

# 1 Definitions

*\*Principle: Creativity relies on connecting differing but viable ideas in unique and unexpected ways.*

## Music and Meaning

At the beginning of the nineteenth century, a French music teacher named Jean-François Sudre invented what he hoped would become a universal language (Crystal 1987, p. 353). He called this language Solresol. This *langue musicale universelle* was based on the seven notes of tonal musical scales called *do, re, mi, fa, sol, la, and si* or solfège. These syllables equate respectively to C, D, E, F, G, A, and B, using the single-letter note names more commonly found today. Sudre created words in his language by using one solfège syllable or by combining solfège syllables as in:

<i>si</i>	yes
<i>do</i>	no
<i>re</i>	and
<i>dore</i>	I
<i>domi</i>	you
<i>doredo</i>	time
<i>doremi</i>	day
<i>dorefa</i>	week
<i>doresol</i>	month
<i>dorela</i>	year

Sudre divided four-syllable combinations into different classes or *keys*, each based on a particular note. The *la* key, for example, defined words relating to industry and commerce. He used over 9,000 note combinations for the names of animals, plants, and minerals. Semantic opposites were often expressed by reversing the order of syllables (e.g., *misol* [good] as opposed to *solmi* [bad]).

The unique aspect of Sudre's language was that it could be played, whistled, or sung, as well as spoken. As long as listeners could locate *do*—usually by finding the two half steps of the major scale—they could understand what was being expressed. Solresol became very popular by the middle of the nineteenth century, particularly in France. Indeed, some people still spoke and sang Solresol at the beginning of the twentieth century. It thus became one of the longest surviving artificial languages. However, very few people even know about Solresol today.



**Figure 1.1**  
A simple example of Solresol.

Figure 1.1 presents a brief example of Solresol. Its meaning—sung, played on a clarinet, whistled, and so on—is “Now is the time to serve humanity, to rise to the universal call to forgive our evils forever.” Since rhythm is not a factor, the notes have been printed here as a simple chant with slurs representing words of more than one syllable. To someone versed in Solresol, the organization of notes translates into a meaningful concept, as understandable as any prose in French or English. However, the language makes no pretension toward musical goals. It is no surprise, then, that the melody here lacks musical direction, has little regard for tonal scale-degree resolutions, and has few logical harmonic implications.

What interests me most about Solresol is that this very flexible language offered its users the opportunity to affix concrete meanings to individual or groups of musical pitches, and yet, with all of its potential for universality, Solresol ultimately held little interest even for those who had spent the innumerable years necessary to learn the language.

In contrast to Solresol, music, at least good music, is ineffable. Stravinsky explains that ill-informed music lovers “. . . will demand that we explain something that is in its essence ineffable” (Stravinsky 1960, p. 49). Leo Treitler agrees that “. . . music, uniquely among the arts, is considered ineffable” (1997, p. 26). Harold Cohen, creator of Aaron, the computational painting program, attempts to “get across the notion of art as a meaning *generator* [my italics], not as an act of communication” (McCorduck 1991, p. 125). Charles Rosen adds that music exists

. . . on the borderline between meaning and nonsense. That is why most attempts to attribute a specific meaning to a piece of music seem to be beside the point—even when the attribute is authoritative, even when it is made by the composer himself. (Rosen 1994, p. 75)

Music’s ineffability makes it different from language and, it seems to me, makes musical creativity different from language creativity, even though many of us still cling to the notion of music as a kind of language. Leonard Bernstein makes the point that

. . . language leads a double life; it has a communicative function *and* an aesthetic function. Music has an aesthetic function only. For that reason, musical surface structure is not equita-

ble with linguistic surface structure. In other words, a prose sentence may or may not be part of a work of art. But with music there is no such either-or; a phrase of music is a phrase of art. It may be good or bad art, lofty or pop art, or even commercial art, but it can never be prose in the sense of a weather report, or merely a statement about Jack or Jill or Harry or John. (Bernstein 1976, p. 79)

Language is also clearly representational—the words I write here all represent something other than themselves. The word “chair” represents a chair; it is not actually a chair. Being comfortable with this form of meaning, it is natural for us to force it upon music. In other words, in order to have meaning, music must represent something else. Treitler explains this point of view eloquently:

Language is used here to hold music at arm’s length from the listener but also from meanings that may be attributed to it—to make musical meaning indirect and conceptual and to locate it outside of music. Words are asked to identify not music’s properties or the experience of these properties but abstractions that music *signifies*. That is the doctrinal tendency to which I refer, a tendency to address the question of meaning in music via the semiotic transaction of signifying, hence a tendency to regard “interpreting” as being virtually synonymous with “decoding.” (Treitler 1997, p. 30)

Treitler further argues that music, at least nonvocal and nonprogrammatic music, does not signify something else, as does language. He believes, rather, that any meaning expressed by music is in the music itself. Whether this meaning then stirs some common emotion in its listeners or is ineffable, I leave to philosophers, psychologists, and cognitionists. Either way, however, music clearly serves a different purpose than does language. Rosen notes that “Listening to pure instrumental music, as Charles Lamb observed, can seem like reading a book that is all punctuation” (Rosen 1994, p. 76).

In many ways, I seem to contradict here the thoughts I expressed in 2001a in regard to music’s lack of meaning. In response to Douglas Hofstadter’s statement “I personally think that I hear meaning all over the place in music” (Cope 2001a, p. 322), I stated: “Like Doug, I cannot simply ascribe all the meaning I derive from music to myself” (p. 321). The problem, of course, is semantics: the word “meaning” simply *means* too many things. I clarify my meaning of this word with “I had to know what it was that held so much *meaning* for me. Whether my interpretation of this music coincided precisely with the composer’s intentions seems unimportant. That I could understand the actual musical events that caused my perception *is* important” (p. 321). The word “meaning,” at least when related to creativity, must have a more precise definition—as near a 1:1 relationship between sender and receiver as possible—that was clearly not so important when discussing virtual music.

Therefore, I agree with my comments on meaning in 2001 *and* those made in this chapter. I shall discuss musical meaning further in chapters 5 and 12.

Interestingly, one of my favorite analogies is that mathematics is to physics as music is to language. The first instances—mathematics and music—are abstract, while the second instances—physics and language—relate more to the real world. Mathematics and music also deal in proportions, while physics and language attempt to develop meaning. Mathematics, however, differs from music in that the former is empirical and the latter is interpretive. Though simplistic, this analogy nonetheless serves to emphasize music’s reliance on relationships rather than on meaning and representations of meaning.

In chapter 2 and in the rest of this book, I propose ideas that distinguish music creativity from creativity in the other arts. First, however, it will be necessary to further define and contextualize creativity in general in order to appreciate the differences that music offers.

### Defining Creativity

*Webster’s Collegiate Dictionary* (1991) defines *creative* as “resulting from originality of thought: imaginative” (p. 319). Interestingly, this same dictionary defines *imagination* as “creative talent or ability” (p. 671). The circular nature of these definitions should not be surprising, given that this same dictionary defines *intelligence* as a “capacity for learning, reasoning, and understanding” (p. 700) and *reasoning* as “the power of intelligent and dispassionate thought” (p. 1123). Dictionaries are by definition self-referential, thus providing us with the sense of a word’s meaning given that we have a familiar context of other words in which to place that sense of meaning. E. H. Gombrich asks, “. . . are we not led into what philosophers call an infinite regress, the explanation of one thing in terms of an earlier which again needs the same type of explanation?” (E. H. Gombrich, as quoted in Minsky 1986, p. 150).

Curiously, *Webster’s New World Dictionary* (1984, p. 34) defines *art* as simply “human creativity,” while *Webster’s Collegiate Dictionary* (1991, p. 77) defines *art* as “the quality, production, expression, or realm of what is beautiful or of more than ordinary significance.” I am sure that, given enough time, I could find several more contradictory, or at least significantly varied, definitions of art. Obviously, according to the first definition, the output of computer programs does not qualify as art, unless you consider its output as the human programmer’s output. Certainly, many individuals view creativity as something that only humans can do. (When I encounter someone with this viewpoint, I usually argue that if humans cannot create machine programs that themselves create, then humans are not in fact very creative

after all.) The more generous second definition of *art* above could include the output of computer programs, depending on whether one considered this output beautiful or of more than ordinary significance.

