Bever, T.G. (1987). The aesthetic basis for cognitive structures. In W. Brand & R. Harnish, (Eds.), The representationof knowledge and belief (pp. 314-356). University of Arizona Press

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The Aesthetic Basis for Cognitive Structures

A man does not show his greatness by being at one extremity, but rather by touching both at once.
PASCAL

Introduction and Summary

This paper concerns the cognitive, neurological, and formal bases for indigenous skills such as human language. In particular, which linguistic universals are unique to language, and which are attributable to general properties of human mind? Students of natural language with a wide variety of theoretical assumptions agree that grammars have several interesting properties that must be explained.

(1) There are distinct systems of linguistic knowledge, e.g., phonetics, phonology, morphology, syntax, semantics.
(2) No system can be induced from the others.

Grammars specify the relations between sounds and meanings. Each of the systems of knowledge in (1) represents a logical stage in the sound/meaning pairs: the existence of such systems has a clear functional basis, allowing for representation of intermediate regularities. It is less clear why the relevant regularities in one system cannot be defined as a direct function of regularities in another system. For example, syntactic categories cannot be defined in terms of semantic categories—syntactic gender of nouns almost never completely reflects semantic gender, syntactic transitivity of verbs rarely follows from semantic transitivity.

The inability to induce one system from another is puzzling. If one

could be derived from another, the expressive power of languages would remain unchanged, whereas the grammatical description would be simplified. A grammar in which semantic gender predicts syntactic gender and in which semantic transitivity predicts syntactic transitivity would be much simpler and presumably easier to learn. Yet, grammars never have such simplifying properties—why? In this paper, I suggest that the functional role of the existence of noninducible systems of representation is developmental: they facilitate the experience of language acquisition as an aesthetic and problem-solving activity. Such activities are intrinsically enjoyable in humans. That is, it is the very fact that systems of linguistic representation cannot be mutually defined that creates an intrinsic motivation for the acquisition of a multisystemed grammar.

The most natural way to investigate the uniqueness of linguistic structure is to compare it with structures found in other cognitive behaviors. However, there is a great difficulty that infuses the study of indigenous mental skills—each exists with a palpable function. For example, it is always a vexed question whether the regularity of language behavior is due to its structure or to the communicative and representational function it is serving. Similar problems arise in understanding the nature of object recognition, the use of the number concept, reasoning, and so on. In each case, the naturally occurring behavior is highly functional and may therefore have many properties that are uniquely shaped by its particular function, not by basic cognitive structures.

There are two standard methods to minimize the ways in which a skill's function obscures our insight into its mental nature. One is to examine the behavior of infants, before they have started functionally to apply a skill; much of the current attention to infant capacities exemplifies this approach (cf. Mehler 1984). The other technique is to construct arbitrary situations for adults to solve, which tap the structural properties of the skill without having any real function: linguists do this when they ask informants to render abstract grammaticality judgments; experimental psychologists do it when they require subjects to perform on otherwise meaningless laboratory tasks.

There is a third approach, which goes back to the initial stages of Fechnerian psychophysics—namely, the study of aesthetic judgments, a behavior with no apparent direct function. Aesthetic behavior reveals to us what the mind does when it has only its own purposes to serve and may thereby clearly reveal its real processes. Of course, nothing is *totally* pure in the life of the mind—even aesthetic activity can be viewed as serving the functions of conceptual hedonism. But, at least it must reveal to us what the waking mind likes to do when nothing external matters.

The structure of this discussion is the following. First, I briefly review the limitations of the current optimal-arousal-level model of aesthetically satisfying experiences. I then discuss simple demonstrations of two basic mental processes in perception—perceptual schemata automatically form representations and more conceptual levels of analysis integrate conflicts in those representations. Resolving a representational conflict by accessing a new overarching representation itself releases a momentary surge of enjoyable emotional energy, traditionally known as the "aha" or insight reaction when it occurs in explicit problem solving.

A definition developed with several colleagues (Lasher, Carroll, and Bever 1983; Bever, Lasher, and Carroll, in press) relates the two kinds of processes that occur during perception and problem solving to the processes involved in an "aesthetically satisfying experience." On this definition, such an experience stimulates a conflict in perceptual representations, which is resolved by accessing another representation that allows the two conflicting ones to coexist. As in explicit problem solving, it is accessing the conflict-resolving representation that releases the surge of enjoyable energy characteristic of a satisfying aesthetic experience. I will show that this definition allows for the explanation of the preference for certain traditionally preferred folk objects: the golden mean rectangle, the rhythm "shave and a haircut, two bits," the song "Happy Birthday," and the child's tale "Goldilocks."

The principles of aesthetic activity provide a cognitively intrinsic motive for the child to learn a form of language that has independent systems of representation: multisystemed language is learned because it is aesthetically—and therefore emotionally—satisfying to do so. In this way, the aesthetic principles constrain the form of learnable languages to have independently defined systems of representation.

Such a view has broader implications for the learning of abstract structures of many kinds—in general the successful application of a representation that integrates other representations releases an intrinsically reinforcing experience. Accordingly, we can view the child's acquisition of abstract representational structures as endogenously motivated by his* aesthetic impulses toward an integrated system of mental representations. This means that there is a strong constraint on the kinds of mental structures that children can learn to integrate—the structures must potentiate experiences that meet the aesthetic principles.

*A note on pronouns and their syntactic gender: The historic generic personal pronoun in English is syntactically masculine. This is a typical example of the mismatch between syntactic and semantic categories mentioned in this essay. I use the syntactically masculine pronoun to refer to all humans, while recognizing the linguistic arbitrariness of this choice.

The Current Theory of Aesthetic Satisfaction

A current psychological theory of the basis for aesthetic judgments is that we prefer an optimal arousal level (Berlyne 1971, 1974). This theory goes back to Wundt's notion that as stimulus intensity increases, it excites first a positive and then a negative affect. In the modern reformulation (Fig. 1), the optimal level is the result of summing a positive and negative function related to the intensity of an experience—preferred stimuli are those that involve an intermediate range of intensity. This is the "goldilocks" theory of aesthetic experience—what humans like must not be too intense, not too weak, but *juuuuuust* right. Such a theory is acceptable insofar as it is

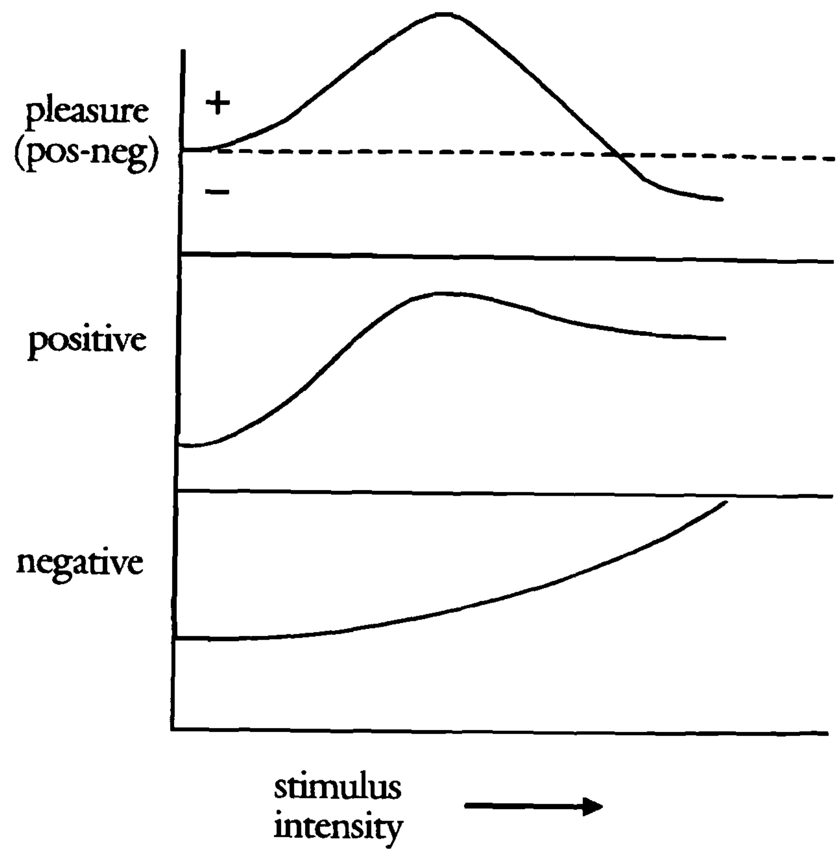

Fig. 1. The two-component theory of the relation between stimulus intensity and pleasure (Berlyne 1971, 1974).

nearly tautological, but difficulties arise as soon as one attempts to apply it to real art forms. Music is one of the flagship cases of this approach: an ideal melody is one of "optimal complexity." Optimal complexity is in turn defined as an "optimal level of predictability" of a note sequence—that is, we expect to hear a particular sequence but are most satisfied with a sequence that slightly departs from our expectation.

It is clear that this is wrong, even on trivial formal grounds. Often the musical form itself dictates what must occur, as may the listener: anybody who has endured the indeterminate end of a Bruckner symphony knows that expecting the final chord is best satisfied by in fact hearing it. The definition of ideal "melodic complexity" must lie in the interaction of perceptual and representational mechanisms with melodic form, not post hoc predictability. Even worse, the central assumption of the arousal theory of aesthetics cannot explain how one could possibly enjoy a melody the second time, never mind the thousandth time, since the expected tone sequence is the actual tone sequence once the melody has been memorized. It is striking how theorists in the optimal-arousal school deal with this simple fact—generally they argue that our memory is mercifully short, so we keep forgetting what we have heard and are able to be *re*-surprised by it afresh to ***juuuuust*** the right degree (Meyer 1967).

The Study of Mental Representations in Children and Adults

The optimal arousal theory flows from a general principle of behavior regulation enunciated by Wundt. Let us see if we can do better by considering more recent theories of mind. Existing research and theories exemplify two processes relevant for this discussion—representation formation, and conflict integration among representations.

