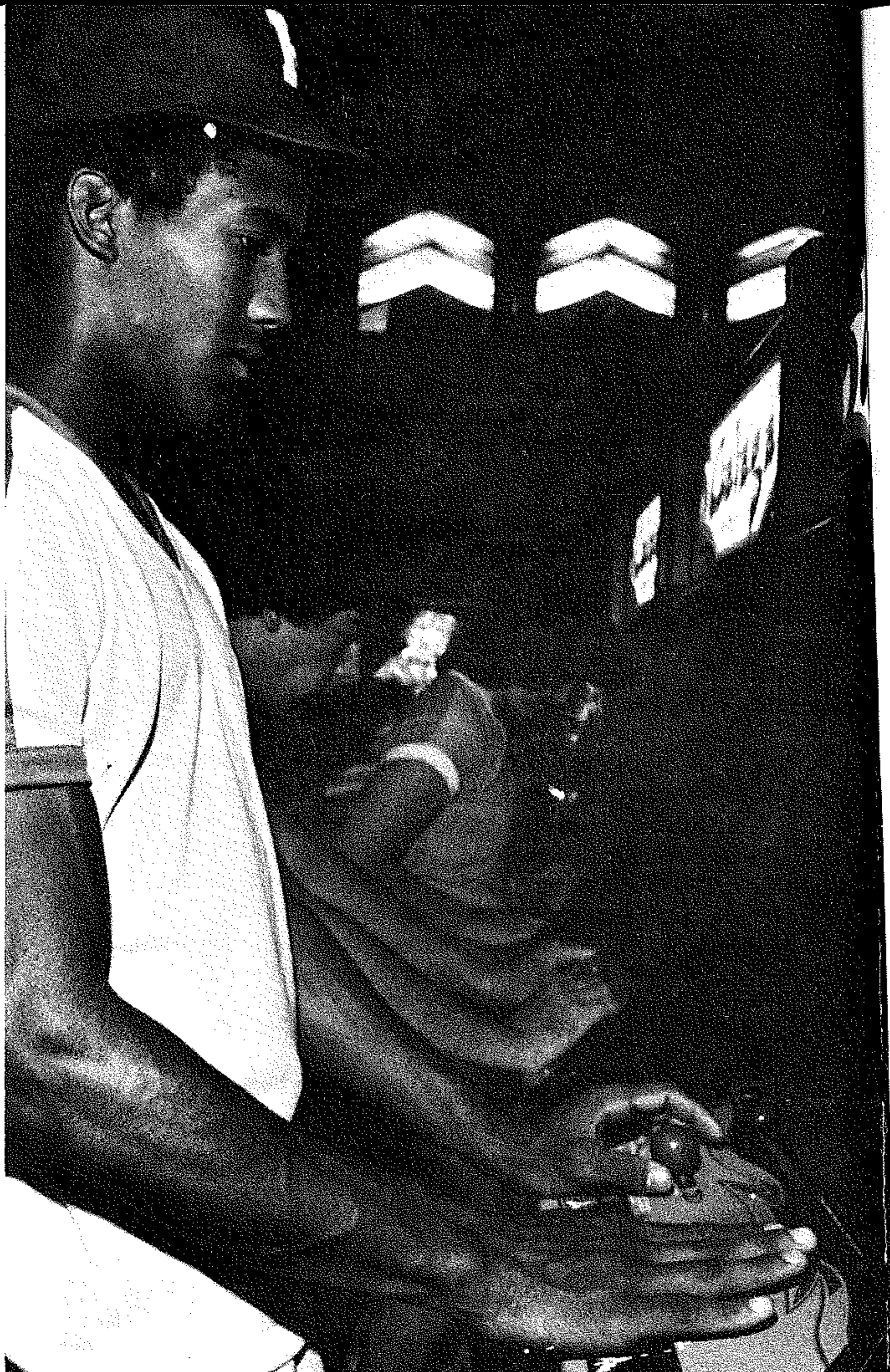


7 / Video Games

In Glendale, California, a suburb of Los Angeles, I witnessed a scene that has recently been repeated in many parts of the United States. The City Council was hearing testimony about a proposed ordinance against video game arcades. These are establishments similar to old-fashioned pool halls, but featuring action games played on TV screens. A mother of two teenagers got up and complained that children use half their lunch money to play the games. The president of the Glendale Council of Parent-Teacher Associations pursued the same theme. In the most eloquent part of her emotional plea, the first speaker said, "It reminds me of smoking. Smoking doesn't do us any bit of good. We don't depend on it to live. And yet it's addictive and it's expensive, and this is what these games are . . . There are kids in there that really cannot stay away from them."

Let us go through this list of complaints and see what is known about each of them. First, are video games addictive? J. David Brooks interviewed 973 young people in video arcades in southern California. While he found some who felt compelled to play, they were in a minority. In fact, about half the kids were playing games less than half the time they were in the arcade. The rest of the time they were socializing. The arcades, like the ice cream parlor of yore, were providing a social gathering place, more than a place for compulsive play.[1] In terms of management and physical environment, however, some arcades, unlike the old-fashioned ice cream parlor, are not healthy places for young people to gather. We should be concerned about regulating this aspect of the arcades in our communities.

In northern California, Edna Mitchell had twenty families keep diaries for one week each month for five months after getting a video game set. If the games were addictive (whatever that means), this should have been reflected in long hours spent playing, particularly since the games could be played at home without spending quarters. However, Mitchell found that the game sets were used an average of 42 minutes a day per *family*—and many families included more than one child, as well as parents who played.[2] This is hardly an addictive pattern, especially compared with the amount of time spent watching television. According to even the most conservative estimate, preschool children in the United States spend two and a half hours a day with the television set on.[3]

Second, how expensive are video games? Eighty percent of the kids interviewed by Brooks spent five dollars or less per week, the price of a movie. Only 7 percent spent lunch money. In fact, because they are better players, children put less money in the machines than adults do. In the world of video arcade games, skill is rewarded with play time, and a good player can play for an hour and a half on a quarter.

