI,
Perhaps you feel had.
In your shoes, so would I.
When one's fooled, one feels bad.

And if you were right,
Not a single guess wrong,
You've the right to feel smug
For a while — but how long?

So you told Bach from EMI,
So you've got quite keen ears;
But EMI's evolving —
Just wait a few years.

To *Sound* Like Bach and to *Speak* Like Bach

It is indeed true that EMI is evolving — it is a moving target. Cope began work on his program in 1981, and in all these years he has not let up on it. EMI's early pieces are, like any fledgling composer's, pretty amateurish affairs, but her later output sounds increasingly impressive, and Cope has grown more and more ambitious over time. Whereas initially he was proud of EMI's production of short two-part inventions and short mazurkas, he now has EMI producing entire sonatas, concertos, and symphonies. There is even a "Mahler opera" under way or in the works — something that would certainly be a challenge for any human composer to carry off.

What exactly is the difference between stylistic imitation as carried out by a human being and stylistic imitation carried out by a computer program? My friend Bernard Greenberg has been writing music in the style of J. S. Bach (and other composers, but Bach most of all) for decades. Indeed, among my life's most amazing memories are of visits to Bernie's apartment, where, as I listened to him play his own soulful pieces on the organ, filled with complex dissonances and marvelously unexpected turns of phrase, I felt as if I were in the presence of Old Bach himself. One time I brought along a mutual friend to listen, and he — also a gifted musician — made the following unforgettable remark to Bernie: "Gee, not only is your music in the Bach style but it *sounds* good, too!"
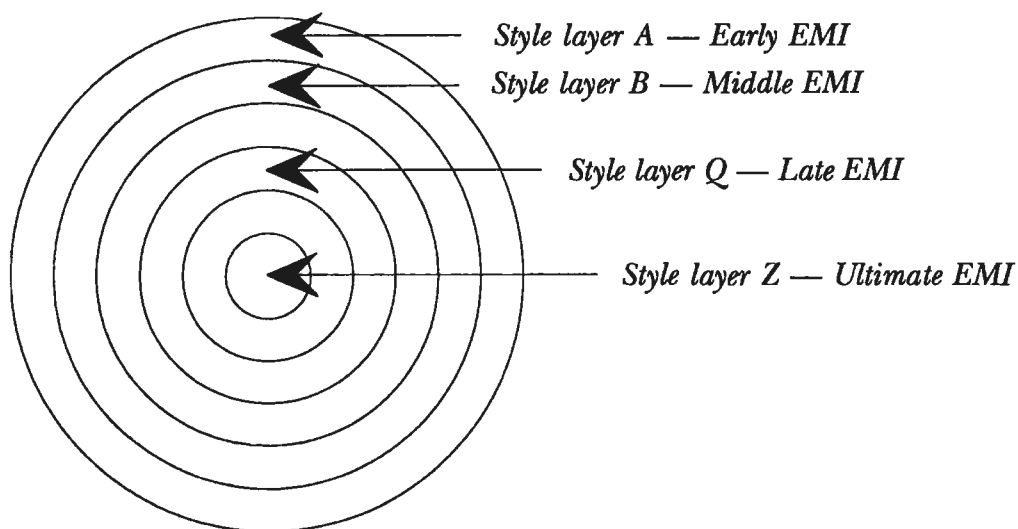
I always found this remark extremely puzzling, since to me the very *essence* of Bach style is that it "sounds good". How could something possibly sound deeply *Bachlike* and yet also sound *bad*? The tone of the remark made no sense to me — and yet I must admit that Bernie himself once made a related remark about the secrets of capturing Bach's style:

The trick is to make music not that *sounds* like him, but that also *speaks* like him.

The Nested Circles of Style

Well, of course, what is being hinted at here, though in a blurry way, is that style is a multi-layered phenomenon. There are shallow aspects to style (how a piece "sounds", in Bernie's terms), and then there are deep aspects (how it "speaks"). It is quite possible that someone could be capable of capturing many of the shallower trademarks of a composer and yet miss the bull's-eye as far as essence is concerned. I always think of Schumann's short piano piece called "Chopin", which occurs in his *Carnaval*, which on one level "sounds like" a Chopin nocturne — it has the characteristic wide left-hand arpeggios and a lot of melodic embellishment — and yet on a deeper level, it quite misses the mark in terms of Chopin soul (at least to my ear).

This talk of different levels of style and of targets and bull's-eyes suggests the following extremely simple yet seemingly inevitable diagram pertaining to stylistic imitation.

Style layer A — Early EMI
Style layer B — Middle EMI
Style layer Q — Late EMI
Style layer Z — Ultimate EMI

Someone who glibly captures only the most obvious features of a composer's style — an Alberti bass, say, for Mozart — would fall in the outer ring but leave all inner rings untouched. A deeper imitator would add other outer layers of style but fail to penetrate all the way to the core, or stylistic bull's-eye. But only someone who had dedicated years to the art, and whose emotional makeup, moreover, bore a deep affinity to that of the composer in question (and this is how I see Bernie *vis-à-vis* Bach), could hope to come close to that elusive central core that constitutes true Chopinity or Bachitude.

And yet... there is something most troubling to me about this diagram, as I have drawn it — namely, the fact that the ring with the greatest area is the outermost one, not the innermost one. This disturbs me because it suggests that you will get the most effect from the simplest and shallowest tricks. The diagram suggests that as you proceed further and further in — as your mastery of the art ever deepens — the area you are

adding becomes smaller and smaller. When you have acquired but one layer of style mastery, your music will surely not fool experts, but it might fool 80 percent of the general populace. Work harder, add the second ring of mastery, and now you fool 90 percent. Add the third ring, and your fooling-rate goes up to, say, 95 percent, and the fourth ring gets you to 98 percent. There's still something missing, but sadly, the missing ingredient is getting subtler and subtler, tinier and tinier... In the end, then, with all but the innermost circle, you may wind up reliably fooling all of the world's top experts, while still lacking Bach's true soul. In short, it's a most depressing thought, if the nested-circles image is accurate, that the innermost layer, though surely the most difficult of all layers to acquire, is also the smallest and perhaps, therefore, the least significant in terms of its effect upon listeners.

> *There are layers of style*
> *From the skin to the core.*
> *The former are patterns;*
> *The latter — something more?*
>
> *If style's many layers*
> *Are like circles that nest,*
> *Then the ones near the crux*
> *Grow more tiny. I'm depressed.*

When Does a Beatles Song Sound Like a Bach Chorale?

In an email exchange with me, Bernie Greenberg was discussing his attempts to impart to others his ability to write Bachlike music, and he wrote this:

> There are tricks of the trade, and you can teach chorale-writing such that anyone with a little talent can write a chorale that sounds like a Bach chorale *that you are not listening to closely*.

A little later in that same email exchange, in relating an episode in which he had helped an acqaintance who wrote four-part chorales and who wanted Bernie's advice on how to get them to sound more Bachlike, Bernie amplified his remarks as follows:

> There is no question that by further refinement of style, I can make them sound more like Bach chorales than many other church hymns. Perhaps the right question is:
>
> "Do they sound more like Bach chorales *than what?*"
>
> rather than
>
> "Do they sound like Bach chorales?"

> After all, compared to jet takeoff noise, or even Balinese gamelan music, most Beatles songs "sound like Bach chorales", right?

A Portrait that "Looks Like" Its Intended Subject

Bernie's humorous point is right on the mark, and forces one to think carefully about what it means to say glibly "X *sounds like* Y". And further light is shed on the question by considering the analogous issue of what it means to say "X *looks like* Y". To make this issue vivid, let us take a standard "Smily Face" image, as shown below. Presumably, the bland face shown below does not remind you of any individual you know, right?
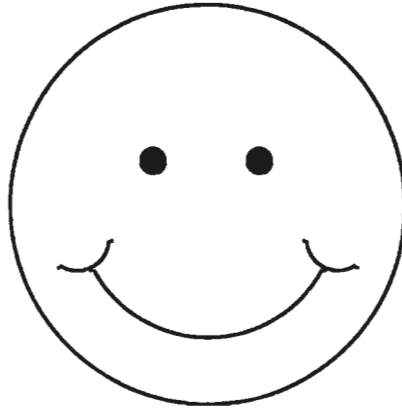
It would be surprising if it did. But if we now add to our bland, generic Smily Face a tiny amount of "style" — just a few strategically placed parallel vertical lines — lo and behold!
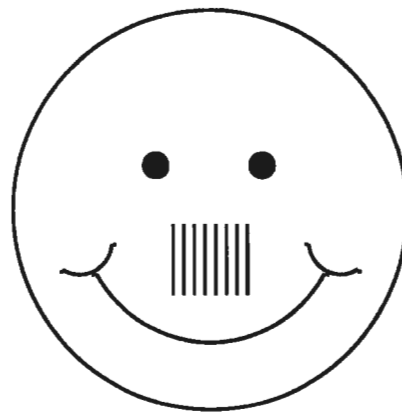
All of a sudden, nearly everybody recognizes the familiar face of the Führer of the Third Reich. To be sure, nobody would say about this mustachioed inanity, "It looks very much like Hitler"; perhaps nobody would even say, "It looks like Hitler"; but despite that, everybody *sees* Hitler in it. They can't help it. The point of this example, invented by David Moser (who grimly subtitled his ironic image "Have a Nice Holocaust!"), is that just a minimal gesture in the direction of a known style can, if well executed, have a stunning effect, summoning up much more than is really there.

So... How much are we being fooled when, on hearing a piece of music, we respond to some gestures that in the past we have come to associate with composer X, and then exclaim to ourselves, "This piece sounds like X"? Can we even distinguish clearly between responses at a shallow level and a deep level? Indeed, what *is* the difference, in music, between "shallow" levels and "deep" levels of style? Is it just a question of different levels of depth of syntactic pattern, or is it something more than that?