Representation Formation

If current psychology accepts anything at all, like Helmholtz (1895, 1903) it accepts the view that the mind is a representation-bound organ. I wish to avoid entanglement in the many idiosyncratic and technical differences between competing psychological theories of perception—the formation of representations. Most theories generally agree that the mind forms partial representations of reality by transducing neurologically coded information in terms of internal schemata. Many arguments revolve around the question of whether such schemata have their effect before final recognition of an object (Helmholtz 1895) or after, if at all (Gibson 1962), but the theories agree that such schemata exist.

The most obvious of such schemata are gathered under the rubric of gestalt principles of basic form. An important gestalt principle for this discussion is the unifying force of unit repetition. For example, a series of repeating dark dots form a line, a series of repeating motives form a shape (repeating rectangles), a series of repeating pairs of weak–strong beats elicit perception of an underlying rhythm (Fig. 2). In each case, the repeating units are integrated into a larger whole: a line, an evenly divided figure, a rhythmic pattern beat that conveys a particular meter.

When a unit is repeated, but backward, it defines a "symmetry"—and symmetries are also powerful organizing principles for percepts. For example, a line that goes up and down can be perceived as unified, opposite motives are perceptually unified, a symmetrical pattern of beats is unified (' ''' ') (Fig. 3).

Gestalt schemata are characteristic of the output of systems that form representations—that is, gestalt properties are of theoretical interest because they attest to the existence of automatic representation-forming mechanisms, which impose immediate representational organizations on sensory information. The nature of these representation-forming mechanisms has also been the subject of recent discussion. In their purest form, they are described metaphorically as the output of opaque "modules," mechanisms that automatically transduce information of one kind into another (Posner 1980; Fodor 1983); alternatively, they can be viewed as

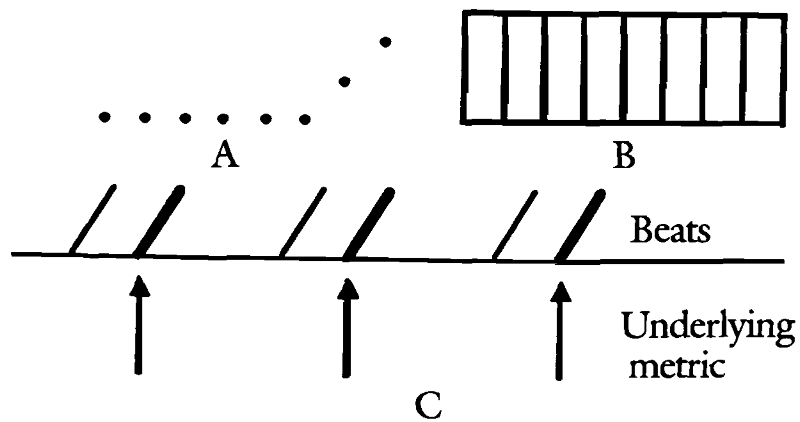

Fig. 2. Examples of the perceptually unifying role of the repetition of individual units; (a) repeating data form a line, (b) repeating rectangles form a larger rectangle, (c) repeating pairs of beats form an underlying metric.

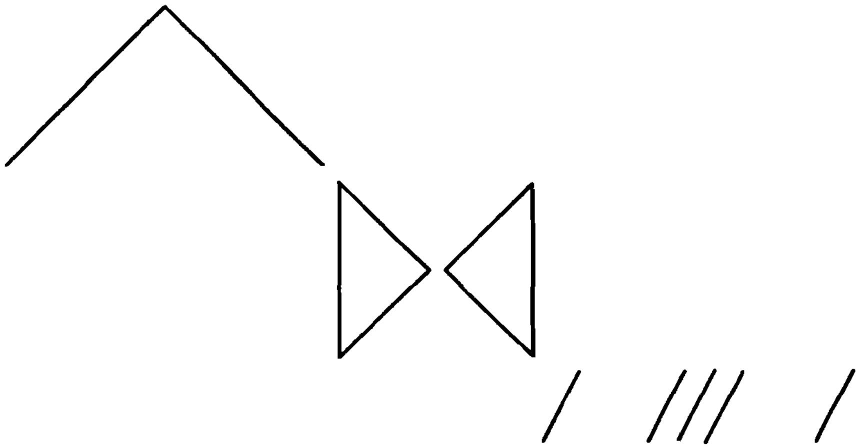

Fig. 3. Examples of the perceptually unifying role of symmetrical units.

"automatized" skills, cognitive mechanisms that have become so habitual that they operate autonomously, without conscious control (Neisser 1963; Posner and Snyder 1975; Shiffrin and Schneider 1977). This controversy revolves around the modularist's claim that the mechanisms are innate, involve unique processes, and are uninfluenced by current knowledge. In the present discussion, we can avoid this controversy: the crucial property of the perceptual systems is that once acquired, they characteristically operate *automatically* and autonomously. They provide an immediate cascade of partially independent representations coordinated with every input.

Conflict Integration (Conceptualization)

If the mind automatically forms representations, by way of distinct automatic mechanisms, the initial analysis of a single object will yield representations that conflict. Representations "conflict" when they present analyses that are incompatible along some dimension. For example, if I blink my eyes while a hummingbird moves from one flower to another, I am presented with two successive views of "hummingbird" in different locations and with differing silhouettes—the needs of worldly comprehension require that I make an intuitive decision about how many hummingbirds there are. In fact, hummingbirds move so fast that I might not even have to blink my eyes for this representational problem to arise. Accordingly, the mind must have a way of reconciling representational conflicts. The corresponding mental principle is that conflicts between representations can be resolved by accessing a separate conceptual representation that integrates the conflicting ones—for example, I might intuitively develop a representation of a single hummingbird in rapid motion between two locations. The conflicting representations are allowed to coexist within the overarching framework of a single-bird-in-motion.

Helmholtz (1903) assumed that such resolving entities are basically direct associations, underlying "unconscious inferences." It is interesting that whereas such inferences may affect our representation of the world through unconscious mechanisms, they have a direct impact on our conscious perception of reality. Indeed, we might suggest that the conscious organization of what is perceived as reality is often a representation that exactly reconciles apparent conflicts in other representations. This interpretation of consciousness reappears at the end of the paper.

Representational Integration in Adults

In everyday perceptual life, the autonomic and conflict-resolving processes occur so fast that they are difficult to observe and study. There are, however, simple laboratory demonstrations of their existence. Consider first an example of the extraction of "prototypes" from varying presentations of an object. If subjects successively view dot patterns in which the dot placements vary randomly from a single underlying pattern, the subjects eventually come to believe that they saw an exemplar of that underlying pattern, even when they never did (Fig. 4) (Posner and Keele 1968). This is a simple but precisely controlled demonstration of the extraction of prototypical representations from varying presentations of an oject. On the conflict-resolution analysis, the viewer abducts the underlying concept of the shape as an integrated representation of the conflicting images seen

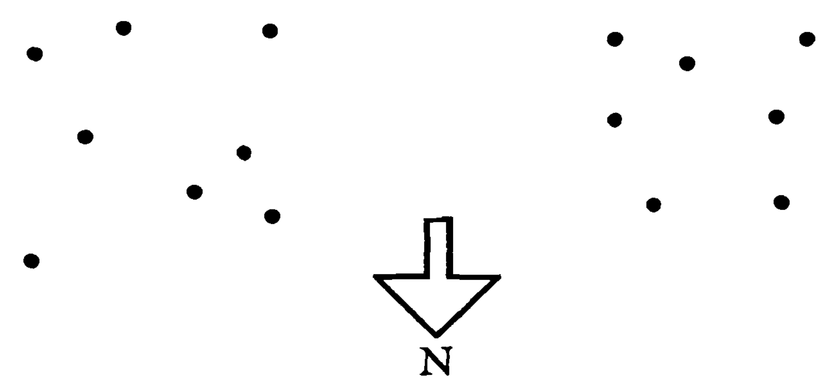

Fig. 4. Sequential perceptions of distinct data arrays are eventually organized in terms of the underlying figure from which each array randomly deviates (Posner 1969).

over time. I say "abducts" because no *exact* ideal instance of the underlying pattern could ever be presented.

In this case, the integrating representation is the presumption of a single static object pattern. There are other well-studied instances of representational conflict resolution that involve the abduction both of a presumed object and a directed dynamic relation between its different perceptual representations. A classic example is the "phi-phenomenon," the perception of an image of motion when an object is briefly presented first in one place and then in another. An everyday example of this is the perception of a yellow traffic light; if it blinks back and forth from one lamp to another we perceive back-and-forth motion, even though we know that the light does not move. Our analysis of this phenomenon is straightforward—one is presented with superficially distinct stimuli, a light on the left and then a similar light on the right. The initial perceptual mechanisms assign the two lights largely identical structure, leading to a representational conflict over where they are. The integration of this conflict is simply the perceptual assumption that the light moved from the first position to the second. The viewer automatically contributes the percept of motion that subsumes the otherwise conflicting percepts [see Rock (1983) for a wide-ranging discussion of perception viewed as problem solving].

Such an example of inferred motion might seem to be the quintessence of a laboratory curiosity, but, after all, it is the most typical of experiences. For example, if I pass one hand behind the other, you see the sequence as continuous, inferring the motion during the period that you cannot see the moving hand. Since much of our visual world is made up of partially obscured objects, it is clear how common the abduction of motion really is. It is no surprise that this phenomenon has become a major area of investigation of modern psychology.

