ALSO BY SHERRY TURKLE

PSYCHOANALYTIC POLITICS: Freud's French Revolution

THE SECOND SELF

COMPUTERS AND THE HUMAN SPIRIT

by Sherry Turkle

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To Robert Bonowitz
and
Mildred Bonowitz

spends more and more of his time programming alone. There is a chance that the computer will keep him lost in the world of things.

Most children of Henry's age are involved with mastery, with testing their competency. But here, as at every age, most children strike a balance—the need for mastery of skills and concrete materials is tempered with the desire to do things with people where the results are never as clear. The computer is a powerful medium for playing out the intense desire to win that is at the center of Henry's preoccupation. The danger is that its challenge will be so seductive that he will play and replay winning to the exclusion of more complex satisfactions beyond it.

CHAPTER 4

Adolescence and Identity: Finding Yourself in the Machine

The concerns of the youngest children were metaphysical. These "child philosophers" were from four to eight years old, a time when children are forging fundamental categories to make sense of the world. They were intrigued by the nature of computers and computer toys and how they were like and unlike other things. The children were reflective. Most of them were eager to talk about the attributes, capacities, and personalities of the machines, and got into spontaneous arguments about whether computers felt, thought, cheated, knew. Putting very young children together with computers encourages a rich and continual philosophizing.

The interest in sorting out the nature of the machine, and in using computer nature for thinking about human nature, continues with older children, but these questions are less pressing. At eight, nine, and ten years old, children are preoccupied not by metaphysics but by the need to master.

These school-age children's primary interest in computers is in what they can do with them. This stage is dominated by action, not reflection. The hards and the softs, the girls and the boys, are looking for challenges to meet: to beat a game, to produce startling visual effects. Their interests are to make, to do, to master.[1]

With adolescence, there is a return to reflection, but this time reflection is insistently about the self. The questions of the first

stage, What is this machine?, and of the second, What can I do with it?, give way to Who am I?

Adolescence is an often confusing time when there is a need to come to terms with a suddenly maturing body and new social pressures. It is a time of introspection and of trying to fit oneself into increasingly complex relationships. And it is a time when young people are able to bring a widening range of cognitive skills and cultural materials to bear on their reflections about who they are. It is a time of conscious self-creation: adolescents "try on" ideas about politics, religion, and psychology to test and develop emergent ideas of self.[2]

Adolescents use many different kinds of materials to construct their sense of identity. They use their relationships with clothing, with records, with causes. There is an obvious way in which computers can become part of this process: they can become a way of life. Some young people start to see themselves and are seen by others as "computer people," experts at the technical aspects of computation. They spend most of their time programming computers, and a computer center or a computer club can become the focus of their social life. But most adolescents don't take this route. They integrate their computer experience into their developing identities in ways that have nothing to do with becoming computer experts. They use programming as a canvas for personal expression and then as a context for working through personal concerns. They use the computer as a constructive as well as a projective medium.

We began to see examples of "working through" in elementary-school-age children. In the course of learning to program they are grappling with issues that go beyond mastery and competence. Computer programming helps shape their feelings about what kind of person they are (Am I somebody who is afraid of machines and technical things? Am I somebody who can create something beautiful?) Their style of working with the machine expresses something of who they are, giving them a chance to see themselves in the mirror of the medium. At the same time, they can use the experience as an occasion to experiment with who they are not. By this I mean experimenting with a part of the self that is not dominant—indeed, with a style of being that may pose a threat.

Ethan is a fifth grader in a San Francisco public school. His untidiness goes beyond a messy desk and room. He is overweight

and unkempt. He is impulsive and often feels out of control: "I tell myself I am going to go on a diet. But then I will see some candy and I will eat it and then eat a whole box of cookies too." As I watch him program, something interesting emerges. Ethan is expert with the system, and he is very smart. He can hold a lot of code "in his head." He programs by "making a mess." The programs are complicated, unstructured. Instructions weave around like strands of spaghetti. And then he cleans them up by turning the out of control, sloppy programs into models of hierarchical, modularized structured programming. "When I program, I like to make a mess and then I like to make it clean." In programming Ethan is clearly playing with issues that go beyond "cognitive style," that put him in touch with far deeper emotional material.

It is characteristic of fourth and fifth graders that this process of working through happens but is not particularly reflected upon. By contrast, with the beginning of adolescence experiences with the computer are often made into elements for explicit reflection about themselves.

Children in the sixth grade of a school I shall call the Jefferson Middle School were given opportunities to program in Logo. The program was a government-funded collaborative project carried out by a local school committee and researchers from MIT. The researchers followed the children's progress and kept files of their work, noting their attitudes toward the computer, their interactions with each other and the teachers. Sixteen children with a diverse range of backgrounds and interests were selected for closer study. Two years after the beginning of their computer experience, I went back to the school and carried out a series of interviews with each of them.*

The computers used in this project were different from those used at Austen. At Jefferson, children were able to create sharp black-and-white line drawings, including geometric figures like triangles, squares, and polygons, as well as complex and rather beau-

* I also was able to study the computer culture that had grown up at Jefferson in the two years that computers had been present there. This was enough time for there to have developed a rich tradition of computer "stories," computer jokes, computer etiquette, and computer rituals. I visited classrooms and the after-school computer club, talked with teachers and administrators. In addition to the follow-up of the original computer experiment, there were also a three-month study of a new fourth-grade classroom and close observation of five students in that class, chosen for the diversity of their intellectual and personal styles.

tiful spirals and figures such as faces, houses, and street scenes. Where the primary computational objects at Austen were the sprites, here children gave commands to a "turtle." This is a triangular-shaped penpoint that responds to commands to move around the screen and leaves a trace as it goes. It can be told to move a hundred steps and turn ninety degrees with the commands "FORWARD 100 RIGHT 90." Thus the turtle becomes the instrument for a kind of TV screen doodling. (A precomputer generation will remember the feeling of making line drawings with Etch-A-Sketch.)

Programming begins when sequences of commands to the turtle are defined, named, and stored away in the computer's memory. For example, a program to make a square might read:

```
TO SQUARE
FORWARD 100
RIGHT 90
FORWARD 100
RIGHT 90
FORWARD 100
RIGHT 90
FORWARD 100
END
```

This program can then be called upon to build up more complex patterns. So, for example, a program to draw a house might be constructed out of five subprocedures: a large square for the body of the house, a triangle for the roof, smaller squares for windows, a small rectangle for a door, and an even smaller rectangle for a chimney. Defining the "superprocedure"—the "master program"—for the house is a more complicated job than just calling up its parts out of memory. The parts need to be placed in the right relationships to each other. For example, when the turtle has gotten up to drawing the two small windows, it has to finish one, then take its "PEN UP" and move to the exact place where the second window is to be drawn, and it must begin this drawing in the proper orientation.[3]

The grade-school children in the previous chapter are caught up with the challenge of the computer. When they work with a graphics system like Logo they typically pursue projects—making

a space scene, a "movie" of a car going around a racetrack, programming a video game. Whatever personal issues are being worked out are being worked out through what they are doing on the screen. When younger children work with computers, less is immediately visible. First or second graders spend hours tracing lines on the screen and writing a variety of little programs. They are happy to be exploring, to be learning the ways of the new thing. They are involved with the question of how they are like and not like it. So too in adolescence: what is on the screen reveals only a small part of what is going on in the relationship with the computer.