Lewis Rowell's "Bach Grammar"

Not long after I became a professor at Indiana University, I heard on the radio a very engaging piece for organ that to my ear sounded extremely Bachlike; when it was announced, however, I found out to my surprise, though not to my chagrin, that it had been composed by a music professor at IU — Lewis Rowell. I lost no time in contacting

Rowell and suggested we have lunch together to talk over the idea of faking Bach. He was delighted that someone had taken an interest in his piece, and we soon met. Over lunch, I asked Rowell how he had composed such an authentic-sounding piece, and he said, "Oh, that's not hard... Bach developed a kind of grammar that I merely picked up, as could anyone who wished to. And then, armed with this grammar, I — just like anyone with a bit of musical talent — can easily compose any number of pieces in perfect Bach style. It takes no genius, believe me. It's all straightforward stuff. The only place where genius was involved was in coming up with the grammar."

I was astounded to hear how dismissively Rowell described his acquisition of "Bach grammar", and just as astounded to hear he thought that composing long, complex, and coherent new pieces in the full Bach style was basically merely a mechanical act, requiring no act of genius whatsoever. After all, I, a lifelong lover of Bach, had on several occasions tried composing pieces in the Bach style, and had found myself unbelievably stymied. Measures and short phrases, yes, perhaps — but a long movement? No way!

Rowell's claim, however, was that only Bach's own *creating* of his supposed "grammar" was hard, whereas *inducing* that grammar from Bach's output and then *exploiting* it was a piece of cake. A glib hack could create new works as deep and as great as any that had ever issued from the pen of the great baroque master — or from that of any other great master. Profundity becomes a snap, emerging at the drop of a hat. By contrast, my personal feeling, based on my own experience (and, I must say, based also on long observation of Bernie Greenberg), was that *extracting* a true and deep "Bach grammar" from Bach notes was itself an act that would require extraordinary insight — perhaps even genius. And even if such a grammar could be extracted (which struck me as highly implausible, Rowell's claims notwithstanding), I felt that to *exploit* it to make new pieces as great and as engaging as those of JSB himself would still be an act of enormous creativity.

Many years later, grappling mightily with the strange new world of EMI and her algorithmically induced grammars, I remembered my stimulating lunch with Lew Rowell and wondered what Bernie Greenberg would think of our chat. So I sent Bernie the gist of Rowell's claims through email, to which he quickly responded with the following eloquent set of remarks in his own inimitable style (if I dare make such a claim!):

> I'd be very interested in such a grammar. It would have to include a "syntactic description" of the theology of Paul as expressed in Romans, the innate intellectual tension between Christ's roles as Victim and Savior, and other emotional basis vectors of the space which is "Bach".
>
> Anyone who has been moved by the St. John Passion, the St. Matthew Passion, or the Cross dialogue of Cantata 159 understands that the root of their emotional power is in the turgid psychodynamics of the Crucifixion, not in the seventh-chords, which are the mere paint that Bach has used to implement these canvases, incomparable paint though it be.

Although I sympathized with what Bernie was trying to say, I felt he had overstated the case. Does one really need to be a pious Christian to be able to compose deeply Bachlike music, or even to be powerfully moved by Bach's music? In point of fact, Bernie himself, a Jew by upbringing and an agnostic by credo, provided a counterexample. I argued that the essence of Bach's power comes not from his deep piety but from his deep humanity — from just those human experiences discussed in my Speculation (quoted from *GEB*, above) about a computational "music box" producing new Bach and Chopin pieces. Bernie, on hearing this objection, conceded that among the most important "emotional basis vectors of the space which is 'Bach'" are many that have nothing *per se* to do with religion, but that simply follow from being born into this crazy world, growing up in it, and living a full human life. And so Bernie closed his musings by saying this:

When the "grammar" is sufficent to cover such notions, the General AI problem will have been solved, I think.

Amen. As for myself, I was inspired by all these musings on alleged "Bach grammars" and the hidden inner fire of human creativity to write the following series of quatrains.

When music's been treated
By the likes of Dave Cope,
Is the mystery banished,
Or is there still hope?

Does true depth in music
Mean creating new styles,
So that music by mimics
Is worth just snide smiles?

Was Chopin's fourth ballade
A mere splicing of licks
From his previous three —
Or were there new tricks?

What's creative? What's rut-stuck?
What is new, and what's old?
What's derivative? What's novel?
What is weak, and what's bold?

Is a style, once devised,
A mere snap to ad lib
A bunch of new tunes in,
Provided you're glib?

Is Bach-style a grammar
A hack can acquire,
Or is there some essence —
Some deep inner fire?

Just what makes a genius
Than a mimic far better?
The former forges spirit;
The latter worships letter.

'Twixt genius and mimic,
What makes the sharp cut?
The former's unfettered,
The latter's in a rut.

Showing Up Despite Being a No-Show

When I gave my talk with Dave Cope at Santa Cruz in May of 1996, I was hoping to persuade Cope's Santa Cruz colleague Tom Lehrer, of satiric-song fame, to take part in a

panel discussion on EMI, and to that end, I called up Lehrer (whom I had known for some years and who I knew was something of a recluse) and tried to persuade him to join us. He was, however, predictably self-deprecating and in the end turned me down, although in the nicest of ways. In fact, our phone chat lasted at least ten to fifteen minutes, and I found what he said very provocative. When I hung up, I all of a sudden realized that although Lehrer had declined to come, he had actually told me over the phone pretty much what I had most hoped he might say in front of a live audience. Given that irony, I quickly jotted down everything that I could remember, which was a lot, and then promptly translated it into verse. I figured that this way I could give my audience a "virtual Lehrer" (and keep in mind that the German word "Lehrer" means "teacher") if not the real McCoy.

I must admit that I was also secretly hoping that Lehrer would show up in person at the back-to-back lectures Dave and I were giving, because then I could play my little joke on him, of surprising him by delivering his own ideas, in versified form, to the assembled group despite his having declined to participate. Unfortunately, no such luck — Lehrer didn't attend our talks. Nonetheless, my Lehrer quatrains were appreciated by the audience, and I feel they enrich the whole discussion, and so, for what they're worth, here they are:

A teacher I know
Whom I asked to take part
In this meeting, said, "No,
What I do is no art…

"I've nothing to tell folks;
I won't take the stand.
It's true, I write songs,
But they're boring and bland…

"You just name me a form
Such as 'march', and I'll play
You a piece with a march beat,
Cliché after cliché…

"All my songs are deriv —
They're in nobody's style.
If I try copying Kern,
It comes out sounding Weill!

"Still, old Irving Berlin
Has a style I might snag,
For his music's as patterned
As a Scott Joplin rag…

"Berlin plays vanilla
To Kern's chocolate mint;
So I might stamp out tunes
From that old Berlin mint…

"But it's truly a cause for despair
When you come to the genius of Kern.
He pulls magical chords from the air
With an ease too profound to discern...

"Oh, I guess if I truly did yearn
To mimic the magic of Kern,
I could study and probe and might learn
Some tricks that make Kern phrases turn...

"Then armed with this kernel of Jerome,
I might slowly begin out to churn
The patterns that once seemed so special —
The signatures of the great Kern...

"But even at that advanced stage,
Pulling wool over Kern experts' eyes,
The flame of the novel I'd lack —
Lacking genius, I'd just plagiarize...

"No, the greatness of Kern I can't ape;
He's a doctor, I'm merely a quack.
And that's why I wouldn't belong
On a stage with you folks with the knack!"

Ah, the irony of his remarks!
Here's a fellow who <u>does</u> have the knack
To spin songs in the styles of yore,
Yet declines, saying, "I'm just a hack!"

Yet my friend in declining said so much,
And so well that I wrote it all down,
Then converted it into this verse,
So he's here despite turning me down!

His modesty struck me as odd.
Just why, if the Kern style did yield
Its keys to his scan, would he say,
"Still I'm nought in the novelty field?"

To what higher goal could one aspire,
Than the crafting of tunes on one's forge —
Be they Kern-style, or Lerner & Loewe,
Or Bernstein, or Lehrer — or George?

Lennie Is Jealous of George

My allusion to "George" here is, specifically, a reference to George Gershwin. The reason for this is that I was deeply struck when I read, in Leonard Bernstein's book *The Joy of Music,* an article provocatively called "Why You Don't Just Run Upstairs and Write a

Nice Gershwin Tune?" The article is in the form of a dialogue between L.B. himself and a character called "P.M". ("Professional Manager"). The two of them are meeting over lunch, and we tune in on their conversation as they chat 'n' chew:

> *P.M.:* Learn a little from George. Your songs are simply too arty, that's all. George didn't worry about all that. He wrote tunes, dozens of them, simple tunes that the world could sing and remember and want to sing again. You just have to learn to be simple, my boy.

> *L.B.:* You think it's simple to be simple? Not at all. I've tried hard for years. A few weeks ago a serious composer friend and I were talking about all this, and we got boiling mad about it. Why shouldn't we be able to come up with a hit, we said? So we went to work with a will, vowing to make thousands by simply being simple-minded. We worked for an hour and then gave up in hysterical despair. Impossible. I remember that at one point we were trying like two children, one note at a time, to make a tune that didn't even require any harmony, it would be that obvious. Impossible. It was a revealing experiment, I must say, even though it left us with a slightly doomed feeling.

Let me quote from the fellow whose lyre
Gave us <u>West Side Story</u> and <u>Candide</u> —
He's a dragon whose music breathes fire,
Yet he sighed, "By George, I'm out-keyed!"

A fake luncheon chat he once penned:
"Hey, Why You Don't Just Run Upstairs,
And Write Me a Nice Gershwin Tune?"
Its point was the depth of simple airs.

Len denies, in this chat,
That new tunes he could spin
That would capture the essence
Of his idol, Gershwin.

Indeed, his whole point
Is the fact that it's tough —
Not just tough but damned tough —
To make new Gershwin-stuff.

You struggle and strive
To be Georgishly alive,
To be simple, to jive,
Yet you never arrive.

There's a spirit inside
That just won't show its face,
Though you hear it inside
Every note, graced with grace.

Lenny's right, I would say:
To dream up "I Got Rhythm"
Takes something beyond
A pure pattern algorithm.