Most books that deal with creativity in serious ways provide descriptions of the contributions of the human biological system. Axons, dendrites, synapses, neurons, sensory transducers, and so on, along with explanations of the related hydrocarbons, phosphates, and various proteins, appear often in these sources. The various lobes (frontal, temporal, parietal, occipital), as well as the right (principally visual-spatial) and left (principally verbal) hemispheres, function as separate and integrated parts of the brain, providing a foundation for creative thinking. However, I will avoid these kinds of biological descriptions of creativity here for a variety of reasons. First, there are other, more detailed sources for such information (Adelman 1987; Jacobson 1978; Shepherd 1988), and a simple summary here would do them and their subject an injustice. Second, while we have begun to unravel the chemistry and processes of thinking and cognition, we still have very little understanding of the neurobiology involved in human biological creativity.

At the opposite extreme, more casual definitions of *creativity* take forms not unlike those expressed by Frederick Dorian (1947) in his book *The Musical Workshop*:

Everything is inspiration to the born musician. The voice of his mother. The smile of his friend. The muffled tread of human passions—life on earth from the cradle to the grave. The curses of hell and the glory of God. There is no vision and no experience which has not been turned into an inspirational impulse by creative musicians. Inner and outer events, the whole gamut of psychic and physical experiences to which the human being is exposed or which his imagination can conjure up—they all have been the springboard of inspirational impulses in the music of thousands of years. “There is a song,” in Eichendorff’s beautiful words, “which slumbers in all things that dream endlessly, and the world will begin to sing if thou findest the key word.” (Dorian 1947, p. 19)

This broad description of inspiration leading to creativity would be difficult to code. While I do not doubt the sincerity that the author brings to his observations, and while a certain emotional part of me resonates with at least some of his words, I cannot find much practical use for these sentiments.

Herbert Simon suggests that we

... should not be intimidated by words like “intuition” that are often used to describe human thinking. We have seen that “intuition” usually simply means problem solving by recognition, easily modeled by production systems. (Simon 1995, p. 689)

Douglas Hofstadter describes creativity more explicitly as consisting of four basic ingredients:

*Having a keen sense for what is interesting:* that is, having a relatively strong set of *a priori* “prejudices”. . . . This aspect of creativity could be summarized in the phrase *central but highly discriminating taste*.

*Following it recursively:* that is, following one’s nose not only in choosing an *initially* interesting-seeming pathway, but also *continuing* to rely on one’s nose over and over again. . . . This aspect of creativity could be summarized in the term *self-confidence*.

*Applying it at the meta-level:* that is, being aware of, and carefully watching, one’s pathway in “idea space” (as opposed to the space defined by the domain itself). This means being sensitive to unintended patterns in what one is producing. . . . This aspect of creativity could be summarized in the term *self-awareness*.

*Modifying it accordingly:* that is, not being inflexible in the face of various successes and failures, but modifying one’s sense of what is interesting and good according to experience. This aspect of creativity could be summarized in the term *adaptability*. (Hofstadter 1995, p. 313–314)

As I will demonstrate in chapter 6, “adaptability” is programmable. The notions of “self-confidence,” “taste,” and “self-awareness,” however, continue to baffle our most distinguished philosophers (see Damasio 1999; Dennett 1995; Searle 1997), no less computer scientists wishing to model or emulate these characteristics. Hofstadter’s use of the terms “prejudices,” “interesting,” “sense,” “good,” and so on, unfortunately means many different things to different people. His choice of these terms, therefore, presents enormous challenges to those of us who would attempt to code them into computer programs.

Antonio Damasio posits that:

Creativity itself—the ability to generate new ideas and artifacts—requires more than consciousness can ever provide. It requires abundant fact and skill memory, abundant working memory, fine reasoning ability, language. But consciousness is ever present in the process of creativity; not only because its light is indispensable, but because the nature of its revelations guide [sic] the process of creation, in one way or another, more or less intensely. . . . there is a circle of influence—existence, consciousness, creativity—and the circle closes. (Damasio 1999, p. 235)

I have chosen to ignore such highly romanticized definitions of creativity even though I know that many individuals share their sentiments. One wonders if Damasio, and those who agree with his views, could recognize these ingredients for creativity (e.g., consciousness) in a test of human versus computer output (see chapter 2).

Margaret Boden eloquently points out that

. . . [the] way in which people commonly deny the possibility of “real” creativity in computers is to appeal to the consciousness argument. “Creativity requires consciousness,” they say, “and no computer could ever be conscious.” We have seen, time and time again, that much—even most—of the mental processing going on when people generate novel ideas is not conscious,

but unconscious. The reports given by artists, scientists, and mathematicians show this clearly enough. To that extent, then, this argument is misdirected. (Boden 2004, p. 294)

Marvin Minsky takes a somewhat different tack to defining creativity by addressing the often conflicting nature of creative and logical thought:

What is creativity? How do people get new ideas? Most thinkers would agree that some of the secret lies in finding “new ways to look at things.” . . . Why must our minds keep drawing lines to structure our reality? The answer is that unless we made those mind-constructed boundaries, we’d never see any “thing” at all! (Minsky 1986, p. 134)

Modeling this bifurcated nature of the mind with computers seems possible by measuring, cataloging, and referencing boundaries while simultaneously attempting to extend those boundaries. However, Damásio would argue that without consciousness, we would not have to define boundaries, and thus never really need to create anything at all. Hofstadter might add the notion that without “discriminating taste,” computer programs could never really know which boundaries to extend.

Boden, Bringsjord and Ferrucci, and Damasio all take up the consciousness argument—that creativity requires consciousness—with interesting but contradictory and inconclusive results. Two particular questions arise when “consciousness” becomes a requisite for creativity:

1. Is it important that creators know they are creating?
2. Is it important that creators appreciate their own creations?

As interesting as these questions may be, however, I have opted not to respond to them. My reasons are simple: How do we know that *humans* know they create, and in fact appreciate their creations? It would certainly seem important that creators know the difference between a creative output and an uncreative output, but is it necessary for them to self-relate to this output or to find this output appealing? Can we, as interpreters of their creations, discern the creators’ feelings toward their own creations without being explicitly informed of these feelings? These questions all relate to creativity but, it seems to me, skirt the primary issue of precisely what constitutes creativity. Henceforth, I have avoided considering them in the definition I will use in this book.

According to Scott Turner, creativity should produce significantly different results than noncreativity does.

We all recognize that creative solutions must be original. They must be new and different from old solutions. But the differences must also be *significant*. If an artist were to paint the *Mona Lisa* in a red dress instead of a blue one, the resulting painting would not be considered

creative, despite its differences from the original. Significant novelty distinguishes creative solutions from ones that are only adaptations of old solutions. (Turner 1994, p. 22)

As well, originality must be useful.

We expect problem solvers to be capable: They must develop solutions that solve their problems. Replacing a flat tire with an air raft is novel but not creative, because it doesn't effectively solve the original problem. (Turner 1994, p. 22)

Musical creativity, on the other hand, does not offer clear "flat tire" and "air raft" equivalents. The question of legitimate creativity regarding works of art seems tied less to novelty and more to aesthetics.

Daniel Dennett offers yet another view of creativity:

... my three-year-old grandson, who loves construction machinery, recently blurted out a fine mutation on a nursery rhyme: "Pop! goes the diesel." He didn't even notice what he had done, but I, to whom the phrase would never have occurred, have seen to it that this mutant meme gets replicated. As in the case of jokes discussed earlier [a result of a slow evolution], this modest moment of creativity is a mixture of serendipity and appreciation, distributed over several minds, no one of which gets to claim the authorship of special creation. (Dennett 1995, p. 355)

Dennett's prosaic but pertinent observations demonstrate how cross-wiring can produce interesting, unique, and important *creative* connections. This notion of cross wiring will offer a valuable resource when I define association networks in chapter 9.