Deborah and the Machine as Microworld

Deborah is thirteen, blond, round-faced, sweet-looking, poised between innocence and sophistication. Her hair is cut in a tousled "shag" style that she picked out of a magazine. She is wearing a Western fringed jacket that she proudly announces she chose herself. After we have been talking for several days she tells me she wants to show me "the best thing I have done all year." It is a beautiful drawing of a horse that she says her art teacher wants to frame and hang in the art room. She is on a diet and solemnly sips a Diet Pepsi as she watches me eat the lunch of the day offered by the school cafeteria: a peanut-butter-and-jelly sandwich and ice cream.

Deborah first encountered the computer two years ago, in sixth grade. Her teachers remember her at that time as withdrawn, frightened, and explosive. When teased by the other children for being overweight ("They used to call me Fatso"), she would break into a tearful rage. She had little self-confidence. When she was asked to do something on her own she would become petulant or tune out ("My father calls it going onto Channel Thirteen"). The explosions, the petulance, and the Channel Thirteens were frequent. Deborah describes her eleven-year-old self as dependent and unhappy, a child who could not control her tears or her temper.

She was the youngest of three children, the baby of her family. Her family's efforts to compensate her for a history of childhood illnesses exaggerated her "baby" position. Other people were always doing things for her, buying her clothes for her, telling

her that she was not yet old enough to do the things that she most wanted to do—baby-sit, be in charge of going to the Laundromat, stay over at a friend's house, choose her own hairstyle and clothes.

> Everybody else in the family had responsibilities. Things they had to do. I was the baby. My parents used to treat me like I was a little four-year-old. Like they used to buy my clothes, little pants with big strawberries on them. My mother would say, "Oh, aren't these perfect for school?" Everyone would say, "Oh, Deborah, she can't do anything. She can't bring the clothes down to the dryer. It's down in the cellar. She'll be scared. She'll get hurt. The basket's too heavy for her with the wet, damp clothes and the wet dungarees," and my mother would get my sister or brother to do it and they'd always give me a hard time, saying, "Deborah is Mommy's little pet."
>
> I didn't do anything by myself. I wouldn't do anything by myself. I got my mother to go down to the store for me, got my brother and sister to go places with me, to get me this or get me that. Like I'd say to my sister, "Can I have that shirt you have," and I'd make her give it to me. And I'd say things like that to other kids too. I was really bad about my friends. I couldn't do nothing without them. I had to always be with them. And when I wasn't with them, I'd be yelling at my mother and making my house a rotten place, getting everyone into fights. I got into fights in school too. I was very bad. All the teachers hated me in sixth grade.
>
> Me and this other girl, Tessa, we used to be awful when we were in sixth grade. We'd go behind the stage curtains and we'd rip things down and we'd hide in the closet and we used to skip classes. One time we went down to the gym, and you know that big curtain down there, well, that was shut, and we hid behind it. And this kid, he came up and he grabbed me from behind. I peed in my pants. I had it all over the floor and I was so embarrassed. I was so ashamed. That was really my worst day. I had to get Miss Bryan to wash out my things. I was in my gym shorts all day. I wanted to run away.

Dependent on others and with an image of herself as sick, weak, and fat, Deborah had little sense of her own boundaries and no confidence in her ability to say no, to exert control. By eleven, she was already involved with a crowd that was smoking, drinking,

using drugs. Toward the end of that year Deborah was introduced to programming computers in Logo, which, as we have seen, is specifically designed to be accessible to children. Deborah was shown how to draw pictures on a screen by giving commands to the "turtle."

At the beginning of Deborah's participation in the computer project, she spent most of her time trying to get as much of the teacher's presence and attention as possible. She refused, as might be expected, to do anything on her own. And she measured any effort that she did make against the progress of the other children. She always found herself lacking, and this made her want more and more help from others.

Children experience making computer graphics—including dynamic "special effects"—as a source of great power. For Deborah, the sense of power was not liberating, it was threatening. A breakthrough came when she had the idea of restricting the commands she could give to the turtle. She made a rule that she would allow herself only one turning command—a right turn of thirty degrees. Deborah describes her decision as arbitrary ("One day I just decided to do it, and I picked out thirty degrees"), but this world turned out to be extraordinarily rich. By repeating rotations of RIGHT 30 it is possible to make 90-degree right turns, "about-face" 180-degree turns, and 120-degree turns, all useful maneuvers for making geometrical shapes.

Once she had her rule, Deborah got down to serious work. She drew flowers and rabbits and stars and abstract designs, everything built up from right turns of thirty degrees. "I really liked my rule. It was neat. It was hard. I had to figure everything out. I thought about it all the time. I was the only one who had a rule." Suddenly she found herself, perhaps for the first time, in a situation simple enough for her to feel in control, yet varied enough to allow for creative exploration. Weeks later, Deborah was the master of her restricted world and she began to dare to come out of it to experiment with a less restricted geometry. Her mathematical learning had taken a leap forward.

In building her world, Deborah built an environment in which she could be successful. She had never been successful at anything before—not in school, where she was considered below average in all her subjects, and not at home, where she was not allowed to act independently and was afraid to try. The thirty-degrees world was

an environment in which a girl who thought of herself as a loser got a first taste of what it was like to be a winner.

> One time the teacher, he showed a movie that this guy did about computers and how to make stars with them, and then I tried. But of course I made them with the thirty degrees. I made the star and I got a letter from the person who made the movie, saying that it was a really hard thing to do and that he was really proud. I still got the letter in my book.

The thirty-degrees world provided more than a first taste of success. Deborah first knew the computer as something apparently uncontrollable. She was afraid to press its keys without asking the teacher to stand by, because whenever she got an "error message" from the machine she reacted as though the machine were "yelling at her" and she started to cry. Later, she saw the computer as something she could control—indeed, as a part of her mind that she could examine, reflect on, manipulate.

> When you program a computer, there is a little piece of your mind and now it's a little piece of the computer's mind . . . and now you can see it. I mean, the computer can be just like you if you program it to be, your thoughts, your pictures, your feelings, your ideas, not everything, but a lot of things. And you can see the things you think and change them around.
>
> Sometimes I would go down there, and like if I had a fight with the kids it would be good to go down and really sort of have a conversation with it. Like you could, um, make it talk to you if you programmed it right. I mean it wasn't really talking, but it was like talking. I would get all tense and just want to get away, just want to get away so I would go down to where the computers were, I would sneak away. I couldn't wait until computer classes could start every day. I would tell it what had just went on with my friends, all the really bad things. It made me a lot happier than when I came in. You could talk to it. Say you drew pictures in it. You get your feelings into that picture, and it just makes you happier. If it's just on a piece of paper, it's not the same. With the computer it's different. It's somebody there. It's having something that you make your own things on. I liked it because I could put my feelings into it.