Devilishly Infectious Rubbish Spouted by the Orwellian Versificator

While we're on the topic of famous Georges, there is another George whose ideas are highly germane to our topic. I speak of George Orwell and his frightening novel *1984*. When I read it in high school, many nightmarish images haunted me, but there was one odd passage that came flashing back to me from far across the decades when one spring morning in 1996 I caught myself humming, to my own horror, a certain mazurka in the shower...

> And the Ministry had not only to supply the multifarious needs of the Party, but also to repeat the whole operation at a lower level for the benefit of the proletariat. There was a whole chain of separate departments dealing with proletarian literature, music, drama, and entertainment generally. Here were produced rubbishy newspapers, containing nothing except sport, crime, and astrology, sensational five-cent novelettes, films oozing with sex, and sentimental songs which were composed entirely by mechanical means on a special kind of kaleidoscope known as a versificator....
>
> Under the window somebody was singing. Winston peeped out, secure in the protection of the muslin curtain. The June sun was still high in the sky, and in the sun-filled court below, a monstrous woman, solid as a Norman pillar, with brawny red forearms and a sacking apron strapped about her middle, was stumping to and fro between a washtub and a clothesline, pegging out a series of square white things, which Winston recognized as babies' diapers. Whenever her mouth was not corked with clothes pegs, she was singing in a powerful contralto:
>
> > *It was only an 'opeless fancy,*
> > *It passed like an Ipril dye,*
> > *But a look an' a word an' the dreams they stirred,*
> > *They 'ave stolen my 'eart awye!*
>
> The tune had been haunting London for weeks past. It was one of countless similar songs published for the benefit of the proles by a sub-section of the Music Department.... But the woman sang so tunefully as to turn the dreadful rubbish into an almost pleasant sound....
>
> She knew the whole driveling song by heart, it seemed. Her voice floated upward with the sweet summer air, very tuneful, charged with a sort of happy melancholy. One had the feeling that she would have been perfectly content if the June evening had been endless and the supply of clothes inexhaustible, to remain there for a thousand years, pegging out diapers and singing rubbish.

I didn't recall this passage word-for-word, but the overall image had stuck accurately in my mind for over three decades, and reading it again made me cringe just as I had back then, imagining the ragingly infectious power of the formulaic, mechanical junk-music issuing forth from the quaintly-described "kaleidoscope known as a versificator". But now, having been sucked in myself by the kaleidosCope known as EMI, I really had no choice but to write the following verses:

> *One mazurka by EMI*
> *Has lodged, I confess,*
> *In the grooves of my brain,*
> *Causing shame and distress.*
>
> *Like the proles in George Orwell's*
> *Nineteen Eighty-Four,*
> *I find myself humming*
> *An emotionless score.*

I feel shock and bemusement
And confusion, to boot:
Is this <u>rubbish</u> I've swallowed?
Am I <u>that</u> unastute?

I never did dream
I'd be mortified by
Merely humming some tune;
Now I eat humble pie.

After decades of sureness
That the pieces I hear
Are deep mirrors of passion,
Must I now reverse gear?

The Pea-sized Creative Module Keeps on Truckin'...

Peg Brand, a friend and colleague in Indiana's Philosophy department, sent me through campus mail a remarkable article by Amei Wallach that she'd read in the *New York Times*. Its subject was the American painter Willem de Kooning, whose mental health had, in the early 1980's, suffered a sharp decline. Indeed, by the middle of that decade he was in the fullest throes of Alzheimer's disease, and yet the article was all about a series of paintings that he had executed during that period of his life, and that, rather astonishingly, had garnered high praise from not a few art critics. The curator of a large retrospective exhibit of de Kooning's last set of paintings called them "among the most beautiful, sensual, and exuberant abstract works by any modern painter". And yet one has to remember that during this period, de Kooning often would paint the same painting over and over again, unable to remember having done it before, until one day someone convinced him to keep his most recent canvases right in front of him as he worked, so he would see them and thus be able to avoid incessantly repeating himself.

Psychiatrists and neurologists interviewed in the article stressed that advanced Alzheimer's victims can no longer carry out any kind of mental activity that involves maintaining coherence — for instance, though they can play golf physically, they have to ask, on each stroke, where their ball is. Writing a sensible novel — in fact, most of the time, even uttering a sensible non-routine sentence — is out of the question, as is sustaining a chain of reasoning beyond a few seconds. It is thus definite cause for pause to find out that paintings hailed as great art were produced by a mind whose light was day by day growing fainter, a mind whose owner no longer recognized any other human's face, no matter how long known, a mind that seemed to do nothing but wander in vague, aimless circles — when not filling blank canvases with lines and colors.

There're lots of old-timers
Who still can create;
But those with Alzheimer's —
Can <u>their</u> art be great?

De Kooning is brain-dead,
He paints as in sleep;
Yet critics acclaim him:
"Great stuff — makes you weep!"

Suppose that Old Chopin
Had lived to 89,
Losing all of his memory
As well as his mind.

Yet when he sat down
To make up a fresh tune,
His magical chords
Soon made listeners swoon.

What survived in his brain
Was the size of a pea —
A module for composing
Autonomously.

When Chopin wrote waltzes,
Did he draw on all life,
Or could some "waltz module"
Be excised with a knife?

Is composing a narrow,
Mechanical skill,
So old geezers can compose
Using minds that are nil?

Is music, like chess,
A wee, hard-edged domain,
Algorithmically handled
By a pea-sized subbrain?

EMI Tries her Hand at Doing Chopin

At this point in my lecture, I usually have the second musical interlude, this time involving two or three mazurkas, at least one by Chopin, at least one by EMI. Rather than describing what happens myself, I would like to quote here what one person who was in the audience of my most recent EMI lecture at the University of Rochester wrote to me and Dave Cope afterwards.

> From kala pierson <kpi@ibm.net> Mon Feb 1 19:00:12 1999
> To: howell@cats.ucsc.edu
> Subject: EMI's big day at U. of Rochester...
> Cc: dughof@indiana.edu
>
> Hi, David! I heard Douglas Hofstadter's EMI-demo at the U. of Rochester
> yesterday; and though you'll probably hear an account of it from him, I
> wanted to give you a report from the trenches too, since EMI made such a
> dramatic impression on us.
>
> As you know, Eastman School of Music is part of U.R.; much of the audience
> was made up of theorists and composers from Eastman [I'm a composer]. DH

gave us three listening tests: Bach inventions, live; Bach arias, on video; & Chopin mazurkas, live. It was easy for most of the audience to tell EMI from Bach; there were a lot of knowing smirks among those around me during the not-Bach ones. Okay, we concluded, those imitations are pretty remarkable on several levels but they just ain't the real thing, and we — Those In the Know — can tell.

When the pianist played the two "Chopin" mazurkas, we were similarly smug. The first mazurka had grace and charm, but not "true-Chopin" degrees of invention and large-scale fluidity; there were very local-level, "shallow"-feeling modulations — just the type, I reasoned, that a computer program would generate based on more sophisticated examples of the real thing. The second was obviously genuine Chopin, with a lyrical melody; large-scale, graceful chromatic modulations; and a natural, balanced form.

Although DH told us that the vote on this piece looked like "about 50/50" from his point of view, there was a very definite preference among the theory/comp corner of the audience [true to form, we'd mostly segregated ourselves :)]. I voted real-Chopin for the second piece, as did most of my friends. When DH announced that the first was Chopin and the second was EMI, there was a collective gasp and an aftermath of what I can only describe as delighted horror. We'd been proven wrong — so, wow, EMI must be amazing! — but wait, we'd been proven wrong... I've never seen so many theorists and composers shocked out of their smug complacency in one fell swoop [myself included]! It was truly a thing of beauty.

Cheers for now,
kala

"Truly a thing of beauty"! This is an amazingly refreshing and candid statement from someone at one of the most elite music schools in the United States. Perhaps only a graduate student could have written it. But no, I take that back. There are professors who are just as honest, though certainly it is hard to swallow one's pride and admit having been taken in. For many, it would be tempting not to admit having been gulled, and to go around haughtily pronouncing EMI's compositions to be cheap forgeries of no artistic merit whatsoever. Indeed, I have run into some professional musicians who have done just that. But I personally have heard too much of EMI's music and been fooled too often to be haughty, even though some of it is certainly very weak (thank God!).

Suppose we discovered
A pristine Volume III
Of the "Tempered Clavier",
With the depth of JSB.

It makes a huge splash,
And musicians galore
Compete to perform it
In grand halls the world o'er.

It meets with reviews
That are tops. All agree
These are fugues without peer:
"Ach, it's Bach — only he!"

But for some, strange to say,
If Dave Cope were to spill
Bitter beans — "It's by EMI" —
Then its worth would be nil.

They'd retract all their praise,
No more sing its great powers,
For now it's just fool's gold —
Bouquets of fake flowers.

Musicians a-plenty
There are, who, if told
In advance, "It's by EMI",
Will find flaws. Ain't that bold?

But I fear that it's not,
For it's after the fact.
Forewarned "It's the en-EMI!",
They so "bravely" attacked.

I find it more honest
If one's judgment remains
Unswerved when one learns
It's by chips, not by brains.

When the votes were taken at my Rochester lecture, someone called out, "How'd we do compared to Indiana?" (my own university also having one of the nation's top music schools). Everyone laughed, especially when it was suggested that perhaps a new system for ranking music schools could be based on how few errors were made by faculty and students in telling pieces by EMI from pieces by human composers.

One stunning lesson from my Rochester lecture (and indeed, from all of the times I've lectured on EMI) is that people with deep musical gifts and decades of training can, on occasion, mistake an EMI product for "the genuine article". And remember — we are just embarking, we humans, on the pathway toward the realization of the dream of "preprogrammed mass-produced mail-order twenty-dollar desk-model music boxes" — those boxes on whose "sterile circuitry" I heaped so much scorn, back when I wrote *GEB*.