Finally, do the games "do us any bit of good"? The way to answer this question is to discover what skills are required by the games and what skills, therefore, the players might be developing. Here, I shall not limit myself to arcade games, but will also discuss other types of games that are available for home computers, as well

as games that could become available in the future.

Thus, the available evidence indicates that video games are, in terms of time spent, much less addictive than television. Nor are they, in comparison with other entertainment, particularly expensive. Yet they are undeniably attractive, and there is something about that attraction that disturbs people. Before deciding that video games are bad simply because they are attractive, it makes sense to consider what features make them so attractive.

THE ATTRACTION OF VIDEO GAMES: THE TV CONNECTION

What makes computer games able to compete so successfully with the things children did before the games? As is by now common knowledge, television has in recent years been children's major waking activity. Video games have been dubbed the "marriage of television and the computer."[4] At the most obvious level, what television and computers have in common is a television screen, a cathode ray tube. Both use the screen to present visual motion. We saw in Chapter 3 that children with a television background develop a preference for dynamic visual imagery. And we learned that visual action is an important factor in attracting the attention of young children to the television screen. The popular arcade games involve a tremendous amount of visual action, and this may be one source of their appeal.

Thomas Malone analyzed the appeal of computer games, starting with a survey of the preferences of children who had become familiar with a wide variety of computer games in computer classes at a private elementary school in Palo Alto, California. The children ranged in age from about five to thirteen, and the games spanned the range from arcade games to simulations to adventure games to learning games. Visual elements were important in the games' popularity: graphics games such as Petball (computer pinball) and Snake 2 (two players controlling motion and shooting of snakes) were more popular than word games such as Eliza (conversation with a simulated psychiatrist) and Gold (a fill-in-the-blanks story about Goldilocks). A clue as to the attraction of *moving* visual images comes from the fact that the three most unpopular graphics games—Stars, Snoopy, and Draw—have no animation at all or much less animation than more popular games.[5]

If moving visual imagery is important in the popularity of video games, then perhaps the visual skills developed through watching television (documented in Chapters 2 and 3) are the reason children of the television generation show so much talent with the games. As discussed in Chapter 3, children also pick up and use more information about action from seeing action on television than from hearing action described (as in radio) or from verbal description combined with static images (as in picture books). Children who watch a lot of television get a great deal of experience in taking in information about action—more so than did generations socialized with the verbal media of print and radio. Perhaps this experience with the moving visual images of television leads to skills that can be applied to playing video games. I shall return to this possibility later when I analyze the skill requirements of the various games.

Video games have the dynamic visual element of television, but they are also interactive. What happens on the screen is not entirely determined by the computer; it is also very much influenced by the player's actions. A straightforward example is the original commercial computer game, Pong, an electronic ping-pong game. Like other popular computer games, Pong involves moving imagery, as television does. But instead of merely watching an animated ping-pong match, as one might

watch Wimbledon on television, the player actually plays the match, and thus has a part in creating the video display.

It is possible that, before the advent of video games, a generation brought up on film and television was in a bind: the most active medium of expression, writing, lacked the quality of visual dynamism. Television had dynamism, but could not be affected by the viewer. Video games are the first medium to combine visual dynamism with an active participatory role for the child.

What evidence exists that a desire for interaction (in contrast to mere observation) is an important part of the appeal of computer games? No systematic research exists on this subject, to my knowledge, but studies have been done in other settings in which there are both things to observe and things to interact with, such as science museums, field trips, zoos, and aquariums. These studies show a predictable pattern: children are attracted to activities that let them become personally involved. In the zoo, for example, they prefer pigeons and squirrels, with whom they can interact, to the more exotic animals isolated behind bars.[6]

To get an idea of whether this finding applied to video games and of whether the games were displacing the one-way medium of television, I asked four children, ranging in age from eight to fourteen, what they used to do with the time they now spend on video games. In answer, three of the four mentioned television. Two of those three mentioned only television, the third a number of other activities, including playing games with friends. Information from my tiny sample is confirmed by Mitchell's larger study of families with home video game sets; the children in her sample also watched less television after getting their game machines.

I also asked my four interviewees which they liked better, TV or video games, and why. They were unanimous in preferring the games to television. They were also unanimous about the reason: active control. The meaning of control was both very concrete and very conscious. One nine-year-old girl said, "In TV, if you want to make someone die, you can't. In Pac-Man, if you want to run into a ghost you can." Another girl of the same age said, "On TV you can't say 'shoot now' or, with Popeye, 'eat your spinach now.' " She went on to say she would get frustrated sometimes watching Popeye and wanting him to eat his spinach at a certain time when he didn't.

OTHER REASONS FOR THE APPEAL OF VIDEO GAMES

One of the children I interviewed mentioned playing games with friends as an activity she used to do more before video games. If video games are in fact displacing more traditional games as well as television, then the question arises, what are the elements that make computer games more attractive than other sorts of games? Perhaps the most obvious and important comparison is between computer games and the indoor games that existed before them: board games like checkers and monopoly, card games, tic-tac-toe. (Even though these games now exist in computer form, they were not, of course, developed for the computer medium.)