One can use apparent motion between more complex figures to explore what kinds of motions the mind easily imposes (Shepard and Cooper 1982; Shepard 1984; Shepard and Metzler 1971). In a typical study, arbitrary block-figures like those in Figure 5 are presented to a subject. The task is to decide if the pair of figures indicates the same object in a different orientation. A striking result is that viewers assume that the object itself does not change, when a possible physical motion can be invoked to explain the shift from one presentation to another. This explains the demonstration that the amount of time it takes to decide that the second of two such figures is the same object as the first is the same relative time as it would take a constant-speed device physically to carry out the actual rotation. This reflects the intuition that when making such a same vs. different judgment, we imagine the motion of one configuration of the figure rotat-

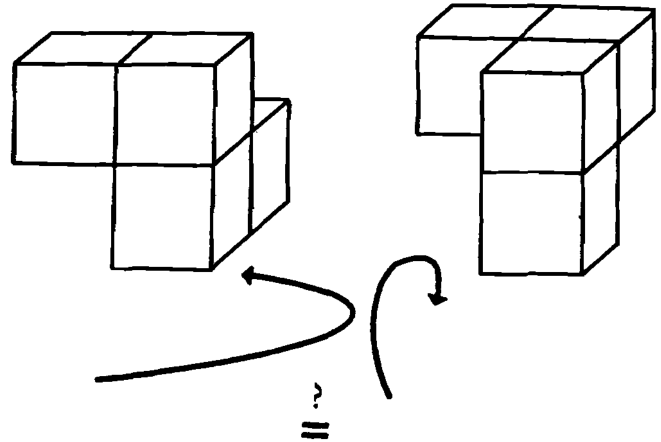

Fig. 5. Evidence for the image of motion: the time to judge if the figures are spatial rotations corresponds to the relative time to carry out the actual rotation (Shepard and Cooper 1982; Shepard and Metzler 1971; the actual studies characteristically use more complex figures).

ing towards the other. This time-taking abstract image of motion demonstrates the "psychological reality" of intermediating representational processes—in this case, an abstraction of the complex movement of a meaningless figure from one orientation to another.

Representational Conflicts in Infants

It takes a special situation like matching meaningless figures to bring out effects that one can study experimentally with normal subjects. Adults have organized the separate processes of representation formation and integration to a degree which ordinarily obscures their separate operation. Infants, on the other hand, can display behaviors that reflect the functions separately, drawn out in time.

Consider a standard example of an infant's behavior—the game of peek-a-boo. There are several things to explain about this game, how it works, and why the infant likes it so much. (This analysis comes more or less straight from Piaget, without any intention to endorse the Piagetian explanations of development, only their description.) On this view, the child playing peek-a-boo is playing with the problem of "mommy-permanence" (Piaget 1950, 1954). The presumption is that the child can develop a representation of what is in front of him, although there are not yet any visually accessible permanent concepts.

In the game, mommy appears as a visual image, then disappears, then

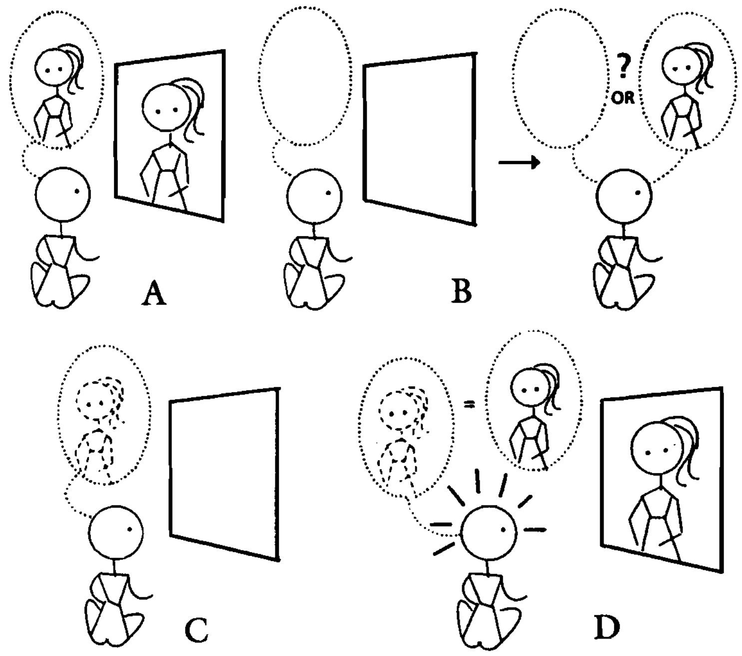

Fig. 6. Stages in the game of peek-a-boo. (a) The child represents the present mother; (b) the child contrasts the recent image of the mother with her absence; (c) the child formulates the concept of a permanent mother; (d) the child confirms the concept with the reappearance of the mother.

reappears, then disappears, etc. (Fig. 6). The child is left with a bewildering phenomenon—first mommy is there, then she isn't. This conflict raises the representational question, IS THERE A MOMMY OR ISN'T THERE? The resolution of the mommy-just-present and mommy-now-absent representations is an inner representation of a permanent mommy, resolving the appearance/disappearance representational conflict. A similar analysis explains the slightly older infant's frequently exasperating preoccupation with looking at a rattle in its hand, looking away, dropping the rattle, listening to the noise, and finally looking down to check where it went. The infant is experimenting with the integration of different kinds of sensory inputs from a single object. The perceptual concept of object permanence integrates the conflict between his visual, motor, and auditory representations. This kind of conflict-integration model is characteristic of Piagetian views of knowledge that emerge later, covering more abstract kinds of knowledge such as number and logic. In each case, a more conceptual mode of representation is accessed as the basis for resolving a representational conflict (Bever 1983). Of great importance for this discussion is the fact that the conflicting representations can remain in the child's

mental repertoire, even while the more conceptual representational mode sets them in an orderly relation to each other.

Of course, playing peek-a-boo is manifestly a social activity, and here again we face the problem of a competing functional explanation of why the child likes the game. Clearly, the child is motivated to play the game at least in part because it is communicative. On my interpretation, a separate motive is that it allows the child to solve and re-solve the problem of person-permanence. Each time his expectation of mommy is fulfilled, the appearance/disappearance conflict is resolved again. And, as you can see, I assume it to be obvious that human beings get a charge out of solving problems—peek-a-boo is simply an early problem-solving game.

The Emotional Impact of Solving a Problem

It is useful at this point to review the structural and emotional phenomena that occur when an adult solves a problem. The original observations by Dunker reveal an initial formation of representational conflicts, discovery of a resolving representation, and an attendant "aha" reaction (Duncker 1945). For example, in trying to solve the problem of how to get X-rays to destroy an embedded tumor, subjects chracteristically waver back and forth between suggesting a hypothetical X-ray gun that would shoot the X-rays at the tumor, destroying both it and the intervening tissue, and a hypothetical gun that would send the X-ray only the right distance, so that it would not destroy the intervening tissue. The ultimate solution, of a focusing lens, resolves the two ways of thinking about the gun: the gun sends the rays at the tumor but does so in a diffuse way until the lens focuses them at the right spot. Finding the integrating solution to the problem also releases a surge of emotion, "aha," that accompanies problem solving. Characteristically, recognizing the solution occurs in two phases: first the subject has the intuition that he "sees" the solution, then he checks it out. It is the first, intuitive phase that is associted with the "aha" reaction.

The emotional force of problem solving is interesting in its own right. This discussion so far has presupposed that it is a basic property of human cognition to get a thrill from solving a problem. In the appendix to this paper, I speculate on why the problem-solving thrill exists. For the moment, I am using the formal similarity between early cognitive growth and natural problem solving to define a set of processes that may occur in aesthetic experiences. From that standpoint, what is important is that the first intuition that a problem is solved evokes a burst of pleasurable energy. Whatever its source, we know this to be true.

To summarize so far: there are two fundamental processes that occur when we perceive and represent the world. We automatically form representations of what we perceive. We integrate conflicts in those representations by accessing perceptual and conceptual knowledge of a variety of kinds. The integration of such representational conflicts is itself accompanied by a release of emotional energy. These processes are functional in everyday perception, conceptual development, and problem solving.

The formal similarity of the processes underlying these three kinds of everyday activities does not mean that they are theoretically identical. One difference between perception, cognitive development, and problem solving lies in the degree of automaticity with which the conflict-resolving representation is formed. In perception, forming a constant object, or one in movement, clearly draws on integrating mechanisms that are nearly as automatic as those which form the conflicting representations in the first place. Problem solving is at the other extreme; in that activity even some of the initial representation-forming mechanisms may be elaborate and conscious. The automaticity of the conflict-resolving mechanisms in cognitive development lies between these extremes: the child is solving intuitive problems and thereby is elaborating a growing permanent set of mediating and integrating systems of representation.

Aesthetic Judgments

The overall goal of this paper is to explore the possibility that basic mental operations can explain the existence of some specific properties of language. The preceding review summarizes the importance and pervasiveness of forming conflicting representations and integrating them. Yet, each of the examples I discussed has a clear functional role; without a theory of functions and their relation to behaviors, we cannot be sure that the representational processes are not adaptations to the functions they serve. I introduced this essay with the point that aesthetic activity may directly reveal the operation of the mind, free of worldly functions. Whatever the mind chooses to do during aesthetic activity might display its inner workings, unstressed and undistorted by the need to solve real problems. Accordingly, I now turn to examples of aesthetic activity. Drawing on the generally accepted processes just discussed, I am going to test, on everyday experiences, the principle of "The Aesthetically Interesting Experience" that my colleagues and I have been developing for the past few years (Lasher, Carroll, and Bever 1983; Bever, Lasher, and Carroll, in press).

On this theory, an experience is aesthetically interesting if it involves *conflicting representations that are integrated within the organizing framework of a distinct representation*. That is, it has exactly the same formal properties as perception, cognitive growth, and problem solving. It is important to note that we focus on the formal properties involved in the simultaneous presence of the distinct representations, rather than the exact temporal processes involved in forming their mental correlates. We are attempting to construct a "generative theory of aesthetics," with the virtues, as well as the limitations, of formal models of other kinds of mental activities. At the end of the discussion, I will point out some of the general features of aesthetic experiences that differentiate them from perception, cognitive growth, and problem solving.