Where will we have gotten in twenty more years of hard work? In fifty? What will be the state of the art in 2084? Who, if anyone, will *still* be able to tell "the right stuff" from versificator rubbish? Who will know, who will care, who will loudly protest that the last (though tiniest) circle at the center of the style-target has *still* not been reached (and may never be reached)? What will such nitpicky details matter, when new Bach and Chopin masterpieces applauded by all come gushing out of silicon circuitry at a rate faster than H_2O pours over the edge of Niagara? Will that wondrous new golden age of music not be "truly a thing of beauty"? Won't it be sweet to swoon in a sea of synthetic sublimity?

If output from EMI
Fooled all but an elite,
To protest, "Crux is missing!"
Would ring quite effete.

When the "heart" that is missing
Is unmissed by most,
Then the essence that's missing
Is a wisp of a ghost.

And this is my fear —
That what's missing will shrink
To near zero, with time.
And then — what to think?

When music's reduced
To the schemas of Cope,
Has the romance all vanished?
I would like to sing "Nope."

Scarfing down Spastroni down in South Delabam'

Have you ever downed a plate of delicious *spastroni* swimming in *caravinese* sauce? Or consumed *pollitucciollo* with a side order of *pomostacchi*? Ever eaten a salad with *pomodorini* and *marboli*? If you answer yes, I'd say you're a brazen bluffer, for these words were produced by a very simple computer program which had been "fed" (for want of a better word!) the names of many Italian foods, such as *spaghetti, ravioli, lasagne, vongole, rigatoni, pomodori, fettuccine, linguine, vitello, pollo, mostaccioli,* and so forth. There is no such thing as *caravinese* sauce or a side order of *pomostacchi,* my friend! (On the other hand, by sheer luck, there really are *pomodorini* — cherry tomatoes — for the computer-generated word just happens to be the standard diminutive form of *pomodori,* "tomatoes".)

This kind of program, first shown to me in the early 1960's by my friend Charles Brenner, and which originated at Bell Labs in the late 1940's, is based on imitating the frequencies of short letter groups — in this case, *trigrams.* Given a passage of input text, the method is based on the probability of a pair of letters (*sp*, for instance) being followed by various other characters (*a*, for instance, would be a likely follower, as opposed to *q*, which would be nonexistent).

To generate a piece of output text that mimics the trigram frequencies of the input text, you begin with any digram (two-letter piece) of the input text (*sp*, let's say). Then you look at *which characters* followed that digram in the input text, and *how many times* each of them did so. Perhaps the letter *a* followed *sp* four times, *i* followed it once, *o* followed it twice, and *u* once, and that's all. That's eight *sp*'s, altogether. Now imagine rolling an eight-sided die, four of whose sides are labeled *a*, one labeled *i*, two labeled *o*, and one labeled *u*. Half the time you'll get a side labeled *a*, but half the time you'll get something else. Take that letter, whatever it is (*a*, let's say) and tack it onto your output stream, giving *spa*. Now your most recent digram is *pa*. Once again, consult the statistics telling which characters followed occurrences of *pa* in the input text, and based on these data, make an *n*-sided die and roll it, telling you which new character to append to *spa* — perhaps *s* this time. Now repeat the probabilistic process, this time with digram *as*. Each time, you will get a letter that really occurred in the input text, thus turning a digram into a trigram. And thus, left to right, letter by letter, character by character, fresh new input-imitating output text is generated in this most simple of stochastic ways.

You want some fake state names for the board game you're inventing? Well, take your pick from the following, which were generated by the trigram-frequency method from

the data base of the fifty real state names (and I could give you hundreds more fake state names at the drop of a hat):

> Nebrado, Wessissippi, Oklawaii, New Yornia, Pentahoma, South Delabama, New Jersetts, Pennectico, Texichusetts, New Hampshington, Michigansas, Oklaware...

Now this is recombinant language, in spades!

Using 8-grams to Ape the Great Art of The Bard

Speaking of "recombinant", back in the 1960's when DNA was quite a novelty, there was a psychologist who trained planaria (a primitive type of aquatic flatworms) on a simple food-finding task, and then ground them up and fed the resultant worm-goulash to other planaria. His hope was that the learning that had taken place in the brains of the victimized worms had somehow been stored as sequences in their DNA and as such, would hopefully survive the chopping-up process, so that the cannibals, after partaking of their worm-goulash banquet, would suddenly find themselves more skilled at finding food. This method of passing on one's learning to others was at first thought to work and made quite a splash in the press, but later was thoroughly discredited. Oh, well.

> *With trigrams, new state names*
> *Can be spewed on demand.*
> *The next stop? Why, Shakespeare!*
> *Can his spirit be canned?*
>
> *Do you remember the sixties?*
> *Some worms were made wise,*
> *Then chopped up and fed*
> *To their relatives in disguise.*
>
> *The wisdom, it was claimed,*
> *Came through quite intact,*
> *Though the poor DNA*
> *Had been chopped up and hacked.*
>
> *So let's chop up old Will*
> *Into 7-grams, or 8 —*
> *Will's wisdom we'll distill;*
> *Then we'll regurgitate!*
>
> *This sounds like a joke —*
> *But take text that's opaque,*
> *And with trigrams you'll make*
> *A respectable fake.*
>
> *When n-grams are used,*
> *As you jack n up high,*
> *The facsimile's fakeness*
> *Gets harder to spy.*

Well, Not Quite The Bard...

The German philosopher Georg Friedrich Hegel produced text that to some folks seems buzzing with wisdom. In my experience, however, most people, at least on their first several hundred readings, find the following Hegel sample fairly unenlightening:

> Further, the living substance is being which is in truth subject, or, what is the same, is in truth actual only in so far as it is the movement of positing itself, or is the mediation of its self-othering with itself. This substance is, as subject, pure, simple negativity, and is for this very reason the bifurcation of the simple; it is the doubling which sets up opposition, and then again the negation of this indifferent diversity and of its antithesis. Only this self-restoring sameness, or this reflection in otherness within itself, not an original or immediate unity as such, is the true. It is the process of its own becoming, the circle that presupposes its end as its goal, having its end also as its beginning; and only by being worked out to its end, is it actual.

What happens if you apply the n-gram–frequency method to this text? We can use trigrams, tetragrams, or higher. Here is what came out of a run using pentagrams:

> Furtherness with itself, or immediate unity and is in truth substance is the doubling its end also as its self-restoring itself-restoring worked out to its own becoming, the mediation of position of the bifurcation of the bifurcation of this substance is, as subject, pure, simple; it actual.

Note that, even though the program knows absolutely nothing about English words, there is not a single non-word here. On the other hand, the grammar leaves something to be desired. But that gives us good reason to jack up the n-value to, say, $n = 6$.

> Further, the movement of position, and only by being which is in truth actual only in so far as its goal, having sameness, or this reflection of its own becoming, the doubling with itself, not an original or immediation in othering which is in truth actual.

Now this time, curiously, we did wind up with two non-words — "immediation" and "othering" — but they fit in so nicely — they seem so *Hegelian*, one might say — that few readers ever notice that they "do not compute". But let us now set n equal to 9 and see what happens...

> Further, the living substance is being which is in truth actual only in so far as it is the doubling which is in truth subject, pure, simple negativity, and is for this reflection in otherness within itself, or is the mediation of the simple; it is the true. It is the doubling which is in truth...

The grammar is surely getting better, although it is not yet perfect. But grammar aside, what about *meaning*? Well, it sounds more and more like Hegel. Of course, we must beware of that slick phrase "sounds like". To adapt Bernie Greenberg's phrase, "It not only should *sound* like Hegel, it should also *speak* like him." And yet sadly, for us philistines who can't hear the wisdom resounding in the original lines, these regurgitated lines somehow *do* seem to "speak like Hegel". And if, to your taste, $n = 9$ isn't good enough to get credible Hegelian semantics, then jack n up further. Each time you add 1 to n, your output will get a little more realistic, a little more coherent. And please note: this method for simulation of text is far simpler than EMI, for it is *purely local*, whereas EMI combines both local and global constraints in a far subtler manner.

Composing in Your Sleep... or in Your Grave

Anyone who has composed a fair amount of music knows the exquisite joy of finding their own personal voice. One dreams of composing more and more, but of course time presses and one's finiteness constrains one's output. It is therefore natural to wonder what EMI would do if fed one's own music as input. And I, given my close connection with EMI's progenitor, could request this favor and actually find out. I submitted a diskette to Dave, containing twelve of my piano pieces (I've written around forty, all told), and he in turn fed my pieces into EMI and started her churning. Promptly, out came pseudo-Hofstadter music!

And in the course of my Santa Cruz lecture, Mary Jane performed both a genuine Hofstadter piece and an EMI-Hofstadter piece (called "Nope"), with me hearing myself aped for the very first time, in real time before the audience's eyes. It was delightful to listen as my own harmonies were spit back at me in new and unexpected combinations, although I have to admit that sometimes the "logic" of the flow, such as it was, sounded a bit incoherent. But then, had Hegel been listening to someone reading aloud order-9 imitations of his own text, I suspect he too would have found the flow of its logic a little wanting, here and there.

If the blatherings of George Frederick Hegel
Are captured to a quite Hei deggree
By 5-grams, shouldn't George Frederick Handel
Succumb to the same skulldugg'ree?

But why tackle just big names?
Let's climb down the ladder
To a far easier challenge:
Let's tackle Hofstadter!

Can we suck out the essence
Of Doug from his notes?
Can we psych out Hofstadter
When he hears garbled quotes?

Once his music we've caught,
That's Step 1 of our plan;
The next step's his lectures!
We'll make Doug-in-a-Can!

His verse, it's just patterns,
Just rhymes in a box.
There are seldom surprises
That off-knock your socks.

But even the trick rhymes
Have a formula behind;
We know that that's all
That there is to Doug's mind.

The hard part was making him
(The original Doug);
The easy part's faking him
(A canned, Doug-less Doug).

Immortality, ho! —
Thanks to Cope. How I'll rave
When I can compose
In my sleep — or my grave.

There's no one at home,
Yet the music pours out.
The lights have gone dark;
Still, my spirit soars out!

That's Prokofiev's fate.
The poor chappie expired,
Tenth Sonata half-done...
EMI finished it. She's hired!