Malone found that the presence of a goal was the single most important factor in determining the popularity of games. This is a quality that arcade games share with all true games. Other qualities he found to enhance the popularity of computer games were automatic scorekeeping, audio effects, randomness (the operation of chance), and the importance of speed. Of these qualities, randomness (as in games controlled by dice) and speed (as in double solitaire) are part of some conventional games. The others, automatic scorekeeping and audio effects, are essentially impossible without electronics.

THE PROBLEM OF VIOLENCE

If dynamic visual graphics, sound effects, and automatic scorekeeping are the features that account for the popularity of video games, why are parents so worried? All of these features seem quite innocent. But another source of concern is that the games available in arcades have, almost without exception, themes of physical aggression. Daniel Anderson points out the parallels with other media: "Video games have violent content; TV has violent content; comic books had violent content; movies had (have) violent content. There has long been the belief that violent content may teach violent behavior. And yet again our society finds a new medium in which to present that content, and yet again the demand is nearly insatiable."[7] And there is evidence that violent video games breed violent behavior, just as violent television shows do: both Space Invaders and Roadrunner have been found to raise the level of aggressive play (and lower the level of prosocial play) in five-year-old children; interestingly enough, they do so to the same degree.[8]

The effects of video violence are less simple, however, than they at first appeared. The same group of researchers who found these negative effects of Roadrunner and Space Invaders have more recently found that two-player aggressive video games, whether cooperative or competitive, reduce the level of aggression in children's play. (In this study, both the competitive and the cooperative games were violent. It is notable that playing the violent but cooperative game neither decreased nor increased subsequent cooperative behavior.)[9]

It may be that the most harmful aspect of the violent video games is that they are solitary in nature. A two-person aggressive game (video boxing, in this study) seems to provide a cathartic or releasing effect for aggression, while a solitary aggressive game (such as Space Invaders) may stimulate further aggression. Perhaps the effects of television in stimulating aggression will also be found to stem partly from the fact that TV viewing typically involves little social interaction.

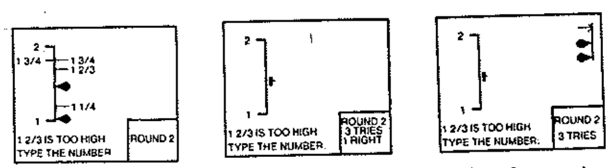
With or without social interaction, violent content is certainly not a necessary feature of video games. It does not even seem necessary to the games' popularity. The most popular game in Malone's survey was Petball, a version of computer pinball, a game that has no obvious aggression in it at all. (Computer pinball does, however, have all of the qualities that distinguish computer games from conventional indoor games.) Similarly, Breakout, the number three game, has a relatively mild aggressive theme (balls knocking a brick wall down); it was more popular than more violent games such as Mission, which involves bombing submarines, and Star Wars, which consists of shooting at Darth Vader's ship.

These rankings indicate that the popularity of computer games does not depend on violence, but on other features that can be used with both violent and nonviolent themes. Ironically enough, the same message comes from recent television research: action, not violence in itself, is what attracts young children to the screen.[10] It follows that programs can present many forms of action other than violent action without sacrificing popularity. There is a clear message for the manufacturers of video games: they should forsake violence because of its undesirable social consequences; they can use other action themes without sacrificing the popularity of the games.

Indeed, some children are actually alienated from arcade games *because* of the aggressive themes. Malone

analyzed the appeal of Darts, a game designed to teach fractions to elementary school children. The left side of figure 4 shows the basic display on the screen. The child must try to guess the position of the balloons by typing in a mixed number (whole number and fraction) specifying each balloon's position on the number line. If the answer is right, an arrow comes shooting across the screen and pops the balloon. If it is wrong, the arrow shoots across to the number line and remains there as permanent feedback about the error. Thus, the game has a mildly aggressive fantasy theme. Malone created several versions of this game, each one lacking one or more features of the original. Two such versions are shown in the middle and right-hand sides of figure 4. Adding the aggressive fantasy (right side of illustration) to a version without a theme (middle of illustration) increased its popularity among boys but decreased it among girls. In short, the aggressive fantasy was a turn-on for the boys but a turn-off for the girls.

This sex difference has important social implications. In the crowds around game machines, boys far outnumber girls. This may be a serious problem, because it appears that games are the entry point into the world of computers for most children. If children's interest in computers begins with games, then the fact that the most common computer games involve aggressive and violent fantasy themes may have the effect of turning



4. *Three Darts displays. The basic game is on the left. The version on the right differs from the one in the middle in including an element of aggressive fantasy. (Adapted from Malone, "Toward a Theory of Intrinsically Motivating Instruction.")*

many girls away from computers in general. This would be especially unfortunate in a field that is still in rapid growth and therefore should be especially promising for women. There is an urgent need for widely available video games that make as firm contact with the fantasy life of the typical girl as with that of the typical boy. (There does seem to be a trend in this direction with the addition to arcades of less violent games, such as Donkey Kong, that are more popular with girls.)[11]

Nothing intrinsic to video games requires one theme rather than another. The same formal features can be embodied in a myriad of themes. For example, as Tom Malone pointed out to me, the aggressive game of Space Invaders is formally similar to the basically nonviolent game of Breakout. Children's Computer Workshop, a division of Children's Television Workshop, is creating educational software with action game formats and nonviolent themes. One that has been developed is Taxi, a game where the goal is to drive a passenger through a city as quickly and efficiently as possible, overcoming obstacles on the way. Taxi has the action and high-speed appeal of an arcade game without the violent content.

Another important point about this and other games being developed by the Workshop is that, besides being nonviolent, they can be played cooperatively with another person. Leona Schauble, the director of Children's Computer Workshop, reports that, in play tests of Taxi, children became increasingly cooperative as they became experienced with the game and learned that cooperation paid off. Like television, the medium of video games is in itself neutral with respect to social values. Nevertheless, the choice of a game design can have an important influence on children's behavior.