My presentation focuses on examples of folk aesthetics rather than the fine arts because of my concern with objects of psychologically natural preference. Professional art reflects functional and historical influences of its own. Indeed, there is no reason to believe that professional art always follows any aesthetic principle whatsoever. But a simple object which is culturally and historically preferred over others is more likely to display the inner human aesthetic than is an arbitrarily motivated art object. Five folk objects display the operation of the aesthetic principles: the "shave and a haircut, two bits" rhythm, the golden rectangle, the song "Happy Birthday," the children's story "Goldilocks," and successful puns. In each case, the object stimulates a clear representational conflict and affords a resolution that integrates the initially conflicting representations. Furthermore, the integrating representation in each case is interpretably related to the social function that the object appears to serve.

Shave and a Haircut vs. Shave and a Massage

Consider the "shave and a haircut, two bits" rhythm. It has a definite social meaning: an attention-getting noise, "knock" or "honk." This is a widely known rhythmic tatoo: for example, in Latin American countries, motorists honk this at others whom they believe to have just behaved in a vehicularily miscreant manner (there is a ritual string of obscenities that go with it). What we must account for then is twofold. First, why is this rhythm so stable, even cross-culturally, and second, why does it have the functional meaning of a single attention-getting noise?

Consider a visual configuration of the rhythm and recall my discussion of rhythmic gestalt units (Fig. 7). The fifth beat divides the sequence into two parts of equal duration. But the first part is filled with two beats, whereas the corresponding portion of the second part is empty. This typical device opposes in time the two subsequences, identical except that the second has a gap where the first is filled. This, in part, explains the finality of the last two beats, since they occur just after an expectancy for beats has been failed.

Such a traditional analysis in terms of syncopation is consistent with the general representational view, but is not fully explanatory—it explains part

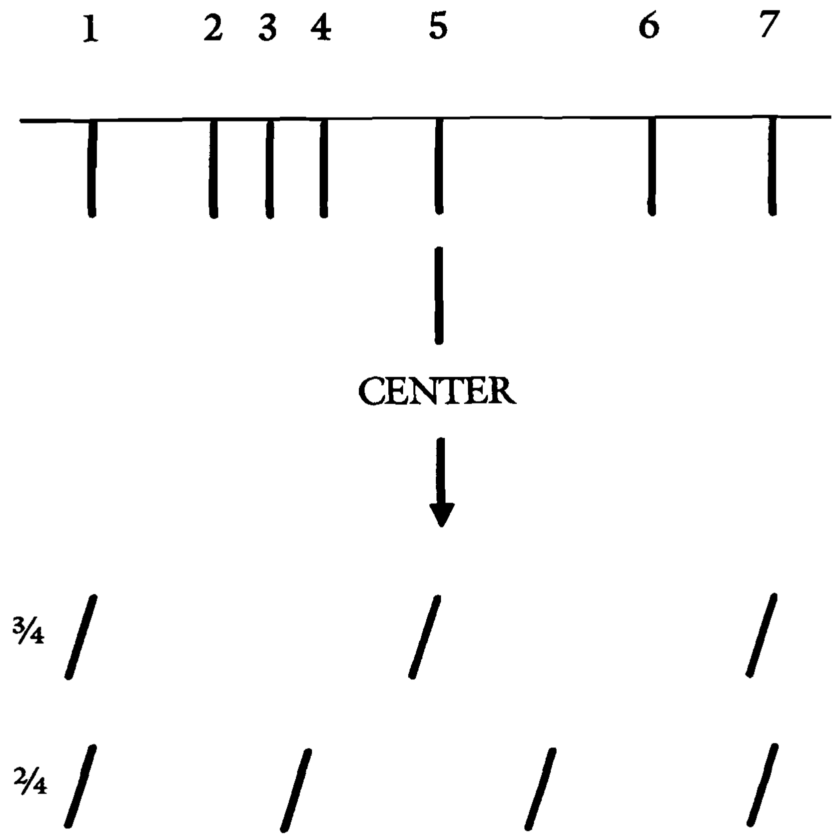

Fig. 7. Two metric analyses of a common attention-getting rhythm. The 2/4 metric places strong beats as in "shave and a haircut (pause) two bits"; the 3/4 metric places strong beats as in "shave and a massage (pause) two bits."

of the satisfaction of the last two beats but not in a way that accounts for the special status of the whole tatoo. To explain this, we must listen further. There is a temporal symmetry defined by the last four beats; this symmetry requires the fourth beat to be stressed, not the fifth (since the fourth beat corresponds to the final beat in this symmetric subpattern.) This interpretation imposes a 2/4 rhythm on the sequence as shown in Figure 7. This stress pattern is conveyed by "sháve and a háircut (pause) two bíts." There is a distinct symmetrical pattern, in fact the first five beats comprise the symmetric rhythm mentioned above. We can also see how the underlying rhythmic pulse coordinates with this, using the principle that stressed beats are interpreted as down-beats that begin each metric unit. On this interpretation, the whole sequence has a 3/4 metric with the strong

beats indicated as on the first, fifth, and seventh beats. This stress pattern goes with the phrase, "sháve and a masságe (pause) two bíts."

Hence, the organization in terms of symmetries imposes conflicting analyses of the underlying repeating metric. This conflict is itself resolved by the last beat, which is the first beat at which the two rhythmic representations both require a strong beat. Accordingly, the last beat is a satisfying resting moment: a brief representational conflict in the underlying rhythm is resolved at that point. This analysis of the last beat as a single conflict-resolving pulse also explains the general social meaning of the tatoo, namely as a single attention-getting noise.

The Golden Mean Rectangle

Consider a simple rectangle (Fig. 8). Why is it that certain ratios of sides seem to be more satisfying than others? Rectangles of approximately ratio 1.6:1 seem to be preferred over other ratios (Fechner 1897; Woodworth 1938). An ancient explanation is that the ratio of 1.6+:1 has an appealing pure property: this ratio guarantees that if a square of the short side is subtracted from the rectangle, it leaves behind another rectangle of exactly the same ratio (Fig. 9). This subtraction can be applied recursively: like turtles, it is rectangles all the way down.

In his investigation that confirmed the preference for the golden mean rectangle, Fechner argues similarly that 1.6:1 is the ratio which presents the greatest "purity" of rectangularity. Yet, this explanation does little to explain the preference for this particular purity—other ratios exhibit similarly pure mathematical properties of other kinds. The formal elegance of

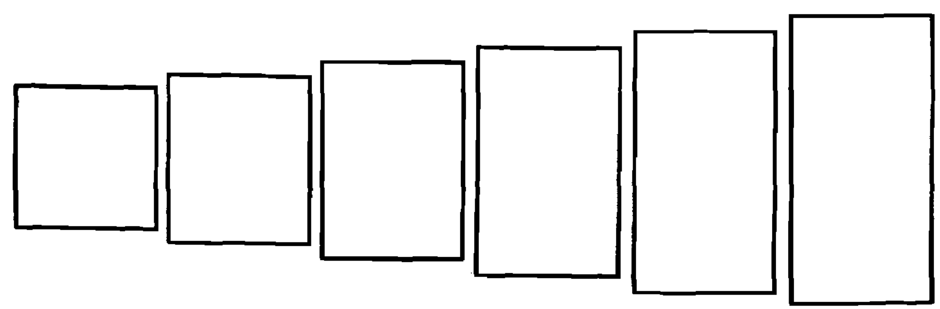

Fig. 8. Rectangles ranging in side ratios of 1:1 to 2:1.

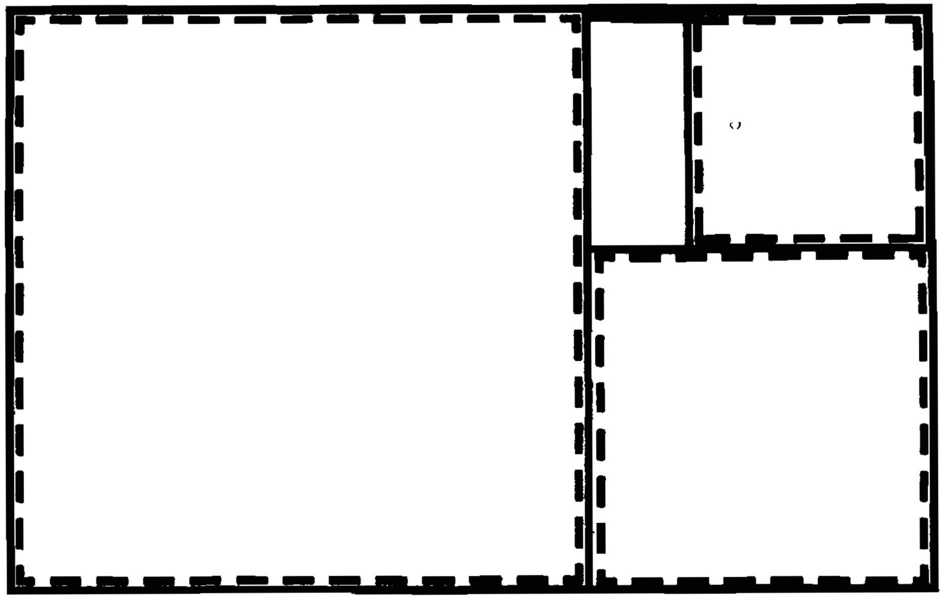

Fig. 9. Three stages of the recursive reduction of the golden mean rectangle: subtracting the square (dotted line) formed on the short side of each rectangle leaves a smaller rectangle with the same side ratios as the original.

such formulae does not reflect what the funtion of a rectangle might be, nor why the ideal ratio for that function is 1.6:1.