A Prokofiev expert
Said she'd give a première,
So Cope sent it off,
Thinking, "She's quite a dear!"

Not too long had passed
Ere arrived her reply:
"Prokofiev would hate this
As much as do I!"

But why the conditional?
Why hedge, using "would"?
If he sings while he's dead,
Can't he hate just as good?

For this is my claim,
Though it sounds somewhat droll:
Total style-resurrection
Resurrects one's full soul.

Is Language Intrinsically Deeper than Music?

You may think that that last stanza was tongue-in-cheek, but no — those precise sentiments have been my recurrent theme, and I'm not about to abandon them now. To delve into such matters more seriously, let me discuss more fully in prose what I hinted at in a couple of stanzas above — the idea of a program *à la* EMI producing a spate of brand-new Hofstadter lectures or — let's go whole hog — books. (After all, if an opera by Mahler, who never wrote one, is in the planning stages, why not a novel by Hofstadter, who never wrote one?) What would it take? Would *n*-gram frequencies with a high value

of *n*, applied to all the previously published Hofstadter books, turn the trick?

Well, you know as well as I do that this would fail ludicrously. That kind of technique doesn't deal with *content*, with *ideas*. It just deals with sequences of letters, and a writer does not deal with sequences of letters. And even if an EMI-like text-imitation program dealt with more global qualities of its input text, the problem is that *new ideas* would not ever enter the scene. Who could have predicted, given my first few books, that I would next write an 800-page book on poetry translation (*Le Ton beau de Marot*)? There's nothing remotely resembling the manipulation and creation of new ideas in EMI — and yet the crazy, undeniable truth of the matter is that EMI's music does at least a decent job of creating "new Chopin" and "new Mozart", and so on. As Dave himself speculated in the journal entry that starts out his first book, "While never as good as the originals, they will be exciting, entertaining, and interesting."

Or consider "Prokofiev's tenth sonata", as Dave calls it. In the liner notes to his and EMI's first compact disk ("Bach by Design"), he wrote the following:

> This computer-composed Prokofiev *Sonata* was completed in 1989. Its composition was inspired by Prokofiev's own attempt to compose his tenth piano sonata, an attempt thwarted by his death. As such it represents another of the many potential uses of programs such as EMI (*i.e.*, the completion of unfinished works).

To me this comes close to blasphemy — and yet let me also add the following remark, to counterbalance that reaction. The first movement of this sonata by EMI starts out with the actual 44 measures that Prokofiev himself had completed, and then continues with EMI's own notes. What happens when measures 45, 46, and so on are encountered? Is it like falling off a cliff? Is there a drastic discontinuity? Well, I would put it this way. Imagine you were reading, for the first time, the genuine Hegel paragraph, and imagine furthermore that it had been extended by a high-*n*-value text-imitation program. Would you instantaneously feel something was fishy when you hit the very first word of the computer's text? Of course not. It would take a line or two, possibly even a dozen, before you said to yourself, "What is going on? I'm even *more* lost here than I was at the paragraph's beginning!" In some sense that is how I hear the EMI-Prokofiev sonata. There is no sudden drop in quality at measure 45 — indeed, it is as smooth a transition as one could possibly imagine, and all the way to the movement's end it sounds quite consistent with the way it started out.

I happen not to *like* this piece by EMI (though Dave Cope adores it!), but then I also happen not to be a fan of the last several Prokofiev piano sonatas (despite loving the first few). So to me, this "tenth sonata", though it rings fairly true, just doesn't appeal. I would never call it a work of genius, but I would credit it as being "well-crafted and Prokofievian in feel".

So what is going on? How come EMI does a fairly passable job at resuscitating composers but couldn't conceivably resuscitate a writer — even a writer of murky and obscure philosophical verbiage? Or am I — a serious author but not a serious composer — being too vain? Are my remarks self-serving? Is my personal verbal spark every bit as susceptible to being captured via algorithmic processing as Prokofiev's musical spark is?

Falling Hard for a Pattern of Blips

For me, analogies always help to shed light on such complex disputes, and the following analogy, which I hope is provocative, came to me one day — indeed, it hit me with great emotional power, I must admit — when I haphazardly picked up a publicity brochure for books about budding new technologies to be put to use in making movies.

I suppose a good deal
Of my EMI perplexity
Can be traced back to issues
Of algorithmic complexity.

To cast all these matters
In a somewhat new light,
Let's turn to attraction,
To chemistry, to "Miss Right".

I recall, and with pain,
A few times in my past
When I fell for some actress
In a romantic film's cast.

The blips on the screen,
We all know, came from her —
A flesh-and-blood person,
Alive, sure as sure.

The image conveyed a full
Human behind the scene,
And that's what I fell for —
Not for blips on the screen.

But now let's imagine
A brave new film world
In which love scenes take place,
Both unboy'd and ungirl'd.

And how would this happen?
Quite simple — by CAD —
The faking of objects,
As in many an ad.

One sees things in motion
That in truth never were;
They're simply bit-patterns
Cranked out in a blur.

Of course it's one thing
To make balls bounce about;
Quite another, a person
To believe in, no doubt.

And yet we are marching
Down that very lane;
We're making CAD filmstars.
Is that not a gain?

At this point in my lectures, I generally show the cover of a book called *Synthetic Actors in Computer-Generated 3D Films* by N. Magnenat Thalmann and D. Thalmann, which features a nearly-believable but clearly synthesized set of images of a woman in a bathing suit, who is instantly recognizable as Marilyn Monroe, walking across a shiny floor; I then read out loud the following blurb for the book:

> Three-dimensional synthetic reincarnations [reader: note this word!] of Marilyn Monroe and Humphrey Bogart were created by the authors of this book for their award-winning feature film "Rendez-vous à Montréal". The advanced computer animation techniques developed for the film are fully described in this book. They form a technological breakthrough that can be used to produce scenes featuring any celebrity in any situation. The opens new vistas in motion pictures, television, and advertising.

To conjure up Monroe,
Just write code — 40 K;
She'll then dance on your screen,
Blow a kiss, make your day.

Or morph her with Binoche —
Hey, I'd call that a coup!
But since they're just code,
It's a no-sweat morpheroo.

So now I can fall
For a screenful of blips
Behind which there's no one —
Just code caught in chips.

A human in 40 K bytes,
Now that's cheap —
And yet I might fall
For this "her". A great leap!

Or is it so great
To be gulled by the spiel
Of some code that's a billion
Times simpler than real?

It shakes me to think
That someday I might fall
For an "actress" who
Never existed at all.

Three Flavors of Pessimism

Yes, what worries me about computer simulations is not the idea that we ourselves might be machines; I have long been convinced of the truth of that. What troubles me is the notion that things that touch me at my deepest core — pieces of music most of all, which I have always taken as direct soul-to-soul messages — might be effectively produced by mechanisms thousands if not millions of times simpler than the intricate biological

machinery that gives rise to a human soul. This prospect, rendered most vivid and perhaps even near-seeming by the development of EMI, worries me enormously, and in my more gloomy moods, I have articulated three causes for pessimism, listed below:

(1) *Chopin* (for example) is a lot shallower than I had ever thought.
(2) *Music* is a lot shallower than I had ever thought.
(3) *The human soul/mind* is a lot shallower than I had ever thought.

To conclude, let me briefly comment on these. Pertaining to (1), since I have been moved to the core for my entire life by pieces by Chopin, if it turns out that EMI can churn out piece after piece that "speaks like Chopin" to me, then I would be thereby forced to retrospectively reassess all the meaning that I have been convinced of having detected in Chopin's music, because I could no longer have faith that it *could only have come from a deep human source.* I would have to accept the fact that Frédéric Chopin might have been merely a tremendously fluent artisan rather than the deeply feeling artist whose heart and soul I'd been sure I knew ever since I was a child. Indeed, I could no longer be sure of *anything* I'd felt about Frédéric Chopin, the human being, from hearing his music. That loss would be an inconceivable source of grief to me.

In a sense, the loss just described would not be worse than the loss incurred by (2), since Chopin has always symbolized the power of music as a whole, to me. Nonetheless, I suppose that having to chuck *all* composers out the window is somehow a bit more troubling than having to chuck just *one* of them out.

The loss described in (3), of course, would be the ultimate affront to human dignity. It would be the realization that all of the "computing power" that resides in a human brain's 100 billion neurons and its roughly ten quadrillion synaptic connections can be bypassed with a handful of state-of-the-art chips, and that all that is needed to produce the most powerful artistic outbursts of all time (and many more of equal power, if not greater) is a nanoscopic fraction thereof — *and* that it can all be accomplished, thank you very much, by an entity that knows nothing of knowing, seeing, hearing, tasting, living, dying, struggling, suffering, aging, yearning, singing, dancing, fighting, kissing, hoping, fearing, winning, losing, crying, laughing, loving, longing, or caring.

Playing the game of pattern and pattern alone will turn the whole trick — or, as the late and witty mathematician Stanislaw Ulam once said, memorably paraphrasing Martin Luther (and J. S. Bach), "A Mighty Fortress is our Math." The only difference would be that Dave Cope would proclaim, "A Mighty Fortress is our Mac." And, although Kala Pierson and many others may hail its coming as "truly a thing of beauty", the day when music is finally and irrevocably reduced to syntactic pattern and pattern alone will be, to my old-fashioned way of looking at things, a very dark day indeed.

If the basis for EMI
Turns out to be true,
Then all my dear notions
Will die; I'll be blue.

Upon hearing an étude,
I'd no longer conclude
That I sensed a heart's mood;
'Twas just some "pattern dude"!

Likewise Bach would be shown
To be one "pattern guy",
Whose secrets are none —
At least not to E.M.I.

Are these two just shallower
Than ever I'd thought,
Their styles simply patterns
In EMI's net caught?

Or is music itself
Just one big formal game,
So that using brute force
You can ape any name?

Or — worst of my nightmares —
Can a full human 'I'
Be stamped on a chip made
By VLSI?

Now don't get me wrong —
I maintain we're machines!
But PC's?! What a slap
In the face to our genes!