THE SKILLS OF VIDEO GAMES

Another concern about video games is that they are merely sensorimotor games of eye-hand coordination and that they are therefore mindless. I take issue with that proposition on two grounds. First, sensorimotor skills such as eye-hand coordination are important in themselves. They are useful in many occupations, as well as in everyday life, and according to Piaget's theory they are the foundation for later stages of cognitive development.

Second, it turns out that there is much more to the games than eye-hand coordination. In fact not only are they complex, they incorporate types of complexity that are impossible with conventional games. I am convinced that many of the people who criticize the games would not be able to play them themselves, and that their problems would be more than just those of eye-hand coordination. Let me illustrate with the game of Pac-Man.

Pac-Man. When I played Pac-Man for the first time, I had watched it played quite a number of times, and I assumed I would be able to play it myself, even if not with consummate skill. But when I started, I found I could not even distinguish Pac-Man, whom I was supposed to control, from the other blobs on the screen! A little girl of about five had to explain the game to me.

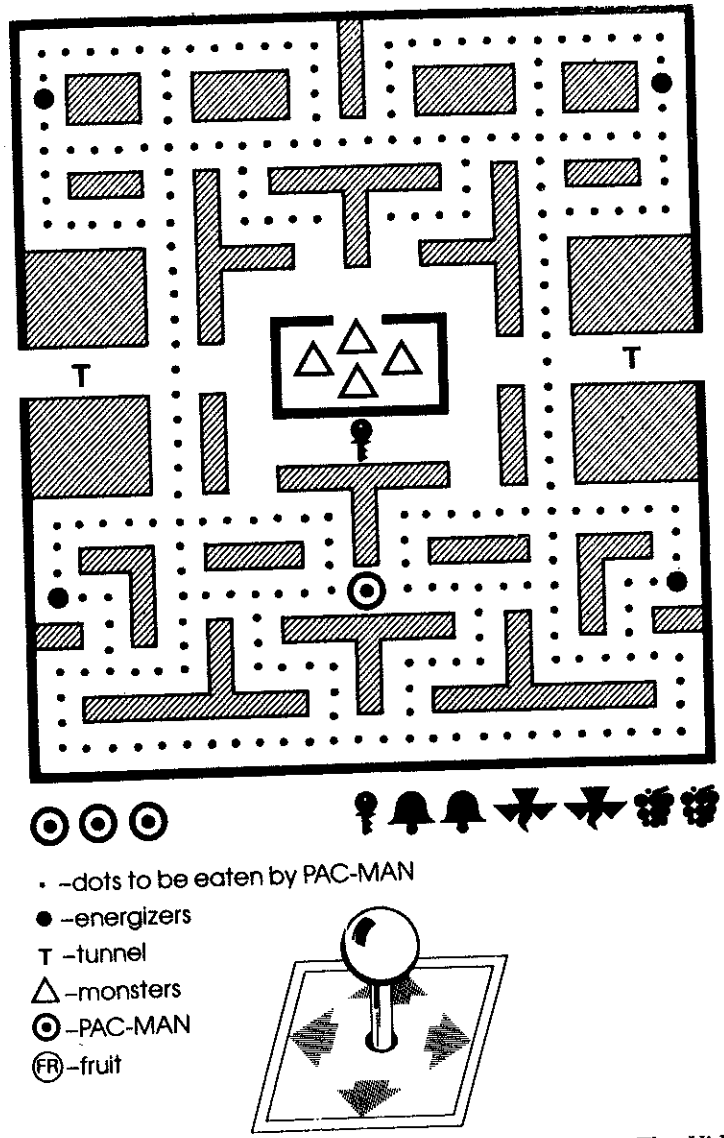
On a later play, I decided that I had so much trouble finding Pac-Man that first time because when Pac-Man first appears in the complex array of blobs and dots he does not have a wedged-shaped piece cut out of him; he is simply a yellow circle. I think that, as a person socialized into the world of static visual information, I made the unconscious assumption that Pac-Man would not change visual form. My hypothesis is that children socialized with television and film are more used to dealing with dynamic visual change and are less likely to make such a limiting assumption.

After trying the game again, I thought I had the basics. True, my score was not very good, but I assumed that was because my reflexes were not fast and I lacked sensorimotor practice. A few months later I bought *The Video Master's Guide to Pac-Man* in the hopes of finding out something about the psychology of video games. I was amazed to discover that I had missed all but the most obvious aspects of the game. Pac-Man is much more complex than I had imagined. Furthermore, most of the complexities are of a sort that cannot be incorporated in conventional board games such as checkers, chess, or monopoly. True, Pac-Man is an action game and therefore requires a certain amount of eye-hand coordination, but that is only the beginning of the game, not the end.

I am convinced that the people who criticize video games do not understand what the games involve. As I found out to my chagrin, a game like Pac-Man is not something one can pick up by standing around a machine for a few minutes, watching someone else play. I will describe Pac-Man in some detail in order to analyze the learning and cognitive processes that one must go through to become a skilled player.

When a player inserts a quarter into the Pac-Man machine, a maze filled with white dots appears on the screen (see figure 5). In the middle of the lower half of the screen appears Pac-Man, a yellow circle. The player uses the control stick to guide Pac-Man (now with open wedge-shaped mouth) through the maze. As Pac-Man encounters each white dot he "eats" it and it disappears; the object is to clear the maze of dots by having Pac-Man eat them all.