Before she met the computer Deborah didn't think about her problems in terms of control. Of course she knew people who did not break things or cut classes or stuff themselves with candy until they were sick. She saw herself as different not because they had resources for self-control that she didn't, but because they were that way "by nature." They were good, she was bad. This kind of global characterization gave her no way to think about how to be better. She needed a world apart in which to build a new set of distinctions that she could then transfer to her way of thinking about herself and others. The computer provided this world. It gave her categories more useful than good or bad: things could be in or out of control. With the new distinction came a new way to think about her problems: I am in trouble because I have no rules. I am not in control. And I should be. I can be. The thirty-degrees world not only suggested that control was the issue, it presented a strategy for dealing with one's lack of control: make a rule, make a safe place, experiment within it.

Control has remained a central issue for Deborah. It is the thing she thinks about most: controlling her temper, her eating, her smoking.

> You program yourself how to be. In sixth grade I got really upset, and I started drinking and smoking. I don't even know why I did it. A lot of kids would say, "Oh, you're a chicken." And I'd say, "I am not," and I'd gulp down the beer. I didn't even want it. But I didn't know a thing to do.
>
> Then I started to make rules. The thirty degrees was for the computer, but these are for me. Like today I will not do this thing. Don't eat candy for lunch. If you're angry, hold it in and scream after school. Or I make a rule for two days. Like I'm gonna really work, try hard, I'm gonna do good on my English tests. I won't have a cigarette. Since the computer isn't around now, I take a pencil and draw.

This conversation takes place as Deborah is about to graduate from eighth grade. She no longer has easy access to the computer. The experimental program for her grade had come to an end. Although the computer remains in her school, to use it she would have to compete against a crowd of computer whizzes who monopolize its time. She chooses not to compete. Drawing has in some measure replaced graphics programming for her, but she has moved on with some wistfulness: "When I just wanted a cigarette

it would have been good to be able to go down to the computer instead of picking up a pencil. It is more there with you. And it's funny, even though I did it such a long time ago, it still reminds me of making rules and keeping to them, of being independent."

Computers also represent a threat to independence. You can get hooked on them.

> I liked the computer because I put my feelings in it. But you can't get too hung up on it, because everything else can get screwed up. You just want to do it all day. Once, I was making this really hard picture on the computer and I didn't want to go to class because I was too into it, too involved with getting it just right.

Deborah warms to her subject. I ask her if she ever feels too involved with other things. She hesitates a long time. Finally there is a slow "Yes, maybe with my drawing a little," but then there is an even slower "No. It is different with drawing. It is more so with the computer. It's like somebody's there." This is something I often hear about the holding power of the computer. I hear it from children and from adults. Many people are lonely and isolated, but when they have a computer around it can feel like somebody is always there, always ready, always responsive, but without the responsibility of having to deal with another person. The computer offers a unique mixture of being alone and yet not feeling alone.

Deborah says that she stopped using the computer because access became too difficult. But there is more to it than that. She is withdrawing from something that served its purpose but that she senses as a danger.

> I could start to get bad grades again because I started thinking of the computer all the time. That could screw me up pretty bad. I didn't like getting help from teachers no more 'cause I got so used to people helping me that I couldn't do things on my own. And I could get myself stuck like that with the computer. It would be the same thing. You get so used to it that it's always there, like the teacher helping you. You couldn't do without it.

Deborah's images of what can happen to people with computers come too close to the dependent place where she began. She is not about to go back.

Deborah used the computer to build a safe environment that allowed her to experiment with something new. The way Deborah used her experience of the machine as an "experience-to-think-with" was unique to her. But using the machine for world-building was something I discovered again and again among children her age.

Bruce and the Mirror in the Machine

It is eighth-grade lunch period. The boys' side of the school cafeteria is a sea of blue jeans, Oxford shirts, and windbreakers. Bruce floats out upon it: love beads, open-necked velour sweater, aviator sunglasses pushed up high on his forehead. Bruce at fifteen sees himself as creative, artistic, an individualist. His recollections of childhood include a golden age when he was six and seven, a time when he most felt how different he and his family were from everything around. At that time they lived not in the city but in Glendale, described by Bruce as a "gross suburb." The gross suburb was the backdrop for a clear, marvelous sense of feeling special.

> I hated Glendale with a passion. Everyone was alike. When one kid got a three-speed bike, everyone would get three-speed bikes. And then of course I did not ride a bike. Then they would get ten-speed bikes. I just use bicycles as an example. They were into other things in the same way. Like sports. And I'm not, not at all, into sports. My father was never really into sports—he is more of an artistic person. And so that kind of rubbed off. He wasn't the type of father who would take me out to the lawn and say, "Let's play baseball." I thought my family was the least alike to everybody in Glendale because my father was a college professor. We had a big house, and at night all these people would drive up and they'd come in the house and we'd turn out the lights. Everyone in the town would wonder what we were doing in there. My dad had switched from just being an English professor to running a film center, and every night he would show a movie in the house. I would come home after school, and in the evening my father would have massive movie parties and there would be twenty-seven college kids staying there all night, sitting and talking and drinking. I would really love these parties and the movies. I would come down in my little pajamas at two

o'clock in the morning and say, "What are you doing?" People would be playing guitars and sitting around. I loved it. We were really different.

Even now, the thing I hate most is the idea of being typical. My father came out of a typical—well, he lived in a suburb outside of Washington and he lived a sort of typical, *Leave It to Beaver* life. You know, like "Come on, Bill, let's go over and play baseball in the backyard." And then he rebelled and now he's living a life that's similar to mine, with going to parties and whatnot. An artistic crowd. He doesn't want to be a typical middle-aged father. When we get angry at each other, he says, "Typical teenager" to me and I say, "Typical middle-aged father" to him.

Bruce acts in a local children's theater, and the week of our interviews is tense for him. He has tried out for a part in a summer production of *Peter and the Wolf* and has just been called back for a second audition. First he is nervous about the audition, then about its outcome. Two weeks later Bruce catches me in the hall to tell me that he has gotten the part. "I'm so relieved. The worst thing about these acting tryouts is that everything is out of your control." As with Deborah, control is on Bruce's mind.

I have a lot in common with my father. . . . We both have chaos. Emotionally, we tend to act, not think, be fatalistic, because when you're in a really chaotic state it's easier to say, "Well, yes, however it turns out, it was meant to be that way." I'm a slob in my way of thinking, in how I keep my things. Both my father and I would like to have a little order. That's where my mother comes in. My mother pretty much is the order, and that might be one of the reasons my father married my mother. I think it's the same reason that I think it's good that my parents are a bit protective of me, even though I sometimes complain about it. Like, I like it that we have dinner together every night. I wonder if my father and I were ever alone—I wonder what would happen. I think all hell would break loose. We once went to a wedding without my mother, and we both got really drunk. It was really funny. It was also scary. We both ended up doing a lot of things without thinking. Hoping for luck. Being disorganized. But I would love to have control. I would absolutely love to have control. I know that you're here because you care about what happened with the kids who had the computers. And I really have to tell you that that was the first thing I really loved about them. I mean, you command them. However you want. I remember loving that idea of giving commands.