What, in fact, is the meaning of an ideal rectangle? That is, what does it convey? An intuitive description is that it is more than one square but less than two; somehow a rectangle signifies "two-ness" without actually displaying it literally. This explains at the outset why rectangles that are slightly larger than a square or slightly smaller than two squares are not preferred examples—they are too close to the conventional extremes to be ideal. The quintessential rectangle lies between the extremes. Woodworth put it this way: "The golden section rectangle appears typical for a rectangle, slim enough to be a successful rectangle, without being extreme."

Clearly, the ideal rectangle must lie on an ideal ratio between 1.8:1 and 1.4:1 to avoid blending with one extreme or the other. What does our aesthetic principle have to say about why the ideal ratio is approximately 1.6:1, when other natural candidates might be 1.5:1 or 1.67.1? First, the representation-formation process will impose squares on the rectangle as an immediate simple gestalt form of representation [see the articles in Pinker (1984b) for general discussions of theories of visual perception,

especially by Hoffman and Richards, and Ullman on the initial stages of perceiving simple figures. This initial analysis in terms of component squares is like the traditional analysis of the golden rectangle in terms of component squares. But what the traditional analysis missed is that there are *two* equally valid squares, one defined on the right side, the other on the left side.

This presents competing analyses, one in which the square is on the left and one in which the square is on the right. This does not set up a true representational competition for all rectangular ratios, however, because in some cases the overlapping squares themselves define a rectangle that can repeat to describe the whole rectangle in two dimensions. Rather than providing competing analyses, the overlapping squares yield a kind of representation that is identical to that of repeating rectangles. Thus, the simple gestalt law of repetition of elementary forms would provide a complete representation of such figures in two dimensions, with no need to access a different representational level to integrate initially conflicting representations.

Consider how this works for a rectangle with a ratio of 1.5:1. Overlapping squares imposed on this rectangle define three identical rectangles that exhaustively describe the figure (Fig. 10). Similarly, the ratio of $^5/_3$:1 defines a central rectangle of width $^1/_3$ and two bounding rectangles of

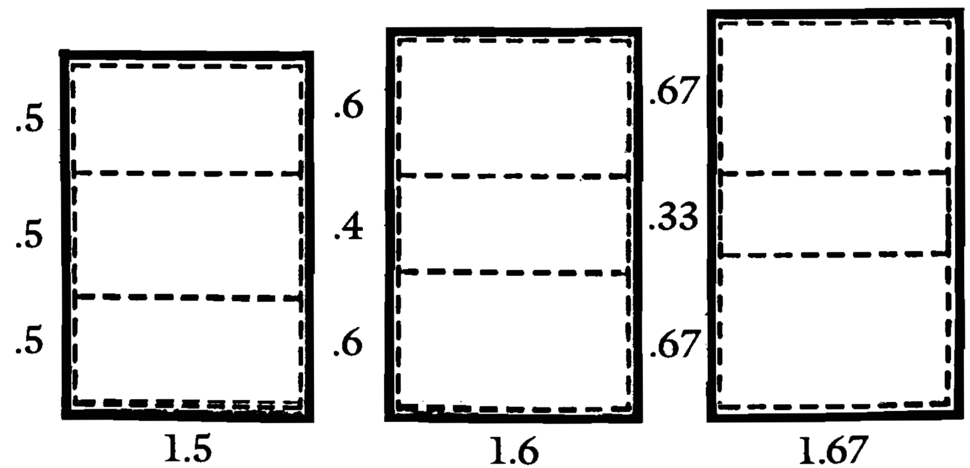

Fig. 10. Internal rectangles formed by overlapping two squares formed on the short sides of a large rectangle: in the 1.5:1 and 1.67:1 ratios the internal rectangle can repeat exhaustively and describe the entire large rectangle; in the 1.6:1 ratio (the golden mean ratio) the internal rectangle cannot describe the large rectangle.

width 2/3 into which it can repeat and completely describe the figure. Here, too, the full rectangle is exhaustively described by repeating the small rectangle defined by the overlap of the squares. In each of these cases, the two-dimensional analysis in terms of overlapping squares is consistent with a simultaneous two-dimensional analysis in terms of repeating rectangles: hence, the squares do not yield a representational conflict that requires accessing another representational form.

Now consider a rectangle with a ratio of 1.6:1, roughly midway between the other two ratios. In this case, the overlapping squares yield a rectangle with length 0.4, that cannot describe the whole figure repetition in two dimensions—one would have to divide it in half and then repeat the result eight times to exhaustively describe the large rectangle in two dimensions. Accordingly, the initial two-dimensional analysis of the golden rectangle into two overlapping squares does not afford a simply derived complete description of it. Hence, the 1.6:1 rectangle presents conflicting representations in two dimensions—either it is the left-hand square plus a leftover, or it is the right-hand square plus a leftover. An obvious resolving integration is to analyze the figure as ***having a third dimension***: this allows an analysis of the figure as having ***two*** overlapping squares, with one in front of the other. In this way, recourse to a conceptual third dimension affords a resolution of the representational conflicts yielded by the immediate two-dimensional analyses. This explains why the preferred ratio is 1.6:1 according to the aesthetic principle, which requires that conflicting perpetual representations be integrated by accessing a separate level of representation. It also explains the functional analysis of the rectangle as indicating "two-ness"—it evokes two simultaneous squares. (Note that it also predicts that the golden rectangle should excite more sensations of depth, a testable prediction.)

Happy Birthday!

Folk music is often composed but is usually culturally winnowed, so it can reflect the long-term effects of aesthetic principles. Consider as an example the song "Happy Birthday," which was originally composed but which seems to have taken on an aesthetically satisfying life of its own. That is, regardless of its origin, it has stood the test of aesthetically selective time. It has also acquired certain ritual functions that are explained by its particular aesthetic structure. Before reviewing the representational languages of music, notice what the social role of "Happy Birthday" actually is.

The most obvious fact about "Happy Birthday" is that it is a celebratory hymn, sung as a solemn recognition of somebody else's special day: the song puts the cap on the celebration. A birthday celebration is considered incomplete until "Happy Birthday" is sung—virtually every other convivial aspect can be dispensed with. Furthermore, the song is characteristically sung near the end of the festivity. To put it operationally, you can leave the party any time after the song is sung but not before: the song says "amen" to the happy occasion.

There is also a special kind of mystery-and-discovery ritual that goes with the singing of the song. Recall your youth of paper hats, rented magicians, rapidly melting ice cream, and mushy cake on floppy paper plates. The lights dim, a rustle approaches from the kitchen, an adult with a basso profundo starts intoning as a dirge, "happy birthday to you . . . ." You mouth along with the words until you get to the point where the person is named—at that point, everybody lets go with the worst string of obscenities that a five-year-old can muster ("happy BIRTHday dear Stinky-pants-in-his-underwear . . . "). That is, the song is really a mystery and a solution, revolving around whose birthday it is or what you are going to call the victim when you get there. The song really should be sung with the words, "Happy birthday to who? Happy birthday to who? Happy BIRTHday dear XXXXX, happy birthday to YOU." Even adults feel the naming tension: for example, when the song is sung at the next table in a restaurant, it is hard not to wait and see "who" the birthday celebrant is.

Now consider a little simplified music theory. [There are numerous ways to present the elements of music theory—in this case, I follow the style of Zuckerkandl (1959), which is appropriate for my purposes. I also use a pure graph notation to aid the nonmusical reader.] Melodies are composed out of scales defined along two dimensions, relative tone height and relative tone stability. Consider first tone height. Each melody is defined in part by a range of notes that it covers—a well-formed melody characteristically fills in all the notes in its range by the time it is over. That is, one of the representational schemata that listeners anticipate is a range of notes with the intermediate ones filled in. Consider "Twinkle Twinkle Little Star" (Fig. 11). The first phrase starts with an upward leap, and then the second descends and fills in all the intermediate steps.

This melody also illustrates that classical melodies are in a tonic key. A key is defined by a scale with seven notes dividing each octave. Characteristically, the tonic key is the first and last note of the melody, and often defines at least one end of the tone-height range. This is what occurs in the first phrase of "Twinkle Twinkle".

The analysis of a melody into a key gives a dimension to the notes in addition to their relative pitch: stability in the key. A functional way of thinking about the key stability of a note is in terms of the likelihood that a melody could stop at it. The most stable note is the tonic itself, the next most stable notes are the 3rd and 5th of the scale. The next most stable are the 2d, 4th, 6th, and 7th, and the least stable notes are those not assigned to the scale at all.

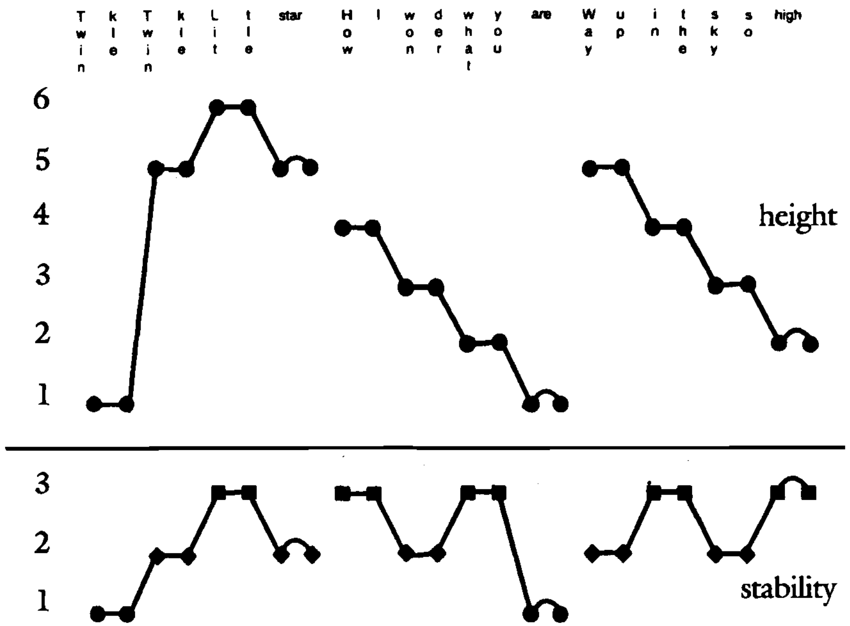

Fig. 11. Graphic representation of "Twinkle, Twinkle, Little Star," in which the notes of each melodic phrase are connected. The height dimension portrays the relative pitch of the notes. The stability dimension portrays the relative harmonic stability of the notes in the base key. (Note that the horizontal dimension portrays temporal order, but not exact rhythm.)