I find David Gelernter's quotations of Gilhooly and Shelley in the following abstraction of creativity equally attractive.

Rather than beating your head against the wall of a difficult problem that doesn't yield to ordinary, methodical approaches, you discover a different way to see the problem ... put another way, "The creative thinker comes up with useful combinations of ideas that are already in the thinker's repertoire but which have not been previously brought together" (Gilhooly 1988, p. 186). Or as Shelley wrote in 1821, "Reason respects the differences, and imagination the similitudes of things." (Shelley 1821/1966, p. 416; as quoted in Gelernter 1994, pp. 79–80)

Edward deBono (see particularly deBono 1970) distinguishes between what he calls "vertical" and more creative "lateral" thinking. For deBono, vertical thinking is selective and analytical, while lateral thinking is generative and instigative. Lateral thinking invites intrusion of possibly irrelevant information. Vertical thinking proceeds by logical steps, while lateral thinking is nonlinear (deBono 1971, 1984).

W. J. J. Gordon describes creativity using analogies and metaphors that play major roles in *synectics*, an important approach to defining creativity (see Gordon 1972). Synectics incorporates personal, direct, symbolic, and fantasy analogies to



creatively solve otherwise intractable problems. Personal analogy involves personal identification, particularly with inanimate objects. Direct analogy compares parallel situations to develop solutions. Symbolic analogy objectifies the elements of a problem. Fantasy analogy follows Freud's view that creativity is wish fulfillment. Each of these analogical processes attempts to make the familiar strange and, in so doing, to provide alternative possibilities that may not otherwise be considered.

Margaret Boden, in her book on creativity (1990), paraphrases Ada (Lady) Lovelace—close friend of Charles Babbage, designer of the first model of the modern-day computer—in her comments on computation and creativity.

The first Lovelace-question is whether computational ideas can help us understand how *human* creativity is possible. The second is whether computers (now or in the future) could ever do things which at least *appear to be* creative. The third is whether a computer could ever appear to *recognize* creativity—in poems written by human poets, for instance. And the fourth is whether computers themselves could ever *really* be creative (as opposed to merely producing apparently creative performance whose originality is wholly due to the human programmer). (Boden 1990, p. 7)

Boden responds positively to the first three of these questions, but negatively to the fourth, arguing that the question has moral and even political (more likely philosophical) implications. I will argue the opposite point of view in ensuing chapters, but certainly agree with Boden's assessment of her first three questions.

Selmer Bringsjord and David Ferrucci (2000) take up these same questions, responding negatively to the first and fourth, arguing in the first case that "... moving squiggle-squoggles around is somewhat unlikely to reveal how *Hamlet* came to be" (p. 11). The term "squiggle-squoggles" here refers to John Searle's well-known Chinese-room argument, in which Searle attempts to prove that computer programs are entirely syntactical, as opposed to humans, who think using semantics as well as syntax (see Searle 1997).

I include these many differing views here to point the reader to their sources and the sources these sources themselves point toward. I also include them to argue that these views, and the many others that arise from the discussions they spawn, critically contribute to any serious study of creativity; for it is on the resulting definition that all arguments for computer creativity, pro and con, rest. After researching this subject for many years, I have chosen the following definition of creativity for this book:

The initialization of connections between two or more multifaceted things, ideas, or phenomena hitherto not otherwise considered actively connected.

I use the word "multifaceted" to differentiate musical creativity from other types of creativity, as suggested by my description of Solresol at the beginning of this chapter.

Multifacetedness here represents, among other things, various aspects of harmony and counterpoint—when notes occur at the same time. I believe that music’s ability to function simultaneously on both the horizontal and the vertical planes helps to make it unique among the arts. (Note that Sudre and his followers had little idea what to do with harmony and counterpoint in Solresol, and hence kept their language monophonic.) One could argue that, say, visual art has the dimensions of color and shape as correlates to counterpoint. However, for me at least, color and shape match timbre and form in music. These and other distinctions between creativity in music and the other arts will become clearer in subsequent chapters.

Note that my definition of creativity does not include the word “human” or any other such limiting words or phrases. To have included such words or phrases would, I believe, be simplistic and self-defeating. Worse yet, such inclusion would limit and do disservice to the human branch of creativity. My definition of creativity is also particulate—each word and phrase is clearly definable within its context—with each part quantifiable in ways that make programming them feasible.

My definition of creativity seems to find resonance with Gelernter:

... the core achievement of restructuring and creativity is the linking of ideas that are *seemingly unrelated*. The originality we impute to an insight centers just on the seeming *dissimilarity* between the problem and the analogy. Of course, similarity between the two must exist on some level, otherwise no analogy would exist. But that similarity must be deep, hidden, obscure, indirect—not a mundane matter of two ideas attracting each other because they share obvious similarities. (Gelernter 1994, p. 84)

Originality, in the view of many, represents a critical facet of creativity. Interestingly, computers can generate seemingly *original* output quite easily. In fact, so-called randomness, a standard function of every computer programming language and which I discuss at length in chapter 3, produces apparently original output far more often and efficiently than it produces predictable output. For those believing that computers cannot be creative, then, originality should *not* be the focus of their definition of creativity.

For many, however, the decisive measure of creativity results from a determination of whether or not the results of a process are “derivative”—few words having more vile connotations for artists. While all art and music are derivative to a degree, at least in the sense of alluding to other art and music (see chapter 5), some art and music apparently borrow too heavily to be considered truly creative. I argue that while plagiarism certainly cannot fall within the boundaries of creativity, many of the most renowned artists and composers of history have borrowed extensively from their predecessors (again see chapter 5 for examples).

Boden (1990) also argues against the notion of creativity as originating from nowhere:

In the abstract, however, creativity can seem utterly impossible, even less to be expected than unicorns. This paradox depends on the notion that genuine originality must be a form of creation *ex nihilo*. If it is, then—barring the miraculous—originality simply cannot occur. (Boden 1990, p. 29)

One measure of the veracity of my definition of creativity rests on the necessary conditions that must prevail before creativity can occur. In other words, if true creativity cannot exist in a vacuum, then the potential for “connectedness” of all of creativity’s connections-to-be must already exist at the time of inception. Boden adds an extremely important point about this creativity-in-context:

If, by some miracle, a composer had written atonal music in the sixteenth century, it would not have been recognized as creative. To be appreciated as creative, a work of art or a scientific theory has to be understood in a specific relation to what preceded it. . . . Only someone who understood tonality could realize just what Schoenberg was doing in rejecting it, and why. (Boden 1990, p. 61)

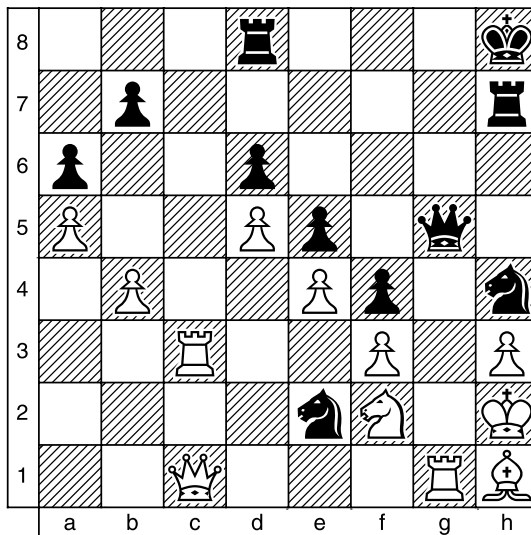
Many of those who attempt to define creativity ignore the types of contextualizations to which Boden refers here. We are much more apt to consider a child’s drawing creative because of that child’s acknowledged inexperience and lack of training, whereas the same drawing produced by an adult would be considered silly or retentive. However, rather than contextualizing every potentially creative act with its creator’s credentials, I have opted to include the more universal “. . . initialization of connections . . .” and “. . . hitherto not otherwise considered actively connected . . .” things, ideas, or phenomena, leaving the interpretation of the context to those evaluating each particular instance.