While he was growing up Bruce found a way to have control. He found it in his toys. He liked toy cars and really loved a set of homemade puppets. With these, he gave the commands. But the less passive toys were threatening—like a toy robot he got when he was five.

I had this robot. A frightening robot. I really hated this thing with a passion. It would start walking. It had a big metal box on it, and all of a sudden the doors would open up and guns would shoot out and it would close its doors and keep on walking and every so often the eyes would light up—it was a horrid thing. Then the batteries would run out and it would go slower and slower and you never knew when . . . and then it would fall over. I remember looking at it, watching it walk around shooting things, and I remember hating it. I remember having my grandmother put it away for three years and then getting it again. I guess it was a pretty expensive thing, so they just kept it for me. And then I know that when I got it back I would make it walk off tables. I still hated it. I would make it start from high places and it would do its horrible things and then I would have it fall off—that kind of thing. It was weird. I never did that sort of thing with other toys, I was never violent or tried to hurt other toys. But this robot, though, it was such a frightening image. It would shoot out, it would break down. You never knew when it would do what. I didn't like them [battery-operated toys], I didn't like the way they started going slower and slower and you couldn't help it, couldn't do anything about it. For me, batteries always meant that the toy couldn't be exactly trusted. I had great fun a few years ago. I dissected batteries. Yeah. I took them apart. I always hated them.

I never was much with machines. Not really machine phobia, more like awkwardness. I always feel that I'm going to break this. That kind of thing. Not really able to interact with it. When my father was showing films at the house he taught me how to thread the projector. But I always used to get nervous that I would do something wrong, that the machine would break—you never knew when it would break, it's flaky like our toaster—and it would be my fault. The first thing I even remember, literally

> my first memory, was when I broke a typewriter when I was like three. My parents were always typing. I said, "What's this?" and I pushed the typewriter off the table. They were really upset.

Bruce and Deborah are both unsure of finding the inner resources to exert self-control. This issue dominated their lives before they ever came near a computer; it is not surprising that it became a major theme in their interactions with it. Bruce and Deborah are contrasting cases of what "microworld" construction can be about. Even though their concerns are similar, what they do with the computer is at opposite extremes. Deborah uses the computer as an emotional medium to "play with the other side," to play with a small world of control and constraint. What she got from the experience is clear: by restricting herself she put herself in a position to experience what it is like to exert a greater degree of control than she had ever known. Her experience did not change her into "somebody else." She still feels that her actions are determined more from without than from within. But she had an important experience of feeling what it is like to be "the other kind of person" and learned to integrate some of their ways of coping.

Bruce took the same computer and used it, not to "play with what he wasn't," but to externalize what he felt himself to be, a chaotic person. Deborah worked hard to create order in her computer world. Bruce worked no less hard to maintain disorder in his. He consistently rejected orderly programming practices even though he was aware of these techniques and knew that ignoring them would cause him inconvenience. He would refuse to take notes about what he did, or would leave them lying around the classroom, perpetually "lost." Perhaps most saliently, the subject matter of Bruce's programs was at the other extreme from Deborah's. Deborah's careful, planned, rule-governed shapes were exercises in restraint. They enforced a demand for total understanding of how they were built. For Bruce, the goal seemed to be to produce as much wild, uncontrolled, and not always explicable movement as possible: one of his favorite programs created triangles that spun in complicated and confusing counterrotations.

Both used the computer to create a microworld, as other children create them with drawing materials or dolls or toy soldiers. The child who begins to draw by taking up a pencil and asking for a ruler in order to draw "perfect" stick figures, and the child who

starts out by applying color in broad, sweeping strokes, the child who arranges dolls in a neat circle and has them all sit down to afternoon tea, and the child who lines up toy soldiers in opposing camps for a battle—in each case there is projection that reveals something about how the child is thinking, feeling, and organizing experience. In all of these cases the world the child creates, of rules or disorder, peace or violence, reflects back an image of who that child is or perhaps wants to be. Such images can help people move toward greater insight about conflicts, problems, and ways of thinking.

But Bruce comes to the computer with a conflicted emotional agenda. He needs not only to put his own disorder into the situation but also to vanquish any sense of the computer as autonomous. The computer must be chaotic—it reflects his inner life—but it can have no life of its own. In order to reassure himself about this, Bruce goes to extremes. For example, the computer comes with aids for editing programs that make it easy to insert a new instruction in the proper place in the body of the program. Bruce would rather retype the whole program than use the automatic device. In the middle of "wasting" a half hour struggling with typing that he knew was unnecessary, Bruce was not upset. He used the moment to reassert his individuality. When he noticed raised eyebrows he would simply say, "Leave me alone, it's my funeral."

Many young programmers who share Bruce's interest in visual effects and love for the spectacular like to produce screen effects that computer scientists call "artifacts." The "straight" route to computer graphics puts shapes onto the screen and sometimes sets them in motion under the logical control of a program. The overall result is often surprising. For example, superimposed shapes can produce illusions of dimensionality. But the surprise is in the mind and the eye of the viewer. Each detail on the screen can be traced back in an intelligible way to the instructions in the program. But sometimes the reign of logic breaks down. In the system Bruce was working on, the computer's display can put up only a certain number of lines. As long as a program instructs the system to put up fewer lines, things proceed smoothly and predictably. But when the critical number is exceeded, the computer shows symptoms of "overload"—for example, a strobelike flickering on the screen. Many children are delighted when they first encounter this kind of

effect and work hard to exploit this "unofficial" unprogrammed behavior of the computer. It adds to the machine's "magic." Not Bruce. For him all artifacts were anathema: they recalled the robot taking off on its own. He didn't want anything going on behind his back.

Bruce wants the machine to be predictable in spite of his most unpredictable programming. He would like it to be as different from the unpredictability and the variety of people as possible.

> I think of the computer as being perfect. People are imperfect, and that's the difference. As of now, when you put things into a computer you pretty much know what it is going to do. With people you never know. That's the point. It could be that someday they could make it so that you would not know what the computer is going to do. It would all get too complicated to know. One of the first movies I remember was Kubrick's *2001*. Wow! HAL in *2001* and my robot that I kept trying to destroy by making it walk off the table—I never thought of them together. HAL was certainly unpredictable, and he was supposed to have feelings.

Bruce was reassured by his experience with Logo programming. He was able to see the computer as "perfect," by which he meant that it did only what it was told. He found a style of working with it that gave it no chance for surprises. Some people not only delight in artifacts, but eventually even develop an aesthetic of programming that puts a value on the surprising, the counterintuitive. For them, programming is a way of walking on the threshold of the machine's mysteries, pushing it to its limit as an "unpredictable system." But this demands a tolerance for the machine as lifelike, as "magic," as surprising. Bruce had none. Against his sense of inner chaos, the world of things was reassuring only if predictable.

Bruce liked the computer insofar as he could see it as at his total command. This is what attracted him to the machine. But then the computer has to be kept in line. For Bruce, concessions to the machine's ability to carry out complex functions or, even worse, to produce artifactual effects outside his control seemed to confer too much "personhood" on it. His response to the threat of what we might call the computer's "automaticity" illustrates its power to reflect the programmer's personality.