This notion of stability, sometimes referred to as "harmonic role" or "chroma," provides a representation of a melody independent of relative tone height, as shown in the chart for "Twinkle Twinkle." The most salient aspect is that the final settling phrase is one that starts harmonically stable, becomes instable, and returns to stability. The intermediate refrain ("way up in the sky so high . . . ") introduces a continuing harmonic instability on this dimension, which is then resolved by returning to the basic phrase at the ending on the harmonically stable tonic note.

This example illustrates that there are two kinds of information that contribute to perceptually determining the key of a simple melody: tone range is usually defined at one extreme by the tonic note of the key; harmonically, phrases tend to end on notes that are stable in the particular key.

Now again consider "Happy Birthday" (Fig. 12). First, in terms of tone range, it seems for the most part to be in the key of C. It starts on C, the first three repeating phrases all start on C, and the full range of seven steps between the two octaves of C are filled in by the end of the melody: all of these features of tone range suggest C. However, the analysis in terms of

pitch stability suggests by the end of the second measure that the melody *might* be in the key of F. The third measure is most confusing: on the one hand it starts again on C, to which the previous two measures have also returned, and jumps an octave to another C. But then on its way down ("happy *BIRTHday dear* XXXXX") it defines an F major chord. Finally in the last measure, the first note, a B-flat, clinches the decision: the melody must now be in F, since the key of C does not have B-flat in it at all—C would require a B-natural. In fact the underlying chords (usually a B-flat triad) further determine that it is F, just at the point when the person is named. The conclusion is that the song ends in the key of F. In brief, the song presents an ongoing perceptual conflict in whether it is in C or F; the initial tone-height information suggests C, the stability information increasingly suggests F. That is, the song might be given the words, "Now this song is in C, now this song is in F, is it C or F major . . . ? This note says now it's F."

Heard prospectively, the song has perceptual cues suggesting it is in C; heard retrospectively it has cues suggesting F. What is the resolving integration of these conflicting representations? The resolution is the interpretation that the song presents a *harmonic progression* from the key of +F to +C. This progression itself is an example of the classical harmonic

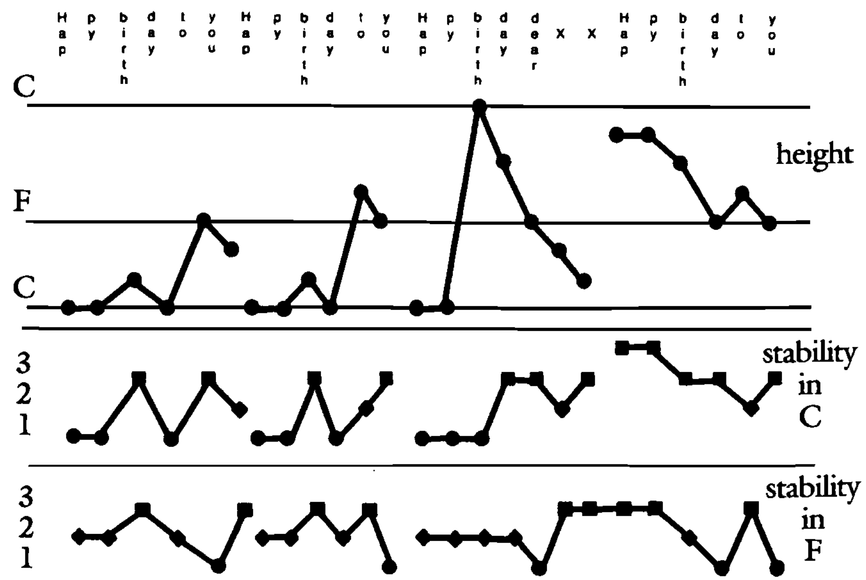

Fig. 12. Graphic representation of "Happy Birthday" (see legend for Fig. 11). Until the last phrase, the height dimension repeatedly suggests that the underlying key is C; the stability dimension increasingly requires it to be in F.

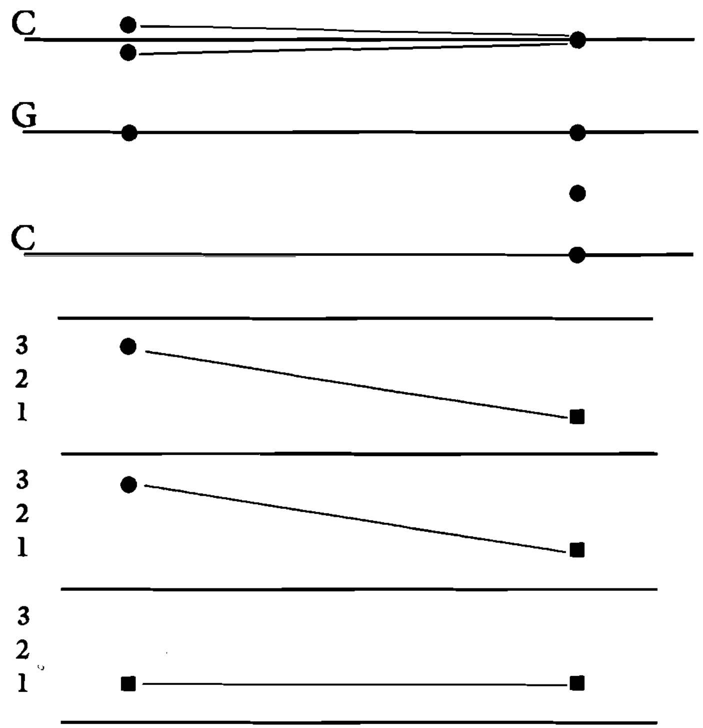

FIGURE 13

movement from a chord built on the 5th note to the tonic chord, a movement that underlies final progressions in virtually all of western folk and art music. One reason for this can be seen in Figure 13—the fifth degree chord presents a stable root (the 5th) with two maximally unstable notes of the scale above it, each of which is one step up or down from the tonic (the 7th and 2d). So, the fifth chord is stably rooted, yet its unstable upper notes lead melodically to the tonic. One of the most typical occurrences of the 5th-to-tonic progression is the full-cadence "amen," which can end hymns and other celebratory songs. Thus, in "Happy Birthday," the apparent movement from the key of F to the key of C presents a melodically drawn-out "aaaaamennnnnn" in celebration of a person's birthday. And that is exactly the overall social function that "Happy Birthday" has.

We can see how this simple song satisfies the aesthetic principle. The two tonal representations together subserve the harmonic salutation. The analysis also explains why the song has the particular social ritual that it does: the immediate perceptual representations of the song make it a tonal mystery about the key it is in, and this mystery is resolved at the end of the

third phrase, just when the mystery celebrant is named. Thus, the ongoing perceptual analysis of the melodic structure of the song relates in a natural way to the mystery-name ritual that the song has acquired. Finally, the overall resolution of the tonal mystery in terms of a melodic movement from the 5th to the 1st notes reflects the celebratory conclusiveness of the song.

GOLDILOCKS—Why She Became a Little Girl and the Three Male Bears Became a Family

Cultural artifacts are modified to accommodate aesthetic needs. Children's stories are indicative examples of this kind of process. A fairy tale is successively passed on from generation to generation, much in the same way as language itself—successive pairings of parents and children reshape a story to fill the intuitive and aesthetic needs of both.

As in the previous examples, we must distinguish between the direct communicative appeal of a children's story and its representational structure. A recent version of the story of Goldilocks serves as a good example of such structures (Cauley 1981). It has several subevents.

> The three bears (father, mother, child) cooked some porridge. It was too hot, so they went out for a walk in the forest to let the porridge cool.
>
> Goldilocks was sent by her mother to go out and pick some flowers and keep out of mischief. She came across the bears' house, peeked inside, and went in.
>
> She tried the porridge in the three bowls:
> —the big one was too hot
> —the medium one was too cold
> —the small one was just right, so she kept tasting it until it was all gone.
>
> Then she tried to sit in the chairs:
> —the big one was too hard
> —the medium one was too soft
> —the little one was just right, so she sat in it but broke it by mistake.
>
> Then she tried out the beds:
> —the big one was too hard/rejecting
> —the medium one was too soft/enfolding
> —the little one was just right, so when she tried it she automatically went to sleep.
>
> The bears came home.
>
> First they noticed the disturbance of the porridge, in the order, father, mother, baby. ("Somebody's been eating my porridge and ate it all up!")

> Then they noticed the chairs, in the same order. ("Somebody's been sitting in my chair and broke it!!")
> Finally, they noticed the beds in the same order. ("Somebody's been sleeping in my bed, and there she is!!!")
>
> Goldilocks jumped out of the window and ran back home. Her mother scolded her (but hugged her too).

Consider first what the real function of this story is—that is, why do children and adults like to share it? It seems intuitively clear that it is about "fitting in," a theme of the story which has been given a rich psycholoanalytic interpretation (Betelheim 1976; Betelheim argues that "Goldilocks" is actually an unsatisfactory fairy tale because it does not provide a complete dramatic solution—on his view, it has survived only because of its rich and analytically compelling imagery). Finding the right food, chair, and bed in the bears' family is an allegory about the child's place in the family. The story symbolizes that, in a family, relationships are three-way, not just a sequence of isolated two-way relations. The child's role is to be between that of the parents on each of several dimensions ("*juuuuust* right"). It is important that Goldilocks then systematically, though unintentionally, destroys the objects that instantiate her own position in the bear family (eating the porridge, breaking the chair, mussing the bed). This emphasizes the transitory nature of those objects and reinforces the fact that it is not the *bears'* family that she belongs in but her own, where she will be appropriately scolded for what she did but hugged at the same time.