Thus far, the game seems simple enough, and it can be played at the level of this basic description. This was



5. *Pac-Man game board layout.* (*From Sykora and Birkner,* The Video Master's Guide to Pac-Man.)

probably about the level at which I played it at first. As in all games, however, there are obstacles. In Pac-Man the obstacles are not physical barriers but four monsters or ghosts, which chase Pac-Man through the maze and eat him if they catch him. Each monster has its own characteristic behavior. For example, the red monster, Shadow, is the most aggressive. The pink one, Speedy, the fastest monster, usually does not chase Pac-Man for very long at one time but does tend to come after him fairly often. The third monster, Pokey, will not cross any of the energizers. (The energizers are four large blinking dots. Each time Pac-Man eats an energizer, he is awarded fifty points and for a few seconds he becomes more powerful than the monsters, so that he can chase and eat them. For each monster he devours he gets more points.)[12]

This situation may sound a bit like chess, in which each piece has its own allowed behavior. But in Pac-Man, as in other video games, no one tells the player the rules governing each monster's behavior; these rules must be induced from observation. In this way, Pac-Man is more like life than like chess. The player must not only overcome the obstacles but must also perform the inductive task of figuring out the nature of the obstacles. The behavior patterns the player must discover lie in the game's computer program. Rick Sinatra, a computer programmer, may have had this aspect of the games in mind when he remarked: "Video games are revolutionary; they are the beginnings of human interaction with artificial intelligence."

As another obvious source of complexity, the arcade-style video games, unlike board games, have real-time movement in them. In chess or checkers the player moves pieces around a board, but the movement itself is not part of the game. Timing does not count. In Pac-Man, by contrast, quickness is vital as the player tries to keep Pac-Man away from the monsters.

Further complexity comes from the nature of the maze. It looks simple; there are no blind alleys or cul-de-sacs, complications of the conventional precomputer maze. However, the Pac-Man maze has complications of a different sort, which would not be possible without computer technology. The possibilities for movement are not uniform throughout the maze, even though the terrain all looks the same. The relative speeds of the monsters and Pac-Man are different in different parts of the maze, so that the monsters can overtake Pac-Man in the labyrinthine parts but not on the straightaways. In addition, there are some areas of the maze where Pac-Man can enter much more easily than the monsters and which therefore provide Pac-Man with relative safety. Such movement-related constraints simply do not exist in conventional games. These invisible complexities are programmed into the game's microcomputer.

Note that, as with the behavior of the monsters, the player does not know these spatial contingencies before starting to play. Whereas a conventional board game gives you all the rules, Pac-Man and other arcade-type computer games require the player to induce the rules from observation. Computer games therefore call up inductive skills much more than did games of the pre-computer era.

Without this inductive effort, the games seem to be something like gambling games, in which a player deals with primarily random events. My son, Matthew, said of Pac-Man, "At first it was thought to be incredibly hard. Then people realized it wasn't random and figured out the patterns." Matthew also confirmed the existence of the inductive process: by watching others and then playing yourself, he said, "You just learn what things have what characteristics and what they do." An idea of the rate of learning is revealed in a saying among players: "You spend fifteen or twenty dollars on a game. Then you can play an hour and a half for a quarter." Part of the excitement of the games surely must lie in this process of transforming randomness into order through induction. (Adults may not learn as quickly; a bartender who had games in his bar estimated that it typically cost one of his customers a hundred dollars to get his name in the top five.)

Pac-Man also illustrates another cognitive requirement of skillful video game playing: parallel processing. As discussed in Chapter 3, this term refers to taking in information from several sources simultaneously; it contrasts with serial processing, in which the mind takes in information from one source at a time. In Pac-Man, to be a good player, you must simultaneously keep track of Pac-Man, the four monsters, where you are in the maze, and the four energizers. Many other games have even more information sources that must be dealt with simultaneously.

Here the skills and habits developed by watching much television may be very useful. Pictorial images in general tend to elicit parallel processing,[13] while verbal media, because of the sequential nature of language (you read or hear one word at a time), tend to elicit serial processing. In television there are frequently several things happening on the screen simultaneously. In Chapter 2 I gave an example from *Hill Street Blues* of how plot development can use this formal characteristic of the medium; Robert Altman's film *Nashville* provides a similar example. Consequently, a child whose main media background was television, rather than print or radio, could be more prepared for the parallel processing demanded by skillful video game playing.

Pac-Man embodies another cognitive complexity that

was impossible in precomputer games: the interaction of two elements yields results that could not be predicted from either one separately. Thus, if you watched Pac-Man's behavior alone, you could not discover the special qualities of different parts of the maze. Nor could you by watching the monsters' behavior alone. Even inspection of the maze itself gives no clue. Only by watching the monsters interacting with Pac-Man in different parts of the maze can you detect the dynamic qualities of the maze.

This quality of interacting dynamic variables characterizes just about all computer action games. In fact, it exists in about the simplest form possible in Pac-Man. This simplicity is handy for getting across the concept of interacting variables to people who may not be familiar with computer games, but it hardly scratches the surface of the cognitive complexity that expert players of the more difficult games (for example, Defender) have to deal with.

Tranquility Base. Let me give an example of complex interacting dynamic variables from an action game that has more educational content. The game, called Tranquility Base, is similar to Moon Lander, a computer game found in a number of children's museums and science centers around the United States. The object of the game is to land a space ship without crashing it. There are six basic variables involved: altitude, vertical speed, horizontal speed, direction, amount of fuel, and terrain (the same as horizontal location). The player controls thrust (acceleration) and horizontal direction. Each of the variables interacts with the others in complex ways. In order to land the spaceship safely, the player must take account of the variables not only one at a time but also as they influence one another. As I tried to learn the game, I found myself wanting to deal with one variable at a time. When that proved impossible, I tried dealing with them simultaneously, but as independent, rather than interacting, variables. That was no more successful. I worked for over an hour without making one successful landing. Matthew, who had taught me the game, strategy as well as basics, was frustrated with me. He could not understand why I was having so much trouble. Clearly, the strategy of integrating the interacting variables had become second nature to him. This may well be an important skill that video players are acquiring through practice with the games.