Bruce expresses who he is in his spontaneous behavior with the computer. He also has worked out a set of abstractly formulated beliefs about computers and people. He has an ideology about "what it is to be a person." A person refuses dictated order. A person is not predictable. A person is emotional. In the sense that the computer is perfect, to be human is to be not-perfect. It is to be not-computer. Bruce fears that somehow computers in their perfection might be a threat to the nonperfection of people. He sees the machines as undermining the things that he and his father most value: unpredictability and variety.

> What I really hate about computers is that they might cut down on the variety of people. I have seen some footage that frightened me. It was on *Nova* a few years ago. They showed a clip from a Kawasaki promotional film. It was all robotized, with all these giant computer arms building motorcycles. All of these identical things. And there were no human workers in the plant. If that happens all over the world, that means that humans won't do that kind of work. I like the idea of variety in people. Some people like to do mechanical work, and I would hate to think that a certain kind of work would be cut out by anything. The idea that computers might cut down on the variety of things that people could do—that's the thing that bothers me.

When I asked Bruce to look back on his whole experience with the computer and tell me what he thought he had gotten out of it, he said, "The very best thing was I loved doing things on my own. Making things that nobody else has ever made. Nobody could have ever done that exact same thing."

Deborah wants more than anything else to be like other people, and she uses her experience with the computer to bring out qualities she might share with them. Bruce wants to be as different as possible from everyone else. He uses the computer to underscore this difference, as a mirror for his own uniqueness. He tells me, "When I saw what I did with the computer, I used to laugh. I could see what a nut I was." Externalization onto a canvas is a way of seeing who you are.

The difference between Deborah and Bruce is not only a matter of psychology, but of the different worlds they live in. Reality for Deborah is protecting herself from drink, drugs, and sex—and

their consequences. Her mother may be protective, but she can't protect her in the social world outside. Deborah's difficulties in asserting control place her at risk, and she knows it. In self-defense, in the machine she found an aid for making rules.

Deborah's family is poor. Bruce's is relatively well off. Deborah's father does odd jobs. Bruce's father is a teacher and writer. In Bruce's world the threats are not those of the street, not threats on the person, but threats on a felt sense of personhood. He worries about the computer coming too close:

> I think I believe that maybe someday they could give computers feelings. But I would think more of the human race if it didn't happen. We'd be like gods if we could create something that had feelings. It would be something that would be a clone of who we are. I think it would be very hard to do this, but two thousand years ago they didn't think we could do the things we do now. But I think it would be different from the things we do now. Much worse. Putting the feelings into the computers would be much worse. It would be like the apocalypse.

Reflecting on the computer experience leads Bruce into an elaborate theory of what constitutes order in the cosmos.

> To me the Frankenstein story is the apocalypse . . . Being able to create. The test-tube baby always sickened me. But at least the test-tube baby, it's not really all that synthetic. I mean there were still people. But the whole idea of computers having feelings, I could not stand that. It is possible for it to happen, but I hope it doesn't. If there are enough people like me it won't. I think that human beings were meant to be the things with feelings. There are natural things, animals and humans, they can have the right to have feelings. I believe that God made us, animals and natural things.

Here Bruce is struck by a very personal image of what is so bad about the "feeling computer." Such a computer could share in an experience that constitutes one of his most intimate bonds with his father: "I mean, could you just see a computer watching a movie, saying, 'Well, no, this isn't very good'? I hate it. It makes me cringe."

Thinking Through

The story of Narcissus is usually read as a warning against self-love. Narcissus saw his image in the water and fell to his death because of his desire to touch it, to be closer to its beauty. But there is another way to understand the story. Narcissus fell in love with what appeared to him to be another. This image of that other person fascinated him because it objectified a sense of beauty of which he had felt only a vague inner sense.

Mirrors, literal and metaphorical, play an important role in human development. In literature, music, visual art, or computer programming, they allow us to see ourselves from the outside, and to objectify aspects of ourselves we had perceived only from within. Bruce was referring to this when he said, "I could see what I was doing on the computer and I could see what a nut I was." Deborah came even closer to this idea: "When you program a computer there is a little piece of your mind, and now it's a little piece of the computer's mind. And now you can see it."

Infants are fascinated by their reflections as they grope toward a sense of their bodies as coherent wholes. With puberty, there is an assault on the sense of coherence of the body and the mind. There is new growth, new desire, new feelings. As adolescents we return to our mirrors; in programming, Deborah and Bruce found powerful ones. Some children become far more explicit than they about seeing the computer as a mirror of the mind. These are children who make explicit use of computational metaphors to think about themselves. Looking at the detail of how they do so provides a vantage point for understanding something that goes beyond the stories of individual children. It helps us to understand how computer metaphors can turn into a new popular psychology for the culture at large.

Carla is a fifth grader who has been working with the computer for five months. I visit her classroom on an unusual day. Her teacher is out sick, and a substitute teacher is taking over. Unsure of the children's normal routine, the new teacher gives them an unaccustomed chance to sit around and talk about the computers, to compare notes on their experiences. Since the class has thirty-five children, they break up into smaller groups to pursue their conversation. In one circle of twelve, the discussion turns to

whether or not computers are alive. Someone in the circle says, "No, they are not alive, because they are programmed," a comment that is met by mumbles of approval—almost everyone finds this a very good answer. Everyone, that is, except Carla, a quiet girl who usually does not take a stand against any consensus. "Well, I don't know if they are alive. They certainly are not completely alive, but I don't think it has to do with that they're programmed. We are all programmed."

I talk to Carla for a long time. Her family is poor. They are very religious, very observant Catholics. She is the youngest of six children, her parents are in their fifties. Carla's life is filled with complex rules. There are rules of religion, rules of demeanor, rules about whom you can and cannot play with. There are rules for dress: all of her clothes are rank-ordered in terms of their "goodness" so that she can wear the "worst" ones to school and wear them out before proceeding to the next in line. When children are learning to program, one of the things that most delights them is naming the programs. When Carla wrote her first computer program, she called it CLOTHES. The idea of executing steps in a procedure was not new to her. It was how she was made to organize her closet, and to a certain extent, it was how she thought about her life. She answered questions about what she liked to do, what she did after school, and who her friends were, with the rules for what games she is allowed to play, how late she is allowed to stay out, and whom she is allowed to play with. It is not surprising that her encounter with the computer, with its step-wise procedures, was familiar and could be integrated into her way of talking about herself. "I think that I am programmed like the computer. Other kids in the school aren't as programmed as me. They have to do things, but they don't have to do them in order. My mother did my programming. And the Pope. Well, not really, the priest did it. But the Pope did his."

Here Carla breaks out in nervous giggles. She has clearly said something that to her feels like a very bad thing to say, and she looks at me somewhat warily. I don't say anything, and she continues, looking nervous. Finally I say, "Well, I guess that can be sort of rough—all those rules." Her reply astounds me: "Well, you know, you can change the program. Once you know how, you can change the program. I can't do it now, but that doesn't mean that I won't be able to someday." For Carla, experiencing herself as

programmed is not to see herself in a situation of total constraint. It expresses a hope that somehow the program—and her life—might be changed.