To understand why a story survives, we must not only understand the deep symbolic themes it evokes, we must also understand how these themes are supported by its aesthetic properties. When we hear a story, we chunk it up into parts, that is, we apply an overall "story grammar" to it (Kintsch, Mandel, & Kozminsky 1977). Story grammars provide a basic organization of a narrative, and, complex as they are, they guide our initial perceptual organization of the story as we hear it. For example, Goldilocks in naturally chunked into segments that correspond to the separate items in the above summary. This represents the fact that the central theme of the story involves two orderly explorations of three triplets—first, Goldilocks explores three aspects of the bears' world, then the bears retrace her steps.

The three bears themselves specify an ordering that is obvious to a child, from father to mother to baby, big to medium to small.This order is explicit in the second triplet—the bears express their dismay in that order, and with an increasingly high-pitched voice. Goldilocks, however, originally chose the baby bear's possession as the final choice in a different ordering. The baby's object is actually between the other two in the order father–baby–mother: the ideal porridge is intermediately hot, the ideal chair is intermediately soft, and the ideal bed is intermediately resistant.

In this way, the most salient sections of the story have two conflicting representations of how the triplets of objects are ordered.This representational conflict meets one requirement of an aesthetic experience, but there must also be an integrating conflict-resolving representation. In this case, it is the number three itself, which subsumes both kinds of orderings. The number three is what the structure of the story presents and re-presents—not only are there three bears, there are three sets of objects, underlying two sets of three triplets. The result is that the representational structure of the story, brought out by the application of a story grammar, makes available a resolution of the primary semantic conflict within the story. We noted above that the number three is what the story is actually about—the notion that the child's relational world is a family, not a separable father, mother, child, nor a set of dyads.

"Goldilocks" has changed considerably since it was first widely published in 1843 (Southey 1836). Some of the changes may reflect general shifts. For example, the original protagonist was a little old lady, who was a very bad character—the content of the original story seems literally to be about the perils of bad deportment—and thus the reader's sympathy is entirely with the bears. Perhaps the little old lady was a child-surrogate in an age of nannies: this could explain the subsequent transformation of Goldilocks to a child with whom modern children can identify. Other changes in the story seem to be motivated by the aesthetic requirement, once one decides to make it about a child. For example, it is now important that the destructive things she does are "by accident." The original story had no clear beginning and ending; the protagonist wanders into the bears' house out of nowhere and disappears back to nowhere. Having the child partially "running away" from home, and returning with relief, gives an enveloping context that fits with the family-oriented main theme. Most interesting is the fact that the original version had three male bears, differing only in size, not in age or sex. The change to a family unit facilitates the allegorical theme that the story now has, which is supported by its aesthetic structure.

Puns and Jokes

My colleagues and I have argued that the essential elements of an aesthetic experience are rooted in representation-forming and integrating behavior that is typical of perception, cognitive development, and problem solving. It might seem that every time we change our minds about anything, it must be an aesthetic experience, since it involves a change in mental representations. It is important to consider some examples of why mere changes in representations do not lead to aesthetic experiences. Consider puns—for example, in the scene below:

> Q. Aren't all the mafiosi behind bars these days?
> A. Yes, serving drinks.
> Q. (Groan!)

Why is this sequence not aesthetic? It would seem that it involves two conflicting representations of a phonetic sequence ("bars"), with the phonetic sequence itself as the "resolution." This does not conform to the aesthetic principle for several reasons: first, the resolving structure is not itself a level of representation different from the one that presents the conflict; second, and most important, the two interpretations of a pun never coexist within the framework of a single representation—the listener first perceives one and then the other interpretation. It is a central feature of all the examples in this paper that the "resolving" representation creates a superstructure within which the conflicting representations can simultaneously coexist. It is for this reason that most merely ambiguous stimuli are not aesthetic. Similarly, perceptual and conceptual acts that involve merely replacing one representation with another do not conform to the aesthetic principle.

This predicts a situation in which the above sequence could be aesthetic and acceptable as a discourse of wit (in fact, the discourse below recently occurred).

> Q. Why does this restaurant have such a lousy wine list?
> A. I guess they haven't paid off the mob for a license.
> Q. Aren't all the mafiosi behind bars these days?
> A. Yes, serving drinks.
> Q. (Chuckle!)

Why is this pun more acceptable as a witticism than the above version with exactly the same phonetic basis? There might be many reasons, but the important one for our consideration is that it allows the change in representation of the crucial phonetic sequence ("bar") to fit with *either* interpretation in a way that makes sense in the overall context. (That is, if the mafiosi control liquor licenses and are behind bars as criminals, then it makes a punnish kind of sense that they serve drinks while in jail.) Such minor jokes are surely not the height of wit, but the example does clarify that a pun causes a groan if its alternate meanings do not have an overall sense that embraces them, whereas a pun is acceptably witty when the

alternate meanings fit into a larger schema of the kind described by the aesthetic principle. This view also explains why the creator of bad puns always finds them funny—he perceives some connection in his mind between the two interpretations, even if the listeners do not.

This example clarifies why the experience of mere ambiguity is not necessarily aesthetic: there must be an overarching context which includes both interpretations. A Necker cube does not afford an aesthetic experience, because we perceive it as either having one orientation *or* the other. Yet, the same kind of three-dimensional ambiguity may allow an aesthetic experience, as in many paintings by Escher: Escher takes great care to provide local contextual support for the simultaneous acceptance of both three-dimensional orientations in different parts of the same pictures.

I have reviewed examples from five folk genres to illustrate a common set of principles underlying aesthetic experience. In each case, automatic representation-forming mechanisms provide conflicting perceptual analyses of an object, a separate level provides a representational framework within which the conflicting representations can coexist, and aspects of the integrating representation often have feautures that explain the function of the object.

The Roles of Art

The conflict-integration theory of aesthetic experience has several advantages over the optimal arousal model. First, the theory can explain the primary facts that are usually marshalled in favor of the more traditional arousal model—in particular, the role of optimal discrepancy between an expected and obtained stimulus. On our interpretation, the relation between an expected representation and an experienced one is simply a special case of integrating conflicting representations. If the representations are very close, little mental activity is involved in their integration and, hence, very little enjoyment will ensue; if the representations are too discrepant, no resolution at all can be found. The representational theory can also explain other facts; for example, simple preferences of a variety of kinds. We can also explain why art works can be re-experienced, without making the counterintuitive claim that audiences have forgotten a work each time they re-experience it. There are general reasons to believe that the historical resolution of a representational conflict can be re-enjoyed, even when it is well known—why else is history itself enjoyable, a mystery re-readable? Such examples demonstrate that we enoy re-solving *old* problems, just as we enjoy climbing the same mountain or re-experiencing the thrill of diving into the same pool from time to time. Similarly, we can re-enjoy a well-known art work simply by virtue of the fact that the representational conflicts it elicits are the result of highly automatized schemata which operate autonomously, even when we can anticipate the result of their operation.

Furthermore, a successful work of art is generally one that offers a variety of structural interpretations—that is, reappreciating an art work may sometimes rest on temporarily assigning it conflicting representations of new kinds. Even if the overarching resolution is the same, the pathway there is different. Of course, in the performing arts, this is just why performance matters—it guides the audience in forming intermediate and final representations of the work.

This theory explains the relationship between normal mechanisms of conceptual growth and aesthetic activity, in a way which may explain the cultural ubiquity of artistic enterprises. I have reviewed some basic processes which are allegedly typical of the mental growth of children as well as adult mental activities. Characteristically, the child resolves representational conflicts by abducing new conceptual representations that integrate the conflicts.The child's emerging conceptual mastery of the world results from a successive construction and abduction of conceptual levels that lead to effective resolutions. On this view, much of what we learn is self-willed, that is, we learn it to serve our own needs for mental consistency and not for any specific identifiable functional reason. I have tried to demonstrate that the same processes define the intuitive aesthetic activities of adults.

This leads to the conclusion that aesthetic experience continues in adulthood the recognition and solution of the kind of mental problems that are functional for us to solve during our childhood. That is, one role of art is to make us feel young. Of course, it may be that both young and old simply like to solve problems: we run out of real problems by the time we are thirteen years old, so we invent ones to solve via art.

The second interpretation of the role of art is that in stimulating the abduction of higher-order representations, art increases the scope of conscious experience. I have not said much about consciousness in this paper because it is even harder to deal with than aesthetic judgment. Nevertheless, on the conflict-resolution model of perception, the conscious inference of reality often reconciles conflicting sources of perceptual information. On that view, art stimulates an internal overarching structure in much the same way as ordinary conscious experience, but with the possibility of stretching the representation beyond the sensational present. To put it another way, by accessing a higher-order representation, an aesthetic experience allows one to transcend more momentary information [see Bever (1983) for a discussion of consciousness and relational processing].

Finally, one can argue that since many integrating concepts are themselves idealizations, art brings the mind into contact with uncaused Platonic universals—that is, it is one way we drag ourselves out of the shadows of Plato's cave.

Implications for Cognitive Theories, Language Acquisition, and Linguistic Structure

Few of these conclusions are novel, nor is the general theory of aesthetic experience that we are proposing without many precedents [see especially Croce (1922) and Langer (1967)]. What my colleagues and I are trying to do is show how the natural functions of mental life explain the structural and meaningful properties of aesthetic judgment. This has brought me far from my original reason for examining aesthetic activity. I started out using the structure of aesthetic judgment as a way of revealing function-free cognitive processes. I have ended up with a theory of aesthetic judgment that has some general implications for language acquisition, cognition, and learning in general.