Do our millions of genes,
And our billion-celled brains,
Yield nothing but rule-bound
Algorithmic refrains?

I'd like to believe
That for music to spring
From a thing, it must strive,
It must struggle, to sing.

It must search and must seek,
Sometimes win, sometimes fail;
It must fight with the world —
If that's so, I'll not rail.

What I fear is a win by
An emotional sham —
A musical poet with
No sense of "I am".

These issues alarm me
And that's why I spoke —
Not to answer all questions,
But to prod and provoke.

And now, please excuse me
For all of my pranks;
And to Dave (and to EMI!)
I express profound thanks.

A Few Standard Questions and Answers

Since this article is an attempt to convey the real-time flavor of my many EMI lectures, I think it only appropriate to include a question-and-answer session with some of the most commonly raised points. Most of them are of the form, "Don't worry, Doug — your dire fears are totally unfounded. EMI is great, and she's not in the slightest a threat to human dignity. Let me tell you why..." So here we go.

Question: I'm a musician by training, and I remember how in undergraduate school my peers and I were required in various courses to copy many composers' styles. We all learned to do this without too much trouble, and some of the pieces we composed were pretty decent. It doesn't upset or worry me to think that stylistic imitation can result in pieces that are fairly effective, because I know that this can only occur *after* a composer has produced a body of material that establishes the style. The original, creative act must occur first. Indeed, I would propose that the most profound act of musical creation lies precisely in the invention of a novel and highly personal idiom or style. Thus I subscribe more or less to the Lew Rowell viewpoint — that the hard part, the only part requiring creative genius, is coming up with a new "grammar"; the easy part then is spinning off pieces that obey that grammar. Mastering musical mimicry may take a bit of talent, but it doesn't take creative genius.

Answer: First off, let me agree with you that coming up with a novel and highly personal idiom, as virtually all great composers have done, is definitely a greater achievement than writing one piece, or several pieces, even very high-quality pieces, that can pass for the composer's own but in fact are forgeries. EMI apes previous styles, but she does not explore her very own stylistic worlds, nor was she ever intended to do so. In that sense, EMI does not represent an assault on what I see as the very highest peak in the rugged mountain chain of musical achievement. So there is some agreement between our positions.

On the other hand, I would take issue with the imagery in your statement, which seems to suggest (although I doubt that you meant it this way) that a composer starts out spending a good deal of time devising a grammar, and then, that having been done, just turns into a drone who spins off piece after piece using the rules of the grammar. Well, the composers whom I respect never did anything like create an explicit grammar. They just composed piece after piece, and as they composed, a set of statistical regularities emerged. Creating rules and then sticking to those rules was probably the furthest thing from their minds!

As a very minor composer, in fact, I might add a brief comment about my own feeling about remaining true to my own style, or staying within my own patterns. I almost always compose at the piano, and most of the time it is my fingers that guide me, in the sense that they are constantly trying out all sorts of small patterns on the

keyboard, and after each such little unpremeditated motoric foray, I judge whether or not I like it, as well as whether or not it fits the piece's evolving and not-totally-stabilized mood. On the basis of such blurry considerations, I somehow decide whether or not to incorporate what my fingers just spontaneously came up with. What's interesting is that quite often my fingers will play a pattern that "I" would *never* have come up with, so to speak. Perhaps they stumble across a wrong note, or perhaps they just make a strange dissonance that I would never have thought of. At that point, my composer's mind enters the picture, and sometimes it says to me, "Hey, Doug — now *that* really was interesting, it was so unlike you — so why don't you incorporate it?" The logic of such a suggestion is that by using "un-Doug-like stuff" I sound more original than I really am, and I somehow break out of ruts. Perhaps over time I come to incorporate these un-Doug-like stylistic patterns and, somewhat ironically, they become Doug-like, at which point it is time for me to break out yet further. So much for a "Hofstadter grammar".

But I would like to answer this question in another way as well. Suppose that Lew Rowell really were able to distill a "Chopin grammar" from all of Chopin's *œuvre*, and that he then sat down to write new pieces using this grammar — say, a fifth ballade, for example (Chopin's four extant ballades being generally regarded as among his most powerful expressive efforts ever). The key question, in my mind, is the degree to which this new Rowell–Chopin ballade will sound like an equal sibling to the other four — something worthy of the name "Chopin's fifth ballade". Will listeners be moved to tears by it? Will pianists flock to perform it? Will audiences clamor for more — for a whole set of new "Chopin ballades"? Will this music move people, in short, with all the power with which the first four Chopin ballades move people?

The reason I raise this scenario is that my impression has always been that for Chopin himself to come up with each of his four ballades was itself a mighty creative act, not anything even remotely like the spinning-off of a rule-bound piece from a fixed grammar. The four ballades are enormously different from each other, and not in any sense a bunch of pieces sharing an abstract skeletal structure.

If I might be excused for making the following rather presumptuous analogy, Chopin's four ballades are as different from each other as are, say, four of my most diverse articles, such as this one, an article on the subliminal connotations of the word "you guys", an article on a class of geometries related to projective geometry, and a humorous article gently mocking John Cage's Zen attitude toward music. Such a collection of articles certainly do not seem to have been cast from the same mold. Likewise, one would hope that anything meriting the name "Chopin's fifth ballade", whether concocted by Lew Rowell or by EMI (or whoever or whatever), would be just as different from its four progenitors as they are among themselves, and that the sixth and seventh and eighth ballades likewise would all differ among themselves in just as significant a way. *If* EMI–Chopin ballades did pass this test, and *if* audiences clamored for more and more of them, then I would feel I would have to despondently throw in the towel as a researcher who is seeking the mechanisms of creativity, for everything that I could ever have imagined seeking would already have been found, and the book on the human mind's mysteries would be closed.

For a sharply contrasting case, though, consider the so-called "prairie houses" designed by the famous American architect Frank Lloyd Wright. He designed many houses in this family, and they all share a certain fairly clear set of properties — so much so that some years ago, a group of professors of architecture at SUNY Buffalo distilled from them a "prairie-house grammar", which they conveyed to a computer,

which then came up with dozens of new "Frank Lloyd Wright prairie houses". When I first saw this, I was quite astonished, but the more I thought about it, the more I realized that the original set of prairie houses itself was pretty formulaic, and therefore lent itself to "grammaticization". It would be entirely another matter, however, for a computer to come up with a Frank Lloyd Wright–style house that lay far outside the bounds of the prairie houses.

As this shows, even a great artistic mind can go into a temporary mode in which a certain fairly formulaic vein is explored for a while, and such explorations may lend themselves relatively easily to mechanical mimicking — but that is not the essence of being a great creator. For all I know — and though it pains me to say this — maybe some of Chopin's weaker mazurkas bear this kind of formulaic stamp. I certainly wouldn't hesitate for a moment to shout "Formulaic!" about many works of certain other hallowed names in music, such as Mozart and Beethoven, so why not Chopin as well? That might explain, at least in part, why an EMI mazurka can sound better, in some ways, than a few Chopin mazurkas.

One last point about humans mimicking style and computers mimicking style. You say that you and your peers were pretty good at coming up with pieces in, say, "the Brahms style" or whatever. Well, part of what allowed you to do that is that *you all were human beings,* as Brahms himself was. Built into being human is the fact of living life and having all the sorts of experiences that — to my mind — underlie what musical expression is all about. And so, part of the power of *your* musical expressions came straight from your humanity. For an EMI-type program to perform credibly at this type of task, however, is another matter entirely, because it does not have any human experience to draw on. So I don't buy into the viewpoint that says, "Stylistic imitation is a routine thing in music schools, ergo it's no big deal that we can get a computer program to do it too." To the contrary, it is indeed a big deal, because a program like EMI, although I facetiously call it "she", is not a person.

The question that EMI ultimately raises is whether people who come out of music schools and who become famous composers are really just masters of a difficult *craft,* people who have absorbed all sorts of complex traditions and styles, and who now practice their craft exactly in the way that a carpenter makes fine tables and bookcases and so forth — *or,* contrariwise, whether composers are constantly, though surely unconsciously, plumbing the furthest depths of their psyches, discovering mysterious yearnings and sighs, and putting a voice to them: making *art,* in short. These two images are unbelievably different pictures of what music is all about, and I must say, EMI is forcing me personally to confront this question in a way that I never imagined I would have to — and making me squirm much more than I would like.

Question: Programs have been written that produce poetry based in rather simple ways based on the poems of a human poet, and one can feel meaning in the output, but one realizes that such meaning is due to the input material. Thus if in a computer poem one finds the phrase "her haunting grace", it may be that this phrase was present as such in some poem, or if not, then its component words all were, and the machine stuck them together on the basis of some syntactic rules, maybe with a few rudimentary semantic guidelines as well. But a reader who feels depth in such phrases can also realize that it is basically *borrowed* depth, not *original* depth. It's just echoes and parrotings, not primordial screams from the depths of a feeling soul. Isn't that really what's going on in EMI? If so, why worry?

Answer: If EMI were just a plagiarizer or reshuffler at the level of simplisticness that you have suggested, then all over the place we would hear traces and echoes of the input pieces. And of course then we would chuckle at its obvious borrowings, and not be in the slightest impressed. What is impressive is that in many of her pieces, we *do not* hear where the elements are coming from. There is no wholesale borrowing of big phrases; rather, the elements of the composer's input have been chopped up into very fine-grained pieces, and those pieces have been reassembled in large structures in such a manner as to disguise their origins. And the reassembly process is faithful enough and subtle enough that at least some of the resulting compositions are good enough to fool excellent musicians — such as students and faculty at Eastman Rochester, for example. They cannot tell that the power has been borrowed.

Indeed, that's precisely the nub of the question: Is it fair to say that the power of a composer has been *borrowed* when EMI dissects the input pieces into such tiny fragments that effectively, the accusation of plagiarism is no longer viable, in that even a sophisticated listener cannot put their finger on where the phrases and gestures in an output piece have come from? If the reshuffling is so fine-grained as to make it virtually untraceable, then in what sense is *borrowing* taking place?