Note that my definition of creativity is relatively active (initialization, *not* discovery) and uses connections (not aesthetics). This definition also avoids notions of consciousness (since no one has yet fully explained consciousness, at least to my satisfaction), interesting and uninteresting work (since such decisions seem personal and have little intrinsic value for a broadly conceived definition), and originality (which, as Boden points out, probably does not exist, at least on any fundamental level). My definition of creativity further avoids such limitations as whether or not the discoveries are easy or hard, beautiful or ugly, and valued or not valued. Critics will argue that my definition welcomes, for example, “creating a mess” as an instance of creativity. In fact, many important artists have created in just this way, to encourage the “initialization of connections between two or more multifaceted things, ideas, or phenomena hitherto not otherwise considered actively connected.” As Anton

Ehrenzweig notes in his book *The Hidden Order of Art*, “But why not a ‘mess’? Any creative thinker who ventures into new territory risks chaos and fragmentation” (Ehrenzweig 1967, p. 147).

There are three particular strategies that I find helpful for developing the kind of creativity I define here. First and possibly foremost, assumptions must be ignored, or at the least momentarily suspended, for creativity to occur. Second, creativity requires making or revisiting connections between seemingly incongruous ideas, with such revisitations possibly leading to inspired thinking. Third, the type of creativity described here involves nonlinear thinking—the ability to avoid dead ends that otherwise might obscure potential solutions to problems. To demonstrate these strategies here, I will use a game, a puzzle, and a riddle. These choices may seem strange. However, as I will establish later in this book, discussing creativity in music can be very difficult, and doing so without first examining the processes in less narrow circumstances can often cause more confusion than clarity. I will focus on music later in this chapter.

Figure 1.2 presents a particularly interesting chess problem, one in which black has the next move. For readers who may know the legal moves of chess but who do not have extensive chess-playing experience, recognizing the best move here may take considerable time. Such novice players typically use brute-force approaches,



**Figure 1.2**  
An in-progress game of chess—Black’s move—as an example of creativity.

experimenting with various possibilities and then discarding those that prove implausible or illogical. These players accumulate points rather than strengthening their position.

Intermediate-level chess players, on the other hand, typically review the positions of both sides in an attempt to discover various strengths and weaknesses, and then focus on the pieces of power (e.g., the queen, rook, etc.) and vulnerability (e.g., the king). These more experienced players—faced as we are here with solving a game in progress—reverse engineer the current position, stepping through the probable moves that resulted in the game’s current status. Even though these processes may be time-consuming, intermediate players ultimately make better moves than brute-force beginners do.

Chess experts, on the other hand, often gauge the occupied and unoccupied squares on the board rather than focusing on the pieces themselves. These experts concentrate particularly on the squares most influencing their opponent’s king. The pieces—and their point representations—become almost inconsequential compared with their relationships to the empty, filled, and covered squares that prevent or enhance the potential for checkmate. In effect, advanced players ignore the assumptions of lesser players, and focus on winning the game.

In figure 1.2, White leads by a pawn (equating bishops and knights for the moment). One strategy for Black involves moving its queen out of harm’s way (currently challenged by White’s rook at G1). Though purely defensive, this move maintains the status quo rather than effecting a big loss (point counting, a beginner’s mistake). A more imaginative solution might have Black’s knight at E2 capture White’s queen at C1. This move would most likely produce a queen exchange, since White would then no doubt capture Black’s queen at G5, resulting in weaker positions for both players. Unfortunately, these mutual captures leave Black’s knight at C1 vulnerable to White’s rook at C3, and places White’s rook, now at G5, in a position to put pressure on Black’s king. Other moves of interest for Black include Black’s knight at H4 capturing White’s pawn at F3 and checking White’s king. However, White could respond by taking Black’s knight with the bishop at H1, thus increasing White’s lead. Black’s queen could take White’s rook at G1, but White’s queen then takes Black’s queen, for an even greater advantage.

Other possible moves for Black exist here, but the ones I’ve mentioned represent those that initially seem most logical. For the expert, however, Black moves queen to G3 (check) in what appears at face value to be an exceptionally poor choice, especially since Black’s queen remains vulnerable to White’s rook at G1. This move actually *forces* White to capture Black’s queen with White’s G1 rook (the only move that relieves the check on White’s king), as shown in figures 1.3 and 1.4.

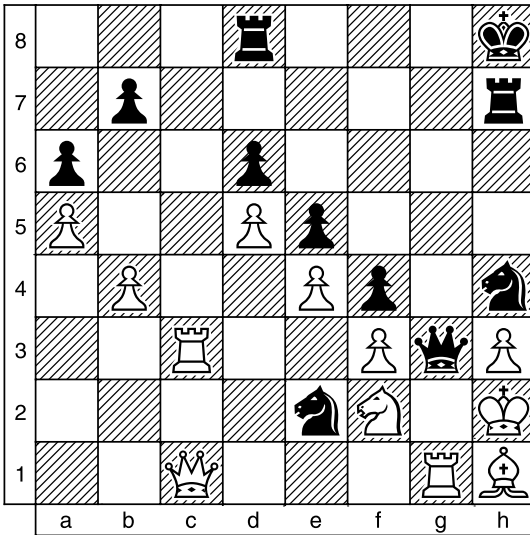


Figure 1.3

Black checks White's king with a queen move but also appears to forfeit this queen.

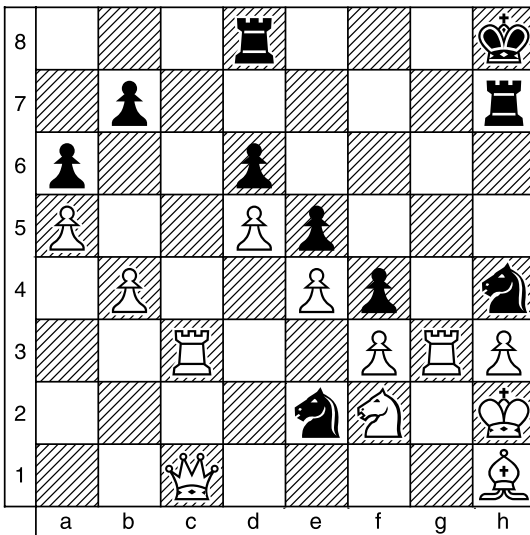
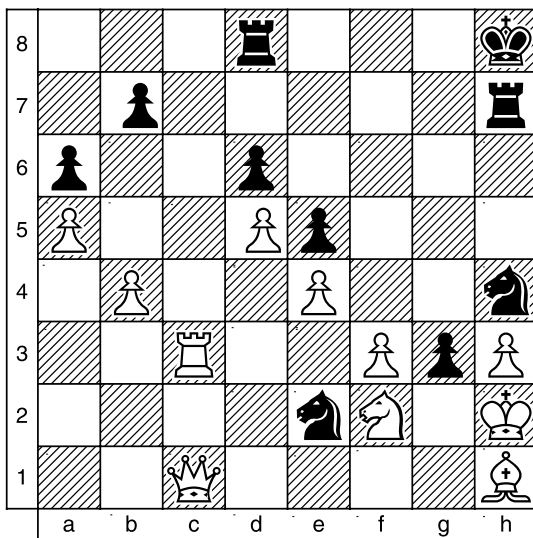


Figure 1.4

White captures Black's queen.

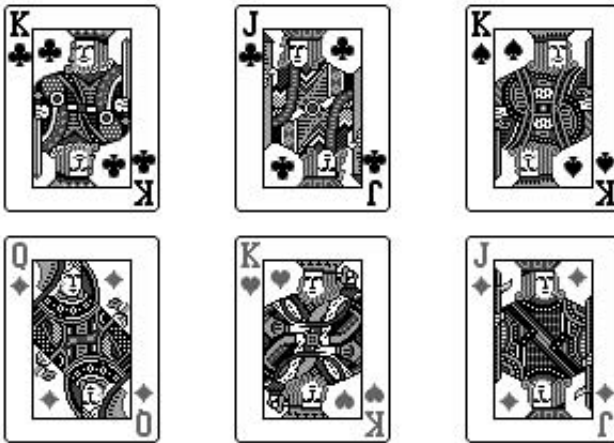


**Figure 1.5**  
Black checkmates White.

At this point, Black trails White by ten points, more than enough in most games to ensure White’s ultimate victory. Black, however, is primarily concerned with filling and covering the squares surrounding—and thus attacking—White’s king (G1, G2, and G3 in particular). This attack now becomes possible (as shown in figure 1.5) by moving Black’s F-rank pawn and capturing White’s rook at G3, a move that subsequently checkmates White’s king, since this pawn is now protected by Black’s knight at E2.