Dennis has just begun high school. He is fourteen and preoccupied with the ways in which he is like and unlike his father. His father is a political-science professor, very successful, intellectual, intense. Dennis feels he is like his father. "The other kids don't think I'm much fun. I guess I turn everything into a brains contest." But he also admires his father. "He really is the smartest person." Dennis is concerned with what there is about him that is "real," what is his "true identity," and what is changeable, accidental (and here he uses a computer expression), "artifactual." Is he like his father in some fundamental way? Will he be like that for the rest of his life?

Dennis started to program computers when he was ten. He got involved with them by hanging around the computer center of a large university that accepted "tourists" on the system, and, indeed, his precocity won him the role of favored guest. Recently, he has found that thinking about levels of programming languages offers a way to think about his personal problem. Each computer comes with its own specific "machine language." This is a fixed characteristic. Dennis explains to me that it is part of the "hardwiring" of the system. He thinks of this as the computer's "real identity." But most programmers do not communicate with the machine by "talking to it" in its machine language, since this would be cumbersome. They communicate with it in a "high-level language" of which Logo is just one example (BASIC, FORTRAN, COBOL, PASCAL, and LISP are others). The machine accepts the high-level language and translates it back into the machine-language commands that are in direct communication with its hardware.

A computer that plays master chess may have the same machine-language identity as a computer that runs a robot arm on an airplane assembly line or passes messages between branch offices of a bank. Yet these machines have different behaviors that are defined in the programming of the high-level language. These behaviors, which Dennis thinks of as "psychologies," can be changed, reprogrammed. When you are interacting with a particular computer, the most salient thing about it seems to be its behavior, its way of interacting with you, but, as Dennis points out, "that's just because you only know enough to get involved with it at that level. That's

your problem, not the computer's. It's not part of the computer's 'core identity.' "

Dennis began to elaborate a model of himself in which he distinguished between his machine language—his "core machine"—and high-level programs written on top of it. He decided that he and his father had different machine languages. They were two very different machines, "like an IBM and a DEC. We are fundamentally, fundamentally different." But, Dennis explained, clever programming, "neat hacking, really neat hacking," had been able to get these two very differently structured machines to behave similarly. This way of thinking landed Dennis in a more comfortable spot. All of the similarities between his behavior and that of his father, similarities that he didn't like and wanted to be able to change, were on the level of a higher-order language that was reprogrammable. The machine analogy left him with an optimism not unlike Carla's. The trick was to find a way to do the reprogramming.

Dennis has never read Freud or any of the American "neo-Freudians" who considerably softened Freud's notions of the determining power of the unconscious when they put forward a notion of an autonomous ego that the individual could feel to be a "center," a "self."[4] But as I listened to him pondering reprogramming strategies for himself, I thought to myself that here was a boy who had rediscovered the notion of a "conflict-free" zone of the ego: a platform to stand on, a zone of mental functioning that is not determined, that is open to change.

Carla's analogies and Dennis' theorizing are not isolated examples of what happens when people meet up with computers. They are taking first steps towards playing with the idea of mind as machine, personality as program. This kind of play with computation and models of the self is very much a part of what the adult world is doing with computers. It is not confined to the experts. It happens among college students taking their first programming course, among people buying personal computer systems for their homes, among people whose contact with computers was initially "just for business," to handle tax returns, to help them run a small company, or to do word processing. It is also part of children's computer experience. It is implicit in the musings of very small children. It is implicit in the anthropomorphization of the machine by the third, fourth and fifth graders who are more deeply committed to mastering it. And it becomes increasingly explicit as adolescence unfolds.

George, a college sophomore, was lethargic, depressed, unable to focus his attention on anything that required him to take an initiative. He was failing most of his courses, did little else during his day but watch television soap operas. He didn't spend time with friends, and he had nearly broken off contact with his family. He was particularly anxious about the prospect of any contact with his father, a successful physician. George had always admired his father, wanted to please him and grow up to be like him. As a freshman George did not have to choose a major, and he did very well —so well, in fact, that he felt he would be able to handle premedical studies. At the end of his freshman year he declared his major to be biology, a subject in which he had always excelled, and he spent the summer sailing with his parents. He came back the following fall filled with expectations—only to find himself in a state of debilitating depression.

Shortly after I met him, George began to take an introductory course in biostatistics required of all biology majors. He quickly became absorbed not in the course itself, but in the intricacies of the computer system that handled the statistical material. George became deeply immersed in computer programming.

In his depression, George's attention span was short. Correcting an error, in a biology experiment or in an English paper, seemed overwhelming because making a change implied starting over, rethinking the whole, like when a tower of blocks falls down for a child. Programming had a different "feel." The "feel" as he described it was that he "could go into the program and deal with the thing that is wrong with it, deal directly with the rotten part. I could fix up the problems but leave things basically intact." He enjoyed the sense of being able to deal in an isolated way with a specific error and see an immediate result. Moreover, he was able to carry out experiments with his programs that seemed (although sometimes he admitted that this might be an illusion) to provide information about how well things were going. He felt himself to be the recipient of continual feedback on his progress. And he could initiate the process that would get that information back to him. In the course of a few months George started to build on this experience.

First, he was able to use his successes in programming to restore

his confidence that he could finish a task. He completed a series of small programming projects; when each one was done he brought the printout of the program to sessions with his psychotherapist. They were symbols of hope, symbols that he could find a way back. Second, programming was the first thing he had ever done that was not "required" of him. He did it for his own pleasure. He could have easily passed the statistics course by learning a few "cookbook rules" on how to feed data into a preprogrammed package, but instead he turned himself into a programming wizard. He discovered a talent and he found that he could pursue it wholeheartedly without outside pressure. But what is most relevant here is that George took a concept from programming and used it as a metaphor for thinking about his mind, his problems, and their possible solution.

Programs are instructions to a computer that tell it literally what to do, what steps to take, what procedures to follow. Their broad outlines can be planned in advance, but they hardly ever come out "perfect" on a first pass. A detail doesn't work or there can be unforeseen interactions among segments of the program that were designed independently from each other. These are the program's "bugs." Programmers learn to think about what ails their products without recourse to the formula "the program is wrong." The program is basically sound; it simply needs to be debugged. Debugging is the search for errors that can be identified and isolated. And once isolated they can be dealt with in a "local" way.[5]

George began to think about his mind in terms of a program, and of working his way out of his depression in terms of debugging. His whole life had not been bad. The foundation seemed solid.

> When I began psychotherapy, I began to read Freud. I thought that it might help. I read some in high school and it seemed pretty interesting. I think that in terms of all the "Freudian stuff," the basic things, I think I had a very good start. Very good basic programming with my mother and father. But there is a bug. Not really fundamental. I started to feel that my father would be disappointed in me if I didn't become a doctor. I started to feel it because I wanted to be like him. I mean I think he is a really tremendous person. But he never said so. And this past week I called him and asked him straight out and he said that he really didn't feel that way.