EMI is not a coarse-grained plagiarizer. If you hear a Mozart-style EMI piano concerto, it will *remind* you all over the place of Mozart concertos, but you won't in general be able to point to a particular phrase and say, "Ah! — *that* was borrowed from the A major concerto, Köchel 488, second movement!" (etc.). Admittedly, there are episodes in some of EMI's two-part inventions that clearly come from specific Bach inventions, but that is probably because only a couple of inventions were being drawn on, in those cases.

Analogously, I remember that when I first heard Mary Jane Cope perform "Nope" (EMI's pseudo-Hofstadter piece) in front of me and the Santa Cruz audience, I had to try to suppress a smile at virtually every measure, because I could just hear its sources so easily. But the reason for that is very simple: it turns out that Dave was unable to use all twelve of the pieces I sent him as input to EMI, but instead he selected just *two* of them, and it was on the basis of just those that EMI composed "Nope". Well, obviously, if you have such a sparse data base on which to draw, your output is going to reek of its sources in a conspicuous manner. If Dave had been able to use all twelve of the pieces I sent him (or better yet, all forty of the pieces I've composed), then of course the mixture would have been far, far subtler and the aroma surrounding any particular harmony or phrase would have been far more elusive.

I must add parenthetically that here we are forced to confront an amazing rigidity on EMI's part, particularly when perceived in contrast to all her complexity and flexibility. Namely, EMI cannot take a 3/4 piece and a 4/4 piece and use them both as inputs on which to base an output piece. All input pieces that are used together have to have the same time signature! Only if you convert your 3/4 piece into a 12/4 piece (putting four measures at a time into a "supermeasure") and also convert your 4/4 piece into a 12/4 piece (three measures making a supermeasure) will EMI be able to deal with both of them at once. But you have to force-fit the pieces in this unnatural way for EMI to be able to extract "style" from both at once.

It seems implausible in the extreme that a human musician would be stymied by the challenge of hearing stylistic similarities in a waltz and a 4/4 piece. But in any case it was this kind of rigidity that barred Dave from using all twelve pieces on my diskette as input to EMI, and it was therefore clear as day to me, as composer, where each tiny part of "Nope" was coming from. But, to take a contrasting case, I know all

the Chopin mazurkas well, and yet I cannot pinpoint where the fragments of EMI's mazurkas are coming from. It is too blurry, because the breakdown is too fine to allow easy traceability.

To recap, then, EMI's power of course comes, in *some* sense, from borrowing, for by definition and by intention, that is all that EMI is — a borrower. But the dissolving and recrystallization processes inside EMI involve "musical molecules" at such a fine-grained level that how the emotions of the input pieces retain their power through it all is not in the slightest obvious. If you eat fish day after day, you do not thereby turn into a fish or come to resemble a fish in any way, because the fish cells are broken down far beyond the level of fishiness. Nonetheless, you do borrow from the power of fish life, because you don't break the biomolecules all the way down into pure chemical elements. EMI likewise "digests" its input pieces using metabolic processes that chop its food apart at a fine level, but not so fine a level as to lose all coherence. It's an exquisite balancing act, that's for sure, and I would be the first to insist that Dave Cope deserves enormous credit for having stuck with it for so many years, and for having refined it with such loving care.

Question: Having just heard a human perform music by EMI and by human composers, and having myself just taken a pseudo-Bach piece for genuine Bach (for which I am not ashamed or crestfallen because I do not pride myself as a connoisseur of classical music), I am led to musing as to whether, rather than the composition itself, it is not its *performance* by a human with a heart and soul that gives meaning to the piece, whether that piece was composed by a person or by a machine. And thus the more sensitively performed a piece is, the greater will be its meaning, and conversely, the more mechanically performed it is, the less will be its meaning — no matter what its provenance might be.

Answer: To me, your suggestion seems analogous to claiming that unless a short story (say) is written out by hand by a human, what it says will be unable to convey any emotion. In other words, a story typeset by machine is empty, but the same story copied out by hand by someone will be rife with meaning. To me, that seems absurd. What contains the meaning is the set of *ideas* behind the notes or behind the words. How those notes/words are rendered is but a minor tweak in the story's effectiveness.

Let's shift back to music itself, rather than stories. I do not feel, as you seem to feel, that one needs a great performance of a piece in order to be able to hear its depths. Consider the first time I heard a mazurka by EMI. Who was the performer? Myself — I was clumsily sight-reading it at my own piano, out of Cope's book. The notes were printed smaller than usual, which made it even more difficult to sight-read. Nonetheless, despite making mistakes left and right and playing it far too slowly and unevenly, I was able to discern a truly unexpected amount of "Chopinity" in that piece, and it was that experience — my own totally junky performance — that really made me feel something eerie was going on with this EMI program. One might put it this way: since the performance was greatly lacking, whatever meaning I found in the piece could come from only one other source: the composer.

A few days later, I received in the mail from Dave a copy of "Bach by Design" (the first CD of EMI's music), and on it there were very mechanical-sounding computer-produced performances of various EMI pieces (including that same mazurka). I got a great deal out of hearing those pieces, even despite the wooden quality of the playing. Such awkwardnesses are mildly annoying, to be sure, but it makes me think of reading

a great poem typed on a typewriter rather than in a beautifully typeset edition, and perhaps with a few typos in it, to boot. What's the problem with that? It doesn't seem to me that beautiful typesetting makes the poem any better.

To me, adding the surface gloss of a virtuoso performer is not critical at all (in fact, confusing such glossiness with the depths conveyed by the notes alone is one big problem that plagues discussions of this sort). Where I would be troubled is if the piano on which I was sight-reading an EMI (or human-written) piece were really out of tune, because then I couldn't really hear the resonances intended. But a decently played rendition on a decent piano will come through loud and clear, to me, in terms of the heart and soul behind the scenes (*i.e.*, the heart and soul of the composer). The fewer the actual errors, of course, the better — but a great performance is not needed. Adequate is just fine.

Question: Why are you upset at the idea that EMI can come up with great new pieces that sound as if they were by Chopin? There's no threat here to human dignity, for it was Chopin himself who created the data base out of which these pieces are coming. The power and the genius reside, thus, entirely in the data base, not in EMI. EMI can do no better than the data she is fed with. So you don't need to worry about threats to human dignity or human genius: after all, if wonderful new mazurkas emanate from EMI, nearly all of the credit should go to Frédéric Chopin, and only a small portion of credit to EMI — or perhaps to Dave Cope.

Answer: This amounts to saying "old genius in, new genius out", which I certainly do not subscribe to. Given a data base that is filled with works produced by a genius, it would still take a fantastic program to come up with *new* works that exhibited flashes of that same genius. To make this more concrete, let's imagine that you were to input the famous *Nine Short Stories* by J. D. Salinger into a 9-gram text-imitation program (or whatever value of *n* you like). What kind of output would you get? A genius-level short story worthy of Salinger, as different from the *Nine* as each one of them is from the others? Of course not. It would be incoherent garbage, and even at its best, just a series of grammatical clauses that regurgitated bits and pieces from the previous stories — hardly a brand-new story filled with events involving new characters in new situations and new locations. Does genius input always give rise to genius output? Certainly not. To make "old genius in, new genius out" work, it would take a program whose depth is commensurate with (*i.e.*, worthy of) the depth of its databases.

Consider literary translation, for example — something that I know quite a lot about, having just spent my past year quite obsessedly translating Alexander Pushkin's celebrated novel-in-verse *Eugene Onegin* from Russian sonnets into English sonnets. Without doubt the data base I was working on — the Russian original — was a work of genius. But does that guarantee that my output will also be a work of genius? Obviously not in the slightest. In fact, if you want to see genius turned into utter garbage, try running a stanza or two of *Eugene Onegin* through one of today's highly-touted machine-translation programs (an experiment I recently carried out with four state-of-the-art programs, by the way). The English that comes out is ludicrous and at times absolutely incomprehensible. It would be a mind-boggling achievement if a machine-translation program came up with so much as a *coherent* English-language rendition of *Eugene Onegin,* let alone a rhymed and metric version!

I might add that I devoted every ounce of my intellectual power for a full year to this translation effort, and I would say without hesitation that in so doing, I was

constantly drawing on all that which makes me human: my life experiences in the fullest — my struggles, my yearnings, my triumphs, my defeats, and so forth and so on. It took all of that to *understand* the Russian deeply enough that I could fully internalize the ideas, reflect on them, turn them around in my head, and then slowly reinstantiate them in a new and alien linguistic medium. If my translation has any merit, it is precisely because I put my whole self — mind, heart, and soul — into it.

And now consider the fact that translation is a darn sight easier than creation *ab ovo*. We are not talking about Doug Hofstadter writing a *new* Pushkin novel — just about reconstructing the poetry of the original in a new medium. How much more would it take for me to write a brand-new novel-in-verse "by Pushkin" (in the same sense that EMI, given Prokofiev input, composed a brand-new piano sonata "by Prokofiev")? Quite frankly, I wouldn't have the foggiest idea of how to even write the first sentence. The mere idea makes me laugh.

So what are we to conclude here? That although today's state-of-the-art machine translation programs can't come anywhere close to giving us a decent or even comprehensible anglicization of a Pushkin novel, today's state-of-the-art pattern-recombination engines can quite handily produce for us any arbitrary number of new Prokofiev sonatas, Mozart concertos, Bach arias, Gershwin songs, and Chopin mazurkas? This would seem to suggest an astonishing and heretofore totally unsuspected discrepancy between the depths of the two different arts (music and literature). Does Pushkin's genius really tower above that of Chopin? Is music basically no more than suave pattern-play, whereas literature is something else altogether? I just can't buy into this view, for to me, throughout my entire life, music has always been just as deep as, indeed even deeper than, any kind of literature.