Stepping through the series of moves taken in figures 1.2–1.5 may not give readers ample explanation of why I find this problem and its solution *creative*. However, the sacrifice of Black’s queen does not initially seem reasonable, given the alternatives. It is, however, a move that ignores assumptions and creates an “initialization of connections between two or more multifaceted things, ideas, or phenomena hitherto not otherwise considered actively connected.”

One might argue that this endgame merely proves Black’s superior intellect. I argue that most creativity seems logical in hindsight, and that the elegant simplicity of Black’s checkmate would not be foreseen by any but the most *creative* of players. Ultimately, winning at chess involves fully understanding not only the relative values of the pieces (points) and strong positions, but also the goal of the game: checkmating



**Figure 1.6**  
Cards from which a player is asked to choose one card.

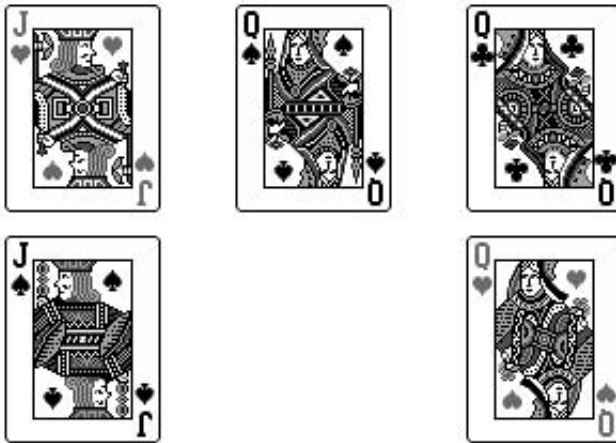
the opponent. Few players remember point tallies or elegance of positions; they remember only who won the game.

I find a particular card trick also helpful when describing creativity. This trick involves laying out six face cards in full view of a player, as shown in figure 1.6, and asking that player to mentally select any card, memorize it, and keep its identity secret. (Readers may act as players in this game as well.) I then retrieve all of the cards, announcing that I have read the mind of the player and know the exact card the player chose. I remove a card, shuffle the remaining cards, and lay the shuffled cards down randomly, as shown in figure 1.7 (the position of the empty space does not necessarily indicate which card the player chose, only that one card is missing). I then ask the player if I've removed his or her choice. Players usually gape at the cards when they discover that indeed the card they chose is missing. It usually takes from ten seconds to a minute or two for players to analyze how the trick works—easier here because you've probably looked back at the cards in figure 1.6 (remember that players have no visual access to the original cards as you, the reader, do).

In order to understand this trick, assumptions that the cards appearing in figure 1.7 are the same cards originally shown must be ignored. Remembering the number of face cards available in a standard deck of playing cards (twelve) helps make the connection between the sets of cards and indicates their differences. As mentioned earlier, these kinds of strategies represent an important aspect of creativity.

At the risk of alienating those of you who do not enjoy such games and tricks, I present one last example that I believe also exemplifies creativity.





**Figure 1.7**  
The player's card removed.

Two men are talking. One says to the other:

"I have three sons whose ages I want you to ascertain from the following clues. Stop me when you know their ages.

One: the sum of their ages is thirteen;

Two: the product of their ages is the same as your age;

Three: my oldest-in-years son weighs sixty-one pounds."

"Stop," says the second man, "I know their ages."

What are the ages?

Aside from seeming impossible to solve, two things are worth noting as you consider this puzzle. First, the assemblage of information here—ages, weights, sums, products, friends, sons, and so on—is certainly strange. Second, this puzzle is typically used as a test of intelligence, not as a test of creativity (Fixx 1978, pp. 24–25).

I suggest that even *devising* a puzzle such as this requires creativity. Solving it requires even more creativity. To do so involves patience and faith that a correct answer can, in fact, be found. Solving this problem also requires nonlinear thinking. My approach begins logically with a translation of the puzzle into math ( $x$ ,  $y$ , and  $z$  here represent the ages of the three sons):

1.  $x + y + z = 13$
2.  $x * y * z \geq 21$  (minimum age for an adult?)
3. 61 lbs?

Since the weight of sixty-one *pounds* does not fit with ages, clue 3 seems remarkably strange, unless this clue means something other than what it appears to mean.

Working then with clues 1 and 2, the possible products of three ages that sum to thirteen are:

Possible Ages				Products
1	1	11	=	11
1	2	10	=	20
1	3	9	=	27
1	4	8	=	32
1	5	7	=	35
1	6	6	=	36
2	2	9	=	36
2	3	8	=	40
2	4	7	=	56
2	5	6	=	60
3	3	7	=	63
3	4	6	=	72
3	5	5	=	75
4	4	5	=	80

Any other combination of ages repeats one of the groupings shown in this list of fourteen, but in a different order, thus producing the same product. Since the man to whom the puzzle has been presented presumably knows his own age, there must be at least two of these age aggregates that produce the same product, or this same man would have known the ages of the sons following step 2. This observation results from nonlinear thinking, since it has nothing directly to do with the correct ages. Only the product 36 appears twice, and—interestingly—one of these 36s is a series containing two of the same higher number (voided by the third clue, since there can be only *one* oldest-in-years son). Hence, the correct ages of the questioner's children are two, two, and nine.

Not only do those solving this puzzle have to ignore assumptions that there are too many possible answers and create new links between apparently unrelated data (ages and weights), but they must also think in nonlinear ways in order to avoid the dead ends—apparently not enough related facts—that obscure the solution to the prob-

lem. I contend that it is not possible to solve this puzzle without being creative, without the “initialization of connections between two or more multifaceted things, ideas, or phenomena hitherto not otherwise considered actively connected.”

To some it may seem absurd to characterize creativity by using examples from chess, card sleight-of-hand, and word puzzles. I think it important to point out, however, that my definition of creativity is not limited to the arbitrary boundaries of historically defined Western art. I think that people act creatively in all sorts of ways, and that confining our understanding of creativity to prescribed forms of expression hinders rather than helps. I cannot imagine, for example, that great chefs and computer hackers are not creative. Imagination, the wellspring of creativity, reveals itself in many diverse ways; to ignore these ways would jeopardize any effective models of creativity we might find.

We must either broaden our definition of creativity to include games and tricks, or limit our definition of creativity to the point that it reflects only what our current sensibilities call *high art*—and in so doing, eliminate the notion of creativity occurring in many world cultures. While possibly expedient, this seems to me a far weaker and less useful approach. I would rather think of creativity as a process accessible to and used by all humans, rather than as an elitist phenomenon available to but a few.

Solving the kinds of problems posed by games and puzzles also requires intelligence. Therefore, creativity might be considered a subset of intelligence. Given this, my definition of creativity here and the notion that computers are capable of creating may seem at odds with my comments on the requirements for intelligence I make in my book *The Algorithmic Composer*:

... there is one attribute of intelligence that subjugates all others. While in and of itself it does not constitute intelligence, it makes intelligence possible. That attribute is *life*: the ability to procreate, to interrelate with one’s environment, to pass on biological and intellectual information from one generation to another. Most other attributes of intelligence pale in comparison to life even though they may be essential to the very survival of that life. (Cope 2000, p. 247)

I still agree with this assessment. Intelligence, it seems to me, could not have originated without the extraordinary training required not only of one lifetime, but of generations and generations of lifetimes provided by the slow evolution of living organisms. For me, intelligence requires many other factors as well, foremost among them being the ability to

learn—not only to acquire information, but to acquire it quickly and efficiently  
remember—to memorize information, connect it together in meaningful ways, and  
especially to prioritize it in useful orders

infer—to deduce new information that has not been explicitly learned  
 analogize—to extrapolate processes (e.g., mathematical processes) from examples  
 create—to solve problems for which there are apparently no correct answers.