Experimental work confirms that games that require the player to induce the relations among multiple interacting variables are difficult for many people. Learning to play this type of game, furthermore, brings out important skills such as flexibility and an orientation toward independent achievement.[14] These skills are not called into play either by simpler games in which the variables do not interact or by games in which the player is told all the rules in advance. This is, I think, an important finding. Learning to deal with multiple interacting variables is a significant accomplishment because the world is not a simple system, but rather many complex systems of multiple interacting factors. But how much transfer can we expect from video games to other domains of knowledge and life?

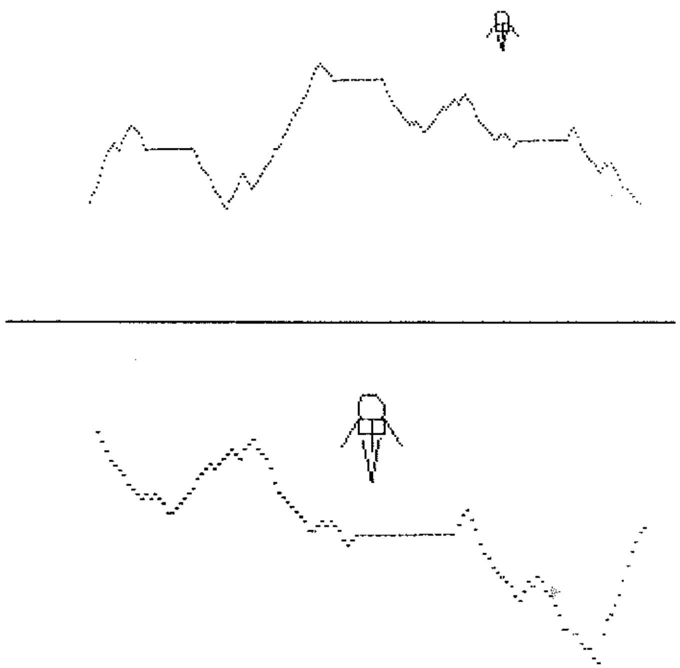
The issue of transfer. Such transfer from the games to other domains cannot be taken for granted; it is far from automatic. As we saw in Chapter 6 with the example of literacy, transfer from a medium to a skill is not just a question of basic knowledge of the medium, but depends on how the medium is used.

Transfer of concepts to a new domain often seems to require their verbal formulation; yet the knowledge gained in playing video games is more than likely nonverbal. We saw earlier that verbal explanation is fostered by the dialogue between teacher and student that typically goes on in school. The transfer and generalization of the formal knowledge gained in playing video games may therefore depend on bringing the games into the school, not necessarily to play them, but to make them an object of study and discussion. An example of this will be presented in Chapter 9.

Spatial skills. Spatial skills are another area of cognitive skills that many computer games require and therefore must promote as players become more skilled. Michael Williams first suggested this idea to me, using the example of Star Raiders. Star Raiders presents three-dimensional information in two dimensions, using conventions of perspective. Thus, in order to play the game well, the player must be skilled at interpreting these conventions. This skill is required by a number of popular games besides Star Raiders, such as Zaxxon.

Many computer games require the ability to coordinate visual information coming from multiple perspectives. This is a skill emphasized in Piaget's account of intellectual development. For example, Tranquility Base involves a very simple coordination of perspectives (see figure 6). As the game begins, the player sees a long view of the space ship and the terrain where it is to land (top of illustration). As the ship gets closer to the ground, the view shifts to a close-up of the particular section of terrain that has been chosen for landing (bottom of illustration). It is a bit like what a pilot would see as a plane (or spaceship) approached the earth.

Castle Wolfenstein is a game for home computers that involves a more complex coordination of perspectives. It is a chase game with an anti-Nazi theme that takes place in a series of mazes. Although the mazes are in two dimensions, they are meant to be part of a three-dimensional prison. The storeys of the prison are linked by visible stairs, whose position serves as the visual cue for coordinating the individual mazes into a three-di-



6. *Two screens from Tranquility Base: top, long shot; bottom, close-up view.*

mensional layout. In addition, each storey consists of more than one maze. Parts of a single storey are linked by doors, which, like the stairs, serve as cues for integrating individual mazes into the layout of a given storey.

When Matthew taught me how to play this game, I completely missed the aspect of spatial integration. I treated the mazes as if they were independent. I was totally unaware that the mazes were linked in the third dimension through stairs. I even missed the connections between mazes on the same level and did not realize that to leave a maze by the same door by which I entered was to go backward to an earlier maze instead of advancing to a new one. Matthew commented, "Most peo-

ple realize *that* even if they are not paying attention." Apparently, the ability to integrate different spatial perspectives has become automatic in him, but not in me. This anecdote cannot tell us anything about what caused the difference, whether it is the male's greater spatial ability, practice in playing the games at a relatively young age, familiarity with particular game formats, a foundation of visual skills developed through watching television, or all of these together. But it does indicate that spatial integrative skills are involved in playing the game and that such skills cannot be taken for granted.

Recall from Chapter 2 that the ability to coordinate information from more than one visual perspective is one of the skills that Israeli children developed through watching *Sesame Street*. Perhaps this skill, first developed through watching television, is later helpful to a child playing a video game such as Castle Wolfenstein.