Question: As a composer, I find Cope's music-composition program quite interesting, but frankly, I think your worry over it is a tempest in a teapot. Decades ago, John Cage taught us that music happens in the brain of the hearer; all a composer can do is create a situation in which music will happen in some of the audience members' minds. I, by some fluke, have the ability to hear music in my head and I've trained myself to put it into a reproducible form (a score). But I have no control over whether it is heard as music! A babbling brook, ocean waves breaking on boulders, or an oriole singing at dusk can create the same experience for the right listener… So what if a machine's output pleases someone's mind through their auditory input channel? That's not the *machine's* doing! So don't worry — music is just as great as you've always thought — it's just that you've been looking to someone *else* (the composer) for the greatness, when in truth the wonder of it all happens in *you.*

Answer: Sorry, but I think this is a grotesque twist on the truth. I would agree that notes in the air can be thought of as vibrations drained of meaning, and the receiver's brain as adding the meaning back to them. But the phrases "drained of meaning" and "adding the meaning back" suggest that there once was meaning in them, and that it has been "sucked out" and requires the metaphorical "adding of water" to recreate it — namely, the processing by a listener's brain. And I will agree that as listeners, we find (or create) meaning in sequences of sounds in much the way that, as readers, we find (or create) meaning in a bunch of black splotches on white paper when we read a novel. However, to claim that the active involvement of our recipient brains transfers all credit for greatness and depth from the creator to the recipient is nonsense. Such a viewpoint would imply that we can find greatness in anything at all,

simply by using our receiving brains' power.

Want to savor a great novel? Then pick up a Jacqueline Susann paperback at the grocery store, sit down, and just turn your mind on *real hard* — greatness will come oozing right out of it. For that matter, take *anything at all* and read it, and in your hands it will turn into great literature — merely provided that you can find it in *yourself* to make it so. Who cares what thoughts and ideas went into its mere *making*? There's really no need for deep and powerful insight at the creation end of things.

Fyodor Tolstoy, you are fully dispensable with, because *my brain* is what makes you powerful and deep. (It will also make Erich Segal's banal *Love Story* powerful and deep.) Frédéric Chopin, you too are dispensable, because it is my great brain, yes, *my brain*, that gives your humble notes meaning. Moreover, my brain, in its infinite wisdom and power, will find (if I so choose) just as much meaning in Michael Jackson or Elvis Presley or Madonna — or for that matter, in random squawks.

Speaking of random squawks, I think it is sloppy thinking to equate babbling brooks and birds chirping at twilight with music (at least with traditional tonal music), which is produced deliberately by a human being in order to express or communicate something to other humans. Or is that not so? Does a composer have no intent to communicate, nothing to say? I think you will find the case is quite the contrary, if you read the biographies of any composers of note.

Given the absurdity of the notion that the creator/sender's role is irrelevant to the meaning produced in the receiver's brain, what is left but to shift the burden back to the creator/sender? *That* is where the power resides. To be sure, my listening brain — my "inner ear", so to speak — "adds water", but the level of quality of what results is not due to my *added water*; it is due to the *seeds* (or the recipe, or whatever it is that you are adding water to — our metaphor is a little blurry…). After all, my water is the same, whether I add it to Chopin, to Elvis Presley, or to the sound of garbage cans being picked up in the early morning; what makes one recipe appealing and addictive and another recipe flat and boring to me is not the "water" used in preparing them — it is the difference between the two recipes!

No, the meaning of a piece of music (or literature) is not invented out of nothing by us receivers; it resides in the mysterious catalytic power of *the sequence of notes* that somehow that composer was able to find, and which other people had never stumbled across before. Yes, "catalytic" — yes, we *realize* the meaning (both in the sense of "come to understand" and in the sense of "manufacture") that lurks in the notes, but the true responsibility and credit redound to the *sender's* brain, not the *receiver's* brain. To rank listener above composer as the source of musical meaning is, I'm sorry to say, no more than extravagantly self-indulgent, egomaniacal solipsistic silliness.

Question: Mightn't it be the case that *composing* music is easier than *appreciating* music? Maybe you should only start to feel threatened if EMI (or some cousin program) can listen to pieces and decide which ones are good and which ones are weak. Perhaps Cope's achievement can even be taken as constituting a proof that *composition* of music is, in some sense, relatively simple, compared to *understanding* music.

Answer: Whew! That's a bizarre claim. I'd start out by saying, "Composing is not a free lunch courtesy of a big data base or a predefined grammar." By this, I mean that composing involves genuine musical intelligence, and in fact musical intelligence of the highest degree of refinement and subtlety. How could a composer know that a piece was coming along well without being able to make positive or negative

judgments? How could listening, understanding, and judging be bypassed? Well, of course, your retort may be: "Just as in EMI, that's how."

And to this retort, I guess I would have to say, "EMI's compositions are precisely as deep as her capacity to listen to and understand music." Which forces us to ask, "Does EMI listen to music, or understand music, at all?" Well, of course EMI doesn't *hear* music, in the sense of having eardrums that vibrate in response to complex waveforms — EMI's way of perceiving music involves just the ability to deal with *numbers* that represent pitches and times and so forth. This may seem a funny sensory modality to us, but in a sense, it *is* an abstract kind of "listening". After all, our eardrums also produce a set of numbers that then affect the neurons in our auditory cortex. And remember that there are highly trained musicians who can merely *look* at a score and "hear" the music in their heads.

Hearing music really means accepting some representation of pitches and timings and so forth, and producing the proper end result in the brain (or in the computer analogue thereof). Exactly which kind of representation kicks off the process is not crucial. In some sense, EMI ingests notes (even though they don't have the rich timbres that we hear), and she makes sense of those notes by chunking them into larger and larger structures, labeling such structures with *SPEAC* labels, discovering signatures, detecting motif templates, and so forth. That's how EMI "listens" to her data bases. What EMI *doesn't* do, as we know, is to associate the structures she finds with emotional experiences drawn from life. But in any case, EMI's compositional ability is proportional to her ability to understand or find order in what she "hears". You can only be a composer to the extent that you are a good listener.

Once again, going back to literature, can you really imagine a writer who could churn out superlative short stories by the dozens, and yet who was at the same time incapable of reading a single story with comprehension? Give me a break! Reading is to writing as walking is to running, and the same goes for listening and composing. Don't put the horse before the cart, please!

Question: How does musical *meaning* differ from musical *style*?

Answer: Your question points straight at the heart of the issue raised so marvelously clearly by Cope's work — namely, *Is there such a thing as musical meaning?* Or is music just a set of elaborate, ornate gestures that for some reason please us esthetically but no more?

This reminds me of a wonderful but very rare book that I was lucky enough to get a copy of many years ago — the *Codex Seraphinicnus* by Luigi Serafini. This book poses as an encyclopedia, but of a totally fantastic world. Every two-page spread has one page that is filled with delightfully curly squiggles that seem to form words, sentences, paragraphs, and full articles on subjects of every sort imaginable. But how do you know what the subject under discussion is? Because the facing page is an elaborate picture of some aspect of this bizarre world — flora, fauna, engineering, culture, science, the arts, clothes, foods, and so forth and so on. The question one naturally asks oneself, on looking at this wondrously idiosyncratic book, is: Do the complex arrays of symbols actually *mean* anything, or are they just curly squiggles, end of story?

Although I've looked through the entire book many dozens of times, I have no knowledge of whether Serafini's "language" actually means anything. My guess would be that, although it is very carefully and self-consistently structured, it is nonetheless just empty scribbling. But it's the question, not its answer, that interests me here.

What would make us feel those arrays of squiggles were something *other* than just "empty scribbling"? What would make those squiggles "actually mean" something?

Presumably, we would have to figure out *how to decode them.* We would have to have some kind of objective way of finding meaning in them. If one notices a piece of paper in the gutter and picks the paper up and finds a series of roman letters on it that one cannot read, one can tackle the implicit challenge in various ways, such as asking people who know various foreign languages if they can read it, or trying to decode it by trying out various substitution ciphers (letter-to-letter codes), and so forth. Eventually, one may find the key and a message emerges clearly and unambiguously. Then you feel you have found the meaning. But what if you do not succeed? Have you thereby shown there is no meaning there? Obviously not — you may just not yet have hit on the right decipherment scheme.

I personally think that I hear meaning all over the place in music, but it is very hard for me to explain this meaningfulness in words. That's what makes music so important in my life. Were it just formal gestures, I would tire of it very quickly. But I cannot explain what it is, exactly, that I hear in a given piece, no matter how much I love that piece. I believe, as much as I believe anything, that musical semantics exists, but I don't think it is much like linguistic semantics. I think that when we understand musical semantics — and Dave's many years of hard work and loving devotion to EMI, especially his *SPEAC* notions, may be a significant step in that direction — we will know a great deal more about how human emotionality is constituted. But I think that will be a long time in the coming.

Question: Why aren't you escstatic, instead of very depressed, at the prospect of soon being able to have an unlimited new supply of great Chopin, whom you admire unboundedly?

Answer: If I believed EMI's Chopin simulation would soon be capable of producing a raft of Chopin-style pieces that would make chills run up and down my spine, I would have to revise my entire opinion of what music is about, and that would destroy something profound inside me.

Consider this analogy. Suppose that my beloved father, who died some years ago, were to walk into my study right now as I sit here, typing. Would I not be overjoyed? Well, think of what that event would do to my belief system. Virtually everything that I have come to understand about the world would all go down the drain in one split second. Death would not exist. All the things I thought were true about biology would be instantly overturned. Pretty much all of science as I know it (and in fact as I learned it from my father) would be destroyed in a flash. Would I want to trade the joy of the return of my father for the destruction of my entire belief system?

There is, admittedly, one alternative reaction that I could have, were EMI to spout forth new pieces that touched me to the core. Instead of revising my entire opinion of what music is about, I could conclude that I'm just a shallow listener — a sucker for lightweight aping — and drastically downgrade my opinion of my own personal depth as a perceiver of music, thus coming up with a very different kind of pessimism from the three listed above — namely, this one: "*I* am a lot shallower than I had ever thought." Maybe that's the ultimate explanation of my EMI perplexity. If so, I'd just as soon not know it.

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Footnotes

* The epigram was actually stolen from David Cope, who himself had borrowed it from Pablo Picasso.

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