Some may also feel that intelligence requires intention, self-awareness, and consciousness, as well as less definable elements such as taste, confidence, adaptability, sense of humor, and so on. Regardless of one's take on these potential requirements, I cannot imagine an intelligence that would lack creativity. Thus, regardless of differences concerning the other sources involved, intelligence requires creativity. However, *I do not feel that creativity requires intelligence*, nor does it consequently require life. Therefore, I believe that computer programs are capable of creativity.

Marvin Minsky argues that

... we should not let our inability to discern a locus of intelligence lead us to conclude that programmed computers therefore cannot think. For it may be so with *man*, as with *machine*, that, when we understand finally the structure and program, the feeling of mystery (and self-approbation) will weaken. We find similar views of “creativity.” ... (Minsky 1995, p. 84)

Darold Treffert and Gregory Wallace point out that

Leslie Lemke is a musical virtuoso ... he is blind and developmentally disabled, and he has cerebral palsy. Lemke plays and sings thousands of pieces at concerts in the U.S. and abroad, and he improvises and composes as well. ... Most musical savants have perfect pitch and perform with amazing ease, most often on the piano. Some are able to create complex compositions. And for some reason, musical genius often seems to accompany blindness and mental retardation, as it does for Lemke. (Treffert and Wallace 2002, p. 78–80)

Many savants demonstrate high degrees of creativity while otherwise being unable to converse or demonstrate the capacity for elemental logic.

Bringsjord and Ferrucci (2000, p. 5) contend that computer programs often *appear* to be creative but are not *actually* creative. In reference to a short story written by a computer program called Brutus, they argue that “Brutus didn't originate this story. He [their term] is capable of generating it because two humans spent years figuring out how to formalize a generative capacity sufficient to produce this and other stories, and they then are able to implement part of this formalization so as to have a computer produce such prose.”

Benoit Mandelbrot, in reference to his mathematically produced fractal images, comments on output that is convincing versus output demonstrating understanding:

The man was very scornful of my images saying: “Poof, this guy doesn't know anything about mountains and his formula contains no knowledge of the earth whatsoever. So, what can it

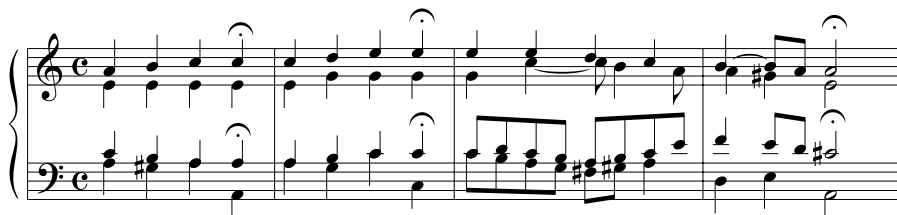
mean? I have a much better formula which takes into account all the available knowledge of mountains.” I replied: “What about providing a picture of it?” “Who needs a picture?” he responded. “I fit the formula’s 15 parameters from nature and the 15 measurements all check.” I insisted: “Please, do make the picture.” He made a picture, and it did not at all look like a mountain; it was some kind of shape that came up accidentally in his effort to model mountains. That model was never heard of again. (Mandelbrot 2001, p. 204)

I have, of course, encountered similar points of view with the music of my Experiments in Musical Intelligence program. Critics have argued that this software is not creative since, from the perspective of the program, it could just as well be producing pasta recipes.

Mandelbrot continues by comparing art and mathematics: “Many fractal compositions [visual art] are more satisfying to people than most of the art sold in galleries, and in fact we are paid more money for these pictures than some people get for their art (which is one criterion for art that some people believe in strongly)” (Mandelbrot 2001, p. 208). Unfortunately, the same is not true for the compositions of the Experiments in Musical Intelligence program.

Translating the creative solutions to puzzles and games of this chapter to music poses some interesting problems, since what one listener may hear as a unique solution, another listener may hear as derivative. As will be seen, however, the example I use here has the force of many decades of analysis to support what represents typical and atypical creative musical solutions.

Figure 1.8 shows the first four measures of Bach’s Chorale no. 48 (Riemenschneider 1941). These four measures contain a number of interesting musical moments. The first measure, for example, while establishing the key of A-minor, includes a diatonically transposed inversion—also a retrograde—of the melody of the soprano voice in the tenor voice. This inversion turns to parallel motion in tenths in the second measure, establishing the relative major key of C. Measure 2 also includes a somewhat unusual (for Bach and for baroque part writing) hidden fifth in the



**Figure 1.8**

The first four measures of Bach’s Chorale no. 48 (Riemenschneider 1941).

soprano/alto voices between beats 1 and 2. In contrast to this apparent creativity, the almost lifeless alto voice simply repeats two different notes over these first two measures, while the bass voice provides the harmonic foundation for the two phrases. The third measure, with its eighth-note motion in the lower voices, consecutive suspensions in the upper two voices in the second half of the measure, and the chromaticism of the melodic minor scale in the lower two voices, contrasts with the simple cadential motions of the first two measures. I point the reader to the fourth measure, however, where I believe the truly creative solutions exist in this passage.

Measure 4 of Chorale no. 48 contains a statistically unusual parallel fifth in the soprano and tenor voices between beats 2 and 3. Such fifths not only are rare, but many contemporary theory books and teachers ban them from their students' chorales (see, for example, Duckworth [1992], who states that "the most avoided sounds in tonal music have been two voices moving in parallel perfect fifths" (p. 307), and Kostka and Payne [1989], who state that the reasons student examples "are unacceptable in the tonal style is that they contain parallel 5ths and 8ves" [p. 76]). Bach, an obviously skilled part writer capable of easily finding other solutions to this voicing, clearly chose his parallel fifths carefully from myriad other possibilities.

Figure 1.9 presents four of the possible alternative solutions for the fourth measure of Bach's Chorale no. 48. In figure 1.9a the parallel fifth has been avoided by moving the soprano upward to the third of the ensuing chord and holding the tenor at the note E to avoid the doubling of this third. This solution, however, does not provide the completeness of ending on the root of the chord—and tonic of the key—in the soprano voice that Bach or the melody he is using here requires. In figure 1.9b the soprano moves to the tonic note as in the original, but without the eighth-note anticipation. Unfortunately, all four voices now move in the same downward direction to the last chord—another statistically small voicing in traditional part writing. Figure 1.9c presents a third solution with the previous problems solved. However, the fifth of the chord has been omitted in the final chord here, with the result being a less than complete-sounding cadential triad. In figure 1.9d, the fifth of the triad has been restored. However, the alto voice does not resolve its leading tone (acceptable in inner voices at cadences), and the bass voice moves upward rather than downward, again causing the cadence to sound less convincing than Bach's more original solution.

While there are other possible revoicings, the point should be clear: Bach's use of the parallel fifth in figure 1.8, measure 4, provides a unique response to the many—often conflicting—requirements of cadence, voice leading, hierarchical completeness, and so on. Though subtle, this example provides us with a glimpse into why Bach's chorales sound so different and so much more musical than statistically correct

(a)

Musical notation for alternative solution (a). The piece is in C major, 4/4 time. The right hand (treble clef) has a half note G4, a quarter note A4, a quarter note B4, and a half note C5 with a fermata. The left hand (bass clef) has a half note G2, a quarter note A2, and a quarter note B2.

(b)

Musical notation for alternative solution (b). The piece is in C major, 4/4 time. The right hand (treble clef) has a half note G4, a quarter note A4, a quarter note B4, and a half note C5 with a fermata. The left hand (bass clef) has a half note G2, a quarter note A2, and a quarter note B2 with a fermata.

(c)

Musical notation for alternative solution (c). The piece is in C major, 4/4 time. The right hand (treble clef) has a half note G4, a quarter note A4, a quarter note B4, and a half note C5 with a fermata. The left hand (bass clef) has a half note G2, a quarter note A2, and a quarter note B2 with a fermata.