George went on to say that he must be stuck in a loop, a vicious programming circle where all paths lead back to the same unproductive starting point. George used the image to get a handle on his experience. It was a place to start talking about the cycle of frustration in which he felt trapped, a frustration born out of misunderstanding and too great a desire to please through emulation.

How far the debugging metaphor can go is another question. In learning situations, the notion can be liberating. It allows you to stop thinking of right or wrong and to start thinking of "fix it." For George it gave a sense of optimism, a belief that once he had identified emulation of his father as a central problem he could get on with the business of living. But the metaphor also has serious deficiencies. The notion that painful emotional states—depression, inability to act, anxiety—are the result of purely local bugs ignores the complex and resistant structures behind the symptom. The "local fix" may work in only a limited way: symptoms may shift or reappear, underlying problems persist. When behavioral therapists "reprogram" one phobia or compulsion, it is sometimes replaced by another.

Psychoanalytic ideas are a powerful language for self-reference, for marking the significant dates, the significant events and relationships in one's life. We live in a "psychoanalytic culture," which has little to do with how many people have been psychoanalyzed, are in therapy, or even have read Freud. A set of concepts that offer guides for what is important in thinking about the self, for what is useful in thinking about personal experiences, has filtered out into the culture as a whole: repression, the unconscious, the superego, the Oedipal struggle with the father. In everyday conversation, when people talk about their problems, they make reference to these.

George, like Dennis and Carla, had stumbled on another language for self-reference, a computational language. They have not picked up their ideas through the diffusion of theories about mind as program. Their ideas have been sparked by interaction with the machine itself. The computer is enough like a mind to make analogies between the self and programs seem plausible.

They are not concerned with whether computers might one day be like people; instead they are struck with the idea that their

minds have something in common with the "mind" of the computer before them. Whether or not computer scientists ever create an artificial intelligence that can think like a person, computers change the way people think—especially about themselves.

PART II

THE NEW COMPUTER CULTURES: THE MECHANIZATION OF THE MIND

believe that they make events happen; they have external locus of control when they tend to see events as "happening to them." Internal locus of control is conceptually closer to hard than to soft. It is also empirically closer. Locus of control tests were administered to the children at Austen and the hards showed an internal and the softs an external locus. See Herman Witkin, *Cognitive Styles in Personal and Cultural Adaptation* (Worcester, Mass.: Clark University Press, 1978); J. B. Rotter, *Social Learning and Clinical Psychology* (New York: Prentice-Hall, 1954); and J. B. Rotter, "Generalized Expectancies for Internal versus External Control of Reinforcement," *Psychological Monographs* 80 (1966). Other dichotomies that suggest themselves for further correlative study include convergent/divergent, verbal/spatial, and "left brain"/"right brain."

The concept of hard and soft had its roots in Papert, Watt, diSessa, and Weir, "Final Report of the Brookline Logo Project." The authors make a distinction between the cognitive styles of planners and tinkerers. In my work, hard and soft refers also to a quality of interaction with the computer and a quality of identification with computational objects.

8. Claude Lévi-Strauss, *The Savage Mind* (Chicago: University of Chicago Press, 1968).
9. David Shapiro, *Neurotic Styles* (New York: Basic Books, 1965), p. 28.
10. *Ibid.*, p. 114.
11. See D. W. Winnicott, *Playing and Reality* (New York: Basic Books, 1971).
12. See Evelyn Fox Keller, "Gender and Science," *Psychoanalysis and Contemporary Thought* 1 (1978), pp. 409–33. My studies of women were deeply influenced by the work of Nancy Chodorow; see *The Reproduction of Mothering: Psychoanalysis and the Sociology of Gender* (Berkeley: University of California Press, 1978) and Carol Gilligan; see *In a Different Voice: Psychological Theory and Women's Development* (Cambridge, Mass.: Harvard University Press, 1982).
13. Keller, "Gender and Science."
14. *Ibid.*, p. 427. In a classic work in the sociology science, Ian Mitroff studied the relationship of Apollo moon scientists to their work. He notes the "intense masculinity" and "aggressiveness" of these scientists: "It is an aggressiveness that not only deeply infuses their relationships with one another, but, as we have seen, their abstract concept of science. . . . They were free and quick in displaying aggressive or harsh emotions; they were far less free, however, in displaying more affective or soft emotions. In this sense they do avoid complex human emotion. They displayed only one half of the sphere of human emotionality and that hemisphere with such an intensity that it tended to obliterate the other." See Ian Mitroff, *The Subjective Side of Science* (New York and Amsterdam: Elsevier Scientific Publishing, 1974), pp. 144–145.
15. Keller, "Women, Science, and Popular Mythology," unpublished manuscript. See also Evelyn Keller, *A Feeling for the Organism: The Life and Work of Barbara McClintock* (San Francisco: W. H. Freeman, 1983).
16. Keller, "Women, Science, and Popular Mythology."
17. Winnicott, *Playing and Reality*, p. 2.
18. *Ibid.*, p. 5.
19. Mitroff's study of the Apollo moon scientists showed that although the scientists were "masculine" in their aggressivity and judged affective and interpersonal dimensions as irrelevant to their concept of the "Ideal Scientist," they also "insisted that it was not an either/or between analysis and speculation, rationality and intuition, and so on." *The Subjective Side of Science*, p. 143. Mitroff takes up this theme in "Passionate Scientists," *Society* (September–October 1976), pp. 51–57.
20. Philip J. Davis and Reuben Hersch write about a session with an interactive computer graphics system that is reminiscent of Ronnie's experience of mathematics as felt intuition. The authors describe the difficulties of imagining a "hypercube," an object that exists in four-dimensional space. A movie that shows the hypercube in motion leaves them disappointed; manipulating the cube in an interactive computer environment has an altogether different effect: "I tried turning the hypercube around, moving it away, bringing it up close, turning it around the other way. Suddenly I could feel it! The hypercube had leaped into palpable reality, as I learned how to manipulate it, feeling in my fingertips the power to change what I saw and change it back again. The active control at the computer console created a union of kinesthetics and visual thinking which brought the hypercube up to the level of intuitive understanding." See Philip J. Davis and Reuben Hersch, *The Mathematical Experience* (Boston: Houghton Mifflin, 1981), p. 404.
21. Alan Wheelis makes the following observation about the changes in psychiatric symptoms: "Many elements of motivation which were commonly repressed in the nineteenth century are now rarely repressed. The evidence concerning aggression is equivocal, but there is no doubt about the liberation of sexuality. The diminished incidence of hysteria is in line with these observations, and is similarly a matter of fact. Hysteria depends upon repression, and is becoming rare; character disorders reflect warped ego-functioning, and are becoming common. As clear-cut symptom neuroses disappear, vague conditions of aimlessness and futility become prevalent." See Alan Wheelis, *The Quest for Identity* (New York: Norton, 1958), p. 128. On the relationship between culture and symptom, see also Ilza Veith, *Hysteria: The History of a Disease* (Chicago: University of Chicago Press, 1965), and Christopher Lasch, *The Culture of Narcissism* (New York: Norton, 1979), which takes the shift in styles of suffering as a central premise. On schizoid process, there is of course a large psychiatric and psychoanalytic literature. For an introduction to some major positions, see Herbert A. Rosenfield, *Psychotic States* (New York: International Universities Press, 1965); Melanie Klein, *Contributions to Psychoanalysis* (New York: McGraw-Hill, 1964); Otto Kernberg, *Borderline Conditions and Pathological Narcissism* (New York: Jason Aronson, 1975).