The suspicion that visual-spatial skills could be useful with and developed by video games was reinforced in my mind when I noticed that almost every child at the computer camp Matthew attended in the summer of 1981 came equipped with the Rubik's cube. Some of the campers had computer experience; some did not. But virtually all were experienced video game players. Not only did they have cubes, as many children did at that time, but the majority of them could solve the cube, some with amazing speed. (There were regular contests, not to see *if* you could do it, but how fast!) It seemed to me that this group of video game aficionados had more interest and skill with the cube than would be found in children with no experience with video games. My hypothesis is that Rubik's cube and video games demand and develop some of the same visual-spatial skills.

The culture gap was impressed upon me when I found that I not only was unable to do the cube but also could not understand my son's patient explanation, even accompanied by demonstration. The very terminology and frame of reference made no contact with anything familiar to me. It was as if he were speaking a foreign language. Clearly, I lacked some sort of spatial conceptualization required for the cube. Perhaps this lack of spatial skills is one element in my great difficulty with video games.

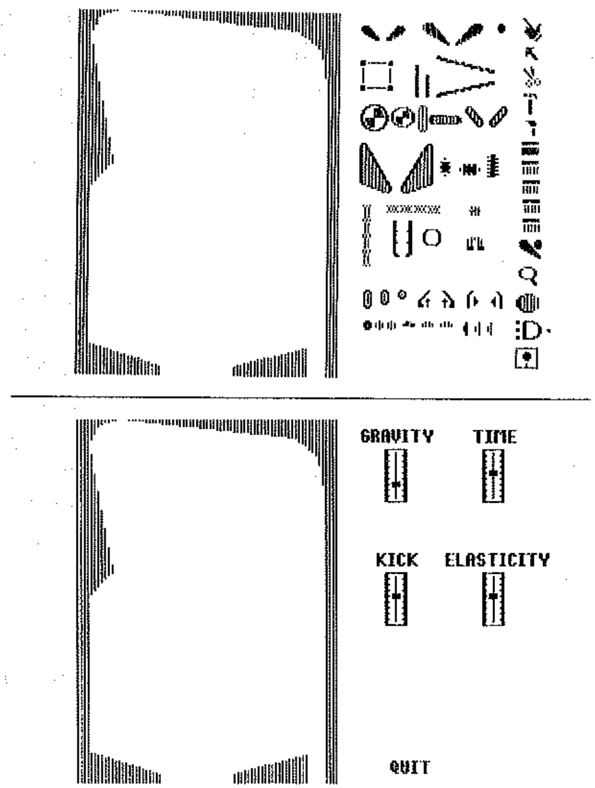
Fantasy games. Not all computer games are action games. Another important type of game is the fantasy adventure game. Until very recently games of this type have not been available in arcades, but only as programs for home computers. Fantasy games involve complex characters with a medieval flavor who go on adventures together and meet a wide variety of circumstances and obstacles. This type of game has a number of interesting features that separate it from traditional games.

One distinguishing mark of this type of game is that there are so many more possible happenings and characters than in a traditional game. Events are constrained by rules, but the constraints are much broader than in traditional games; in this way the games are more like life. Another interesting feature is that characters are multidimensional. In the game of Wizardry, for example, the characters are composed of different combinations of six qualities—strength, IQ, luck, agility, vitality, and piety—in addition to belonging to unidimensional categories, as chess pieces do. (Rather than kings, queens, pawns, and so on, the categories in Wizardry are fighters, priests, gnomes, and so on.) The characters also have complex and varying combinations of external qualities, notably armor, weapons, gold, and spells. Thus, to play such games well, children have to understand and construct multidimensional character structure.

Another interesting feature is that the characters are created by the player. Within certain constraints, qualities are chosen rather than assigned. Thus, the games stimulate creative thinking in the players. Also, there is more character development than in conventional games. For example, characters gain "experience points" as they go through adventures, and their capabilities change as a function of this experience. Characters can be "saved" on computer disk, so that this development can continue over a period of time and continuous progress can be made. Thus, the fantasy games are not only more complex in some ways than conventional games, they are also more dynamic. The player is stimulated to develop or use concepts of character development.

Other examples of creativity. Eric Wanner has suggested that video games could be much more interesting if they provided for more creation, particularly the creation that comes with programming.[15] While it is true that arcade games are totally preprogrammed, the fantasy games, available for home computers, do involve a certain amount of creation. Even more open-ended and creative is a game like the Pinball Construction Set (see figure 7), where you first build your own pinball alley, manipulating its geometry, physics, and electrical wiring as well as the placement of its flippers, bumpers, and so on. Then you play the pinball game you have created. Thus, creative and constructive abilities, as well as the playing abilities of a traditional game, are called into play. The computer makes it possible for video games to have this creative and open-ended aspect.

Going one step further in this direction are games that incorporate programming into a game format. In Robot Wars, for example, the player first programs a robot to behave in certain ways. Each player creates his or her own robot through programming. This type of game seems to combine the excitement of control and creation (when the program works) with the motivation of a goal-oriented game.



7. *Two screens from Pinball Construction Set. Both contain the basic alley. The top screen shows the various parts the player can use in constructing the game: flippers, bumpers, targets, and so on. The bottom screen contains dials for adjusting the physical variables of the game: the player can decrease or increase gravity, the speed of the simulation, the kicking strength of bumpers, and the elasticity (resilience) of collisions between balls and alley surfaces.*

As Wanner points out, it is a shame that the more imaginative and creative types of games are not available to the general public, those who are able to spend quarters but not bigger money on computer technology. Perhaps the invasion of schools by computers will make these creative games, as well as the computer experi-

ences I will describe in the next chapter, available on a much broader scale. Although this is bound to happen to some extent, inequities in school ownership of computers based on social class of the school's population has already arisen, putting poorer children at a disadvantage in this area, as in others.[16]

A LADDER OF CHALLENGES

One more general characteristic of video games is, I believe, an important contributor to their learning potential. This is the fact that almost all the games have different levels, geared to the player's skill. In Pac-Man, after the player has cleared the dots on one maze, a new maze appears on the screen with more difficult characteristics. For example, in later stages of the game, Pac-Man cannot eat the monsters, even after having been "energized"; he can only force their retreat. A series of levels should have several effects. First, moving to a new level is a tangible sign of progress. Secondly, each new level presents a new challenge. And finally, having multiple levels introduces great variety into the game and creates curiosity as to what the next level will be like.