(d)

Musical notation for alternative solution (d). The piece is in C major, 4/4 time. The right hand (treble clef) has a half note G4, a quarter note A4, a quarter note B4, and a half note C5 with a fermata. The left hand (bass clef) has a half note G2, a quarter note A2, and a quarter note B2 with a fermata.

**Figure 1.9**  
Four alternative solutions for the fourth measure of Bach's Chorale no. 48.

chorales. (For other examples of parallel fifths in Bach, see Chorale no. 8, measure 2, and Chorale no. 121, measure 4—two more of the 116 appearances of parallel fifths in the 371 collected Bach chorales.) The Chorale program described in chapter 4 retains these exceptions to rules in its output—one of the reasons I believe that this program’s output is often so effective, and why I believe that it represents a simple but reasonable approach to tonal composition. For other examples of musically creative solutions, see particularly the Bruckner example at the beginning of chapter 7, and the discussions of various computer-created music at the conclusions of many of this book’s chapters.

The definition of creativity I give here does not directly correspond to any of the other definitions discussed in this section. The differences in these definitions may be due to the point raised in my discussion of Solresol at the beginning of this chapter: ultimately, music does not *mean* anything. Many definitions of creativity, in contrast to the one given here, assume meaning as a natural goal. However, as we shall see, one of the ways in which music creativity distinguishes itself from creativity in the other arts results from music’s ineffability.

Musical creativity can involve many elements: pitch, rhythm, timbre, articulation, phrasing, dynamics, and so on, to name but a few. Often these elements converge to create complex counterpoints through which creative minds find many diverse paths. In order to focus the processes I describe in this book, however, I will concentrate on creativity with pitch (primarily) and rhythm (secondarily). This focusing should not be seen as ignorance of the other factors involved, but only for what it is—a narrowing of the involved parameters in order not to spread my efforts too thin.

I will, then, use the definition of creativity as an “initialization of connections between two or more multifaceted things, ideas, or phenomena hitherto not otherwise considered actively connected” as a cornerstone for this book. Each of the chapters to come will exemplify one or more aspects of this definition.

## Originality

“Originality” is often used when discussing creativity. Interestingly, however, the first law of thermodynamics (the total amount of energy and matter in the universe remains constant, merely changing from one form to another) actually voids any true meaning of this word. The theologian Paul Tillich comments:

If creativity means “to bring the new into being,” man is creative in every direction—with respect to himself and his world, with respect to being and with respect to meaning. However, if creativity means “to bring into being that which had no being,” then divine and human cre-



ativity differ sharply. Man creates new synthesis out of given material. This creation really is transformation. (Tillich 1951, p. 256)

There are, however, extraordinarily vast numbers of rearrangements of existing matter, allowing the word “original” to retain its *bite*. For example, Alexander Graham Cairns-Smith notes that the

... *really* big numbers become important when we come to consider not simply how many units there are in a given region, but how many ways they can be arranged. An example can be found in elementary organic chemistry. A class of hydrocarbons can be formed by linking together carbon and hydrogen atoms in such a way that every carbon atom is joined to four other atoms and every hydrogen atom to just one ... it is clear enough that 200 carbon atoms could be arranged, with 402 hydrocarbons, in far more than  $10^{79}$  [the predicted number of electrons in the universe] different ways. (Cairns-Smith 1971, pp. 1–2)

The atoms Cairns-Smith discusses here cover a space considerably smaller than a fraction of a pinhead. In reality, the number of possible rearrangements of atoms in the entire universe is so staggeringly large as to make the actual calculation of their number, even in approximate terms, unimaginable. Some of these rearrangements are more original than others, however.

For example, were I to rearrange the words “complexity masquerading as creativity” into “creativity masquerading as complexity,” it would not be nearly as original as my inventing a new word such as “comtivity” to mean “complexity masquerading as creativity.” In the first instance, while the rearrangement of existing words means something different, the process actually represents something we do commonly in daily life—rearranging the words we say to make ordinary conversation more interesting. On the other hand, the word “comtivity,” a rearrangement of existing letters rather than words, captures a meaning not currently found in the definition of any other word in the English language. In fact, this word signifies this meaning so effectively that I will continue to use it throughout this book. However—and again I apologize for repeating myself—neither of these rearrangements is *fundamentally* original.

Accidents—in this case, accidents of apparently irrelevant combinations—constitute *very* important aspects of creativity and of apparent originality. As Stravinsky points out, “an accident is perhaps the only thing that really inspires us” (Stravinsky 1960, p. 56). He adds that “one does not contrive an accident: one observes it to draw inspiration therefrom” (p. 56). Such accidents—taken seriously—can produce amazingly creative results. Of course, *useful* accidents are not simply everyday accidents, but result from a careful selection from among the many accidents that our universe so amply provides.

The creativity described thus far in this book derives from these kinds of recombinationality and accidents—that is, none of the ideas are really new. However, one can make a distinction between, say, creating a good solution in the game of chess and creating the game of chess itself. The new game we create may itself be a construct of parts of many other games—as I would insist it is—but the new game might involve a deeper creativity than finding the best solution for one particular problem posed by that game (see chapter 6 of this book for such a new game). I discuss this notion of “degrees” of creativity in chapter 10, where I present three different types of computational inductive creation.

In terms of originality in music, Arnold Schoenberg asks:

*What is New Music?*

Evidently it must be music which, though it is still music, differs in all essentials from previously composed music. Evidently it must express something which has not yet been expressed in music. Evidently, in higher art, only that is worth being presented which has never before been presented. There is no great work of art which does not convey a new message to humanity; there is no great artist who fails in this respect. This is the code of honour of all the great in art, and consequently in all great works of the great we will find that newness which never perishes, whether it be of Josquin des Prés, of Bach or Haydn, or of any other great master.

*Because: Art means New Art.* (Schoenberg 1984, pp. 114–115; italics in original)

I suggest that the “new” to which Schoenberg refers here is a new organization of preexisting music, be it notes or small groupings of other already composed works. The new “messages” that Schoenberg alludes to may in fact be similar rearrangements of old messages (e.g., see chapter 5 of this book).

Creativity, then, is not a “bringing forth something that was previously nothing,” but rather a revelation of important connections between things that already exist. Originality thus becomes a synthesis and not a new “something.” Boden notes that:

Cynics may deny that one ever gets anything for nothing, but most people apparently assume that one can get something *from* nothing. Indeed, the first definition of “create” listed by my dictionary is “to bring into being or form out of nothing.” The medieval theologians of Islam, Jewry, and Christendom showed that this assumption can be questioned at the metaphysical level. What is more to the point, it can be queried at the psychological level also. Perhaps the new thoughts originated in creative thinking are not wholly novel, in that they have their seeds in representations already present in the mind? And perhaps they are not wholly inexplicable, in that something can be said about ways of manipulating familiar representations so as to generate others that are somehow fresh, or original? (Boden 1987, p. 298)

“New” art, then, consists of a reassembly of already existing art. One might argue that the smaller the reassembled bits of previous art, the more original and creative the “new” art is (e.g., formalisms such as fugues possibly being more original than

more intuitively composed forms). However, one cannot argue the notion of reassembly as creativity.

As an example of algorithmic musical creativity that seems to rely heavily on originality as its form of creativity, I submit a 2003 composition called *Endangered Species*, for chamber orchestra and electronic tape. This work represents a form of what Margaret Boden calls historical creativity (Boden 2004, p. 2) due to the rules used and the manner in which these rules are applied. In order to adequately describe these rules, I present some background information.