Chapter 4: Adolescence and Identity

1. In discussing children at play Erik Erikson says: "It is true that the content of individual play often proves to be the infantile way of thinking over difficult experiences and of *restoring a sense of mastery*, comparable to the way in which we repeat, in ruminations and in endless talk, in daydreams and in dreams

during sleep, experiences that have been too much for us." See Erik Erikson, "Identity and the Life Cycle," *Psychological Issues* 1 (1959), p. 85.

2. *Ibid.*, especially pp. 101–64. For a discussion of adolescents somewhat older than those in this chapter, one where the focus is on using politics (rather than computation) to think through questions about the self, see Kenneth Keniston, *The Young Radicals: Notes on Committed Youth* (New York: Harcourt, Brace and World, 1960). See also Kenneth Keniston, *The Uncommitted: Alienated Youth in American Society* (New York: Delta, 1967), especially for the discussion of what Keniston calls "the technological ego."

   In this chapter I discuss people's use of theories to help them think through their experience under the rubric of identity. John Flavell has used the term "metacognition" to refer to the ideas people have about their own thinking, the knowledge they have of how they know. See John H. Flavell, "Metacognition and Cognitive Monitoring: A New Era of Psychological Inquiry," *American Psychologist* 34 (1979), pp. 906–11. The Piagetan school relates the ability to think about one's thinking to the emergence of the formal stage. See, for example, Barbel Inhelder and Jean Piaget, *The Growth of Logical Thinking from Childhood to Adolescence* (New York: Basic Books, 1958).
3. For a description of Turtle Geometry see Seymour Papert, *Mindstorms: Children, Computers, and Powerful Ideas* (New York: Basic Books, 1980), and Harold Abelson and Andrea diSessa, *Turtle Geometry: Computation as a Medium for Exploring Mathematics* (Cambridge, Mass.: MIT Press, 1982).
4. On ego psychology and the American neo-Freudians, see Chapter 8, note 15.
5. John Seeley Brown and Richard R. Burton write about debugging strategies in learning as "paving the way for students to see their own faulty behavior not as a sign of their stupidity, but as a source of data from which they can understand their own errors." Brown and Burton also speculate on possible deeper psychological implications of debugging metaphors. See John Seeley Brown and Richard R. Burton, "Diagnostic Models for Procedural Bugs in Basic Mathematical Skills," *Cognitive Science* 2 (1978), pp. 155–92.

Chapter 5: Personal Computers with Personal Meanings

1. The early hobbyist movement is best seen as a technical subculture. The literature on the sociology of subcultures offers an approach to its study and is also useful for comparative purposes. On subcultures see Howard Becker, *The Outsiders: Studies in the Sociology of Deviance* (Glencoe: Free Press, 1963), and David Arnold, ed., *The Sociology of Subcultures* (Berkeley: Glendessary Press, 1970). Paul Willis, *Profane Culture* (Berkeley: University of California Press, 1981), and Hunter Thompson, *Hell's Angels* (New York: Ballantine Books, 1967), deal with subcultures around a technological object, the motorbike. On machines as cultural objects, see also Robert Pirsig, *Zen and the Art of Motorcycle Maintenance* (New York: William Morrow, 1975); Tracy Kidder, *The Soul of a New Machine* (Boston: Little, Brown, 1982); and Frederick P. Brooks, Jr., *The Mythical Man-Month: Essays on Software Engineering* (Reading, Mass.: Addison-Wesley, 1979).

   The concept of computing worlds as cultural worlds is taken up in Rob Kling and Elihu Gerson, "Patterns of Segmentation and Communication in the Computer World," *Symbolic Interaction* 1 (1978), pp. 24–43; Rob Kling and Walt Scacchi, "Computing as Social Action: The Social Dynamics of Computing in Complex Organizations," *Advances in Computers*, Vol. 19 (New York: Academic Press, 1980), pp. 150–327; Lee S. Sproull, Sara Kiesler, and David Zubrow, "Encountering an Alien Culture," unpublished manuscript (August 1983); Shoshanna Zuboff, "New Worlds of Computer Mediated Work," *Harvard Business Review* 60 (1982), pp. 142–52; Sherry Turkle, "Computer as Rorschach," *Society* 17 (1980), pp. 15–24; and Sherry Turkle, "The Subjective Computer: A Study in the Psychology of Personal Computation," *Social Studies of Science* 12 (1982) pp. 173–205. Some of the material on first-generation users that appears in this chapter was presented at the 1980 meetings of the International Federation of Information Processors; see Sherry Turkle, "Personal Computers and Personal Meanings," in S. H. Lavington, ed., *Information Processing 80* (New York and Amsterdam: North Holland, 1980).
2. See Karl Marx, "Machinery and Modern Industry," in Robert C. Tucker, ed., *The Marx-Engels Reader* (New York: Norton, 1978), pp. 291ff.
3. This chapter touches on the question of computers and alienation through the experience of programmers. On this subject, see Philip Kraft, *Programmers and Managers: The Routinization of Computer Programming in the United States* (Berlin, Heidelberg, and New York: Springer-Verlag, 1977). But the issue of computers and alienation goes beyond changes in the work life of programmers. See, for example, Thomas B. Sheridan, "Computer Control and Human Alienation," *Technology Review* 83,1 (October 1980), pp. 60–67; David Noble, "Social Choice in Machine Design: The Case of Automatically Controlled Machine Tools, and a Challenge for Labor," *Politics and Society* 8 (1978), pp. 313–47; Harley Shaiken, *Work Crisis: Automation and Work in the Computer Age* (New York: Holt, Rinehart, and Winston, forthcoming); and David Noble, *Forces of Production* (New York: Knopf, forthcoming).
4. The political charge on the early personal computer movement was only one aspect of its cultural life. Its strongest roots as an organized movement were in the California Bay Area. There it grew up with role-playing fantasy games, with holistic health, and with humanistic psychology. Many of these themes emerged in the discourse of early personal computer utopians, in the early literature of the hobbyist movement, and in the proceedings of the first generation of personal computer "Faires," sponsored by the organizers of the San Francisco Homebrew Computer Club.
5. The distinction between risk and reassurance brings us into a discussion of the psychology of programming for adults. On this subject see Gerald M. Weinberg, *The Psychology of Computer Programming* (New York: Von Nostrand Reinhold, 1971). For more recent work, see Beau Shiel, "The Psychological Study of Programming," *ACM Computing Surveys* 13,1 (1981), pp. 101–41, and Richard E. Mayer, "The Psychology of How Novices Learn Computer Programming, *ACM Computing Surveys* 13,1 (1981), pp. 121–41. Mayer's study is part of a growing literature on novice programming. See also E.