Evidence from work with learning-disabled children in an after-school educational setting emphasizes the appeal of levels of increasing difficulty. A game called Space Eggs, for instance, had such multiple levels. As they became expert players of Space Eggs, children kept moving from level to level, discovering new properties as they did so. "The day finally came, however, when one child achieved to the degree that the computer had no further response to: all that happens is that the most complex pattern repeats itself. The child's response was simple: he stopped playing the game. During future days at computer time, he chose other games, going back to Space Eggs only rarely."[17] It seems that far from being lazy or seeking mindless games, children look for games that challenge them.

Video games and learning-disabled children. The same study of learning-disabled children found that the arcade games were in many ways better educational tools for learning-disabled children than "educational" games or education in general. Children who avoid instruction during reading time were willing to be instructed during computer time. Some children who refused to concentrate on conventional learning tasks concentrated very well on the arcade-style games, showing perseverance and making a great deal of progress from trial to trial. The children also began to act as teachers of their peers and of adults. They would ask one another how to get a game started or how to play, and expert players would coach novices in the game's advanced strategies. Here is a case where computer technology removes handicaps that impede progress in other areas of education.

Multiple levels and addiction. According to Malone's study, the existence of multiple levels does not affect the popularity of particular games. But as the anecdote about Space Eggs shows, this characteristic may well affect *how long* a game remains interesting and popular, as well as how much is learned from it.

The existence of multiple levels may also be responsible for the addictive properties of the games claimed by the Glendale mother at the beginning of this chapter. A video game player makes visible progress in the form of improved score and reaching the next level. Yet there is always another level to master. The challenge of ever-new game conditions, added to the feeling of control that children claim computer games give them, creates a long-term appeal. As Malone has pointed out, learning situations other than computer games ought to be able to incorporate these powerful motivational fea-

tures. Perhaps the most valuable thing we can learn is not how to make the games less addictive but how to make other learning experiences, particularly school, more so.

GAMES OF THE FUTURE

The motivating features of video games are beginning to be put to more explicit educational use. For example, Rocky's Boots, designed for home computers, uses a game format to teach the logic of computer circuitry. Early research findings indicate that players are engrossed by the game and learn from it. In Green Globs the player writes equations to hit randomly placed globs with a plotted curve, making progress in analytic geometry in moving from level to level.[18]

James Levin and Yaakov Kareev have suggested some imaginative possibilities for future games. A video game always creates its own microworld, and they point out that game designers could structure these worlds to reflect knowledge we want the players to acquire. For example, they describe a "chemical adventure" game that could be designed to teach about the periodic table of elements:

> Suppose that in a game world, we personify elements as people having characteristics analogous to their namesake elements. So we would have the muscle men Chromium, Manganese, and Iron, the attractive Chlorine, Fluorine, and Iodine, the casanovas Lithium, Sodium and Potassium, the super rich Platinum, Gold, Silver, and Copper. A goal in this game might be to rescue Silver, who is being held hostage by the seductive Chlorine (the compound silver chloride, used in photographic paper) . . . the player could use a magic powder (free electrons) to sprinkle over Silver to reduce his attraction to Chlorine, so that he can be set free . . . along

> the way the player would have to avoid the dangerous Arsenic and Plutonium, distracting Arsenic with Gallium, or using Lead as a shield from Plutonium's rays . . . This sketch of a chemical adventure points to the ways that a computer game program could draw upon the same aspects that make current adventures entertaining, yet teach an abstract knowledge domain.[19]

Video games are a new medium, and scientific study of them is just beginning. Most of my discussion of skills involved in the games has been based on analyses of the games themselves, plus a few observations of individual cases. Such analyses furnish but a starting point for the systematic research of the future. More important, while this type of analysis can give important clues as to the skill involved in playing the games, it cannot tell us how far these skills transfer to situations outside the game itself. Just as is the case for other media, the games may well have to be used in an instructional context, with guidance and discussion by teachers, for the important skills to transfer very far. We should not forget, however, that knowledge and skill can be of value in themselves even if they are not transferable to new situations.

In thinking about video games, we should not think only of the shoot-'em-up space games that predominate in the arcade. There are, and there can be, a wide variety of game formats that utilize the marriage of computer and television. Because it can be programmed, the computer is a highly flexible medium, and the possibilities are endless.

As with any medium, the medium of video games has its own pattern of strengths and weaknesses. This medium may include more variation than most, however. For example, the real-time action games may foster parallel processing skills and fast reaction time but may

also discourage reflection. (If you stop to think while playing Space Invaders, you're lost.) By contrast, games with a verbal format (for example, some of the fantasy-adventure games) use serial processing and allow unlimited time for reflection and planning. The real danger may be in the very variety, complexity, and appeal of game worlds that are so responsive to the child's input. As Karen Sheingold has speculated, too much control over the fantasy worlds of video games could bring about impatience with the messy, uncontrollable world of real life. This possible danger must, however, be weighed against the positive effects of achievement and control for children who, for whatever reasons, lack a sense of competence and predictability in other domains of life.