Boden distinguishes between “P-creativity” and “H-creativity” in the following way:

What you might do—and what I think you should do in this situation—is make a distinction between “psychological” creativity and “historical creativity” (P-creativity and H-creativity, for short). P-creativity involves coming up with a surprising, valuable idea that’s new *to the person who comes up with it*. It doesn’t matter how many people have had that idea before. But if a new idea is H-creative, that means that (so far as we know) no one else has had it before: it has arisen for the first time in human history. (Boden 2004, p. 2)

During the latter third of the twentieth century, Alexander Cairns-Smith developed a theory on the origin of life based on crystals, the only other self-replicating matter in the known universe (Cairns-Smith 1971). The results of Cairns-Smith’s research, while not currently a part of academic dogma, are generally well received by the scientific community. What I find most intriguing about Cairns-Smith’s theory is that it assumes that life originated from nonorganic matter as a natural consequence of universal processes, rather than as a special case (e.g., lightning striking the primordial soup). This theory underscores, I profoundly believe, that we are doomed to extinction if we do not maintain earth’s natural resources. The work *Endangered Species* refers, then, to both organic and inorganic matter. *Endangered Species* is algorithmically created and based on proportions found in certain crystals as described by Cairns-Smith.

The music of *Endangered Species* presents unique challenges for listeners. For example, the work is not divided into sections and phrases—at least not into easily defined sections and phrases—as one typically expects of most traditional music. In some ways this makes aural analysis easier, since the music follows a single gesture. In other ways, determining the structure of this work, for example, poses difficult problems. The style—which I call *complex minimalism*—makes the texture at once simple and intricate. These characteristics evoke the notion of minimalism in that material is revealed so slowly that each nuance, every slight change in pitch, dynamic, and/or timbre, is heightened. The word “complex” comes to mind here because the

music gives the impression that it continuously changes, yet never really changes at all.

These impressions of stasis and momentum, while obviously contradictory, give the style its uniqueness, though other instances of this kind of minimalism predate it. None of these other instances, however, were known to the program that created *Endangered Species*, though this ignorance does not exempt it from Boden's (2004) P-creativity. I would, however, contend that the interfering processes involved in this style—particularly in terms of timbre—create a new style quite unlike that found in the music of, for example, György Ligeti or Henryk Górecki.

Figure 1.10 is an excerpt from *Endangered Species*. As can be seen, the overall musical texture remains much the same from beat to beat. The entire ensemble plays a majority of the time, with entrances and exits often occurring without metric predictability. The pitches, while themselves seemingly unrelated and to some degree unorganized, accumulate into complex harmonic fields that, while slowly evolving, often seem similar and static. At the same time, however, looking and listening closely to any single small fragment of music will demonstrate how the music changes from instant to instant, with masked entrances—the pianos or harp initially obscuring simultaneous entrances in other instruments—and with dynamic crescendos and diminuendos shifting the overall pitch content.

*Endangered Species*'s achieved effect is similar to viewing a complex landscape where one may simply grasp the overall shape of the scene or follow the intricate details of light and shade, of similar and contrasting colors, of general and specific textures, and so on. The basic concept of this particular work—the plight of the endangered species in our environment—fits well with these kinds of musical choices.

Complex minimalism, as expressed in *Endangered Species*, has an interesting effect on most listeners—a sort of three-stage adaptive process. Initially, many listeners find the music interesting and full of color. However, after a few moments, when these listeners realize that the music is not changing very much, a sense of monotony sets in. After all, most listeners are accustomed to more narrative-like musical structures, where a musical “plot” pits one idea against another, and where some kind of resolution occurs. After relaxing and letting their expectations wane, listeners then begin to hear the music differently: they begin to unlock the sounds they are hearing, and realize that important changes are taking place at the more atomic levels of the music. Once listeners reach this third level, they are, as I see it, attuned to the music in a more natural way and able to hear it freshly from one moment to the next. One can find a similar style in the music of Claude Debussy, Karlheinz Stockhausen, and many other composers. However, the manner in which *Endangered Species* proceeds is, I feel, unique.

# Endangered Species

David Cope

The musical score for "Endangered Species" by David Cope is a complex orchestral work. It features the following instruments and parts:

- Flute:** Part 1 with dynamic markings *ff*, *f*, *ff*, *n*, *ff*, *n*, *ff*, *n*, *ff*, *n*, *ff*, *n*. Performance instructions include *8va*, *breathy*, *normale*, and *bend*.
- Clarinet in Bb:** Part 1 with dynamic markings *ff*, *f*, *ff*, *n*, *ff*, *n*, *ff*, *n*, *ff*, *n*.
- Tenor Sax:** Part 1 with dynamic markings *ff*, *f*, *ff*, *n*, *ff*, *n*, *ff*, *n*, *ff*, *n*. Performance instruction: *(breathy)*.
- Percussion:** Includes Tam-Tam, Timbales, Bells, and triangle. Dynamic markings include *ff*, *sf*, *ff*, *f*, *sf*, *ff*, *sf*.
- Harp:** Part 1 with dynamic markings *ff*, *sf*, *ff*, *sf*, *ff*, *sf*.
- Piano 1 & 2:** Both parts with dynamic markings *ff*, *sf*, *ff*, *sf*, *ff*, *sf*, *ff*, *sf*, *ff*, *sf*, *ff*, *sf*.
- Electronic:** Part 1 with dynamic markings *ff*, *f*. Performance instructions include *4"*, *8"*, *12"*, and *16"*.
- Violin:** Part 1 with dynamic markings *ff*, *f*, *ff*, *n*, *ff*, *n*, *ff*, *n*, *ff*, *n*, *ff*, *n*. Performance instructions include *(tip)*, *(frog) 8va*, *(tip) sul tasto*, *normale*, and *8va*.
- Cello:** Part 1 with dynamic markings *ff*, *f*, *ff*, *n*, *ff*, *n*, *ff*, *n*, *ff*, *n*.
- Contrabass:** Part 1 with dynamic markings *ff*, *f*, *ff*, *n*, *ff*, *n*, *ff*, *n*.

Figure 1.10  
An excerpt from *Endangered Species*.

## Pisces

The musical score is titled "Pisces" and is presented in three systems. The first system (measures 1-9) includes parts for Violoncello Solo, Violin I, Violin II, Viola, and Cello/Bass/Basso Cont. The tempo is marked as quarter note = 72. The second system (measures 10-18) features a Violoncello Solo part with a tempo marking of quarter note = 10, and parts for Violin I, Violin II, Viola, and Cello/Bass/Basso Cont. The third system (measures 19-26) continues the Violoncello Solo part with a tempo marking of quarter note = 19, and parts for Violin I, Violin II, Viola, and Cello/Bass/Basso Cont. The key signature has one sharp (F#) and the time signature is common time (C).

**Figure 1.11**  
The opening of a Vivaldi-style cello concerto, second movement, by Experiments in Musical Intelligence.

Interestingly, the monolithic nature of this work results from almost fifty years of musical evolution that occurs only in my algorithmic compositions, not in the style of my other, more traditionally narrative music. *Spires* of 1956 (see discussion in chapter 2 of this book), *Pleiades* from the early 1980s, and the set of three algorithmic piano sonatas completed in the early 1990s all predate *Endangered Species* with similar nonnarrative forms. *Endangered Species* is nonetheless the only one of these works involving complex minimalism. However, the originality of devising this musical style in no way overshadows the creativity necessary to maintain the subtle interleaving of pitch and timbre that constitutes the essence of *Endangered Species*.

In contrast to *Endangered Species*, and as a proof that striking originality need not be a trademark of creativity, figure 1.11 shows the opening of the second movement of a Vivaldi-style cello concerto created by Experiments in Musical Intelligence. The music in figure 1.11 has few if any stylistic surprises, and for those familiar with baroque music, the style here seems strikingly less original than the music in figure 1.10. However, the music of figure 1.11 *was* composed using what I feel—and will describe in detail in chapters 9 through 12—are very real creative processes, processes that at least equate in value to those present in figure 1.10.

Originality, often considered a hallmark of creativity, is—for me, at least—but a fraction of what constitutes *real* creativity. This real creativity cannot be mimicked by shocking unpredictability or replaced by conspicuous originality. Rather, this real creativity results from an “initialization of connections between two or more multifaceted things, ideas, or phenomena hitherto not otherwise considered actively connected” that often occurs in the subtlest manifestations of art. Creativity should never be confused with arbitrary or convenient contrivances that simply take any road untried for the sake of novelty.