It is a puzzling question why a child bothers to learn the abstract structures of his language, when he is quite successful at communicating with a rudimentary form of it. Two distinct answers to this problem have emerged in the last decade. On one view, the child learns the language as a function of "social interaction," sparked by his desire to communicate fully with the adult world (Bruner 1974–75; Bates 1976); on the other view, the manifest language capacity emerges as a reflection of the maturation of an innate linguist "organ" (McNeill 1970; Chomsky 1981; Pinker 1984a). It is beyond the scope of this paper to examine fully the limitations of each of these positions. We can briefly note that the social interactionist offers no explanation of the form of language that is arrived at except by granting the nativist's view of the ultimate structural goal of the child.The organicist offers no explanation of the dynamic role of the child and the specifics of his language, outside of the language organ—that is, it might explain why universal linguistic structures are the way they are, but not why language-specific patterns are acquired, nor *why the child likes to learn them.*

It is obvious what I am about to suggest: an important emotional source of language-learning zeal in the young child is the fact that it gives many rich opportunities to experience the conflict-integrating role of abstract levels of representation—that is, it offers many opportunities to enjoy aesthetically interesting experiences.

The formal description of how such experience might occur during language learning is a simple one. Consider, for example, a basic feature of language acquisiton, the learning of words during the first decade of life. Children easily learn three to five words a day, much more during certain periods. Such learning must be intrinsically motivating since it often occurs without an external motive. A few simple observations about what words are demonstrates how to relate their acquisiton to the aesthetic principles. Words characteristically specify the relations between semantic analyses and stereotypic concepts they convey. For example, "dog" has a technical definition ("domestic, canine," etc.) that covers a wide range of specific instance; our representation of the word also includes a standard stereotypic instantiation (e.g., "four-legged German Shepherd"). These obvious—largely theory-free—observations about the psychology of word meaning show that word learning involves the formation of categories out of conflicting instances ("cocker spaniel vs. dalmation"). On this view, the word, its technical definition, and its stereotypic application serve together as symbolic representations that unify the distince instances of its application. Accordingly, learning a word involves the kind of experiences characteristic of aesthetic enjoyment. The word binds conflicting representations as a symbolic fiat.

This exemplifies how the aesthetic principle can apply to acquisition phenomena: the levels of representation themselves are presupposed, as well as the conflicting representations at one of those levels—the critical learning process is the attachment of connections ***between*** the representational levels that integrates the conflicting representations. It is the formation of these connections that comprise specific learning; forming the specific connections releases the aesthetic thrill, providing intrinsic motivation to learn arbitrary lexical facts.

Consider now the child's discovery of phrase structure, the systematic hierarchical grouping and labeling of word sequences. Suppose, along with virtually all students of language acquisition, we postulate that the child has available an early "agent-action" schema that can be applied to the linguistic world. One of the most salient features of simple sentences is that the preverbal subject can very in length and complexity. Over a short period of time, the child can use the verb location to segment preverbal agents of varying lenth and complexity. This leads to a set of representations of the different kinds of word strings that can serve as agents—setting up a set of conflicting representations of what can be an agent, in the sense I have been discussing. The abstract phrase structure node, "NP," provides a structural resolution, embracing numerous lower level variants.

It should be clear that such a description is merely an account of the structural state of affairs that the child experiences. Arguments in language

acquisition tend to center around the question of what ***causes*** linguistic structure; I have not made an argument here that the aesthetic principles cause phrase structure to have the properties that it does—I have only argued that phrase structure and the way that the child could discover its role in his particular language conform to the aesthetic principles.

A similar argument can be made about the integration of more abstract levels of representation. A transparent example would be the interrelation of varying syntactic forms with underlying semantic structures. For example, the variants of indirect object constructions ("John gave the book to Harry" vs. "John gave Harry the book") are resolved via the rule system that relates them systematically to the same propositional representation.

It seems possible that the formation of the psychological instantiation of an entire grammar is itself the result of successive conflict-resolving abductions that operate on separately developing kinds of language behaviors. The most obvious separate capacities that develop early are speech production and speech comprehension—clearly there are periods during childhood when these separate capacities compute different sets of sound/meaning pairs. There are sentence types which a child cannot say but understands, and conversely there are sentences which a child says that he does not understand. We know that the gradual resolution of representational conflicts can ultimately lead to the formation of complex and stable mental structures of representation—as in the emergence of naive number theory, naive physics, or naive logic. Continual application of the aesthetic processes would result in the abduction of an entire grammar, itself a gradual resolution of a series of such representational conflicts during childhood (Bever 1975).

Such formulations make predictions about the developmental course of language learning, in particular that new levels of representation are activated as representational conflicts clarify at other levels of representation. It is not obvious how the aesthetic principles could directly ***explain*** the structure of the abstract structural universals of language. However, it is clear that the language-learning child continually reshapes those structures to conform to the ways in which he learns it (see Halle 1962; Bever 1970). I have suggested that the aesthetic principles describe aspects of acquiring indigenous skills, such as naive mathematics and logic: insofar as discovering the structure of these skills affords aesthetically satisfying experiences, the child will learn the structure without extrinsic motivation. The principles may also determine some aspects of the structure of the skill as it is acquired. Accordingly, stages in the acquisition of language must provide the possibility of representational conflicts and their integration. This can lead to a number of predictions and experimental investigations, so my proposal is empirically demonstrable, at least in principle.

The conflict-integration model of acquisition leaves most nativist claims unscathed. I have argued that complex representational structures must have certain properties that intrinsically motivate children to learn how to interrelate them. This constraint on the structures does not explain them away as a mere by-product of individual acquisition: such a proposal *might* be true. A plausible alternative is that the constraint has operated over time, as one of the extrinsic requirements on the evolution of such innately prefigured skills as language. In this sense, the aesthetic constraint on language is like other usability constraints on the form of existing languages, notably learnability, comprehensibility, and producibility. Each system sets limits on what a human language can be, but none explains what it is.

The aesthetic constraint requires that language must conform to regularities that allow it to be described in terms of *levels of representation* which are independently defined and interrelated according to cognitively available principles. In the context of current generative theories of language, it may seem trivially true that grammars involve multiple levels of representation, but it is instructive to recall that many other kinds of grammatical descriptions have been proposed that do not have such properties (e.g., taxonomic phrase structure, string analysis, stratificational grammar, signals grammar). Many such nonrepresentational grammars have the everyday expressive power of a multileveled grammar, so there is no obvious evolutionary or ontogenetic explanation as to why they are not what children learn. On the view in this essay, the explanation lies in the aesthetic constraint.

This constraint may explain another prima facie odd property of grammars that I reviewed in the introduction—languages have multiple overlapping systems that partially describe the same facts (Sapir 1921–49; Sadock 1974). For example, syntactic gender almost never has complete overlap with semantic gender. Yet, the expressive power of a language with complete overlap of the two definitions of gender would not be impaired. It is hard to see how such a fact could be true if children constrained a language to be maximally straightforward. Indeed, it is a frequent goal of theories of language acquisition to show how syntactic knowledge emerges out of semantic knowledge—a goal that is never reached. According to the aesthetic constraint, the apparent complexity of multiple levels of representation is necessary because it makes language fun to learn.

Is the Aesthetic Principle General or Specific?

Many issues in cognition have recently focused on the question raised at the beginning of this paper—whether or not there are general mechanisms of representation and mental computation. On the "organ model," capacities such as language reflect the operation of unique and isolted computational systems that share no (interesting) properties with the systems that underly other capacities: on this view, there are no general cognitive mechanisms. The organ model addresses the genetic basis for special skills. The implications of the model for adult organization of behavior is expressed in theories of the "modularity" of mental organization—each behavioral capacity, like speech comprehension, operates separately from others, with rapid and efficient heuristics (Fodor 1983; Pylyshyn 1984). It is important to note that the aesthetic principle *presupposes* the availability of multiple representations of an object that cluster in natural forms; e.g., static vs. moving ones, two vs. three dimensions, momentary vs. durative, literal vs. metaphorical. The conflicting representations are derived independently of each other and *independently of familiarity with the art object*. That is, each of the representation-forming processes operate independently of the person's other knowledge—and that is a criterial definition for some versions of modularity.

The aesthetic principles, however, do not have the other important property of modularity—unique forms in each module. I have adduced examples of aesthetic processes that seem to operate in the *same* formal way in normal perception, cognitive development, and problem solving. One might be tempted to conclude that the representational conflict-resolving process *is* a general cognitive process that transcends any individual module, but I am not prepared to make that conclusion quite yet. In particular, aesthetic judgment may itself turn out to be a true general property of mental systems—a capacity that is not bound to specific modalities. Rather, it may operate on the output of modular processing systems, isolating *n*-tuples consisting of conflicting representations and their resolving integration.

This interprets the processes of aesthetic judgment to have a scope similar to psychophysical judgments, such as magnitude estimation, which appear to transcend single modalities: it is no accident that Fechner, who was concerned to create a science of aesthetics, devoted so much time to the science of judging intensity.

General Problem Solvers and Nativism

The predilection to search for general learning mechanisms corresponds to recidivist interest in showing that particular complex representational systems like language are acquired via "general" problem-solving systems (Anderson 1983). I have suggested that contingently specific representational systems are indeed acquired via normal problem-solving processes. It turns out, however, that the mechanisms for "general" problem solving themselves are not simple. The most natural form of general problem solving in humans itself follows the aesthetic constraint: it evokes abstract structures and integrating levels on problems as they are solved. Problem solving presupposes independent levels of representations and a set of available interrelations between the levels.

The Reintegration of Motivation and Learning

Behaviorism has died hard. The doctrine had two compelling attractions: it explained the structure of *what* is learned on the basis of *how* it is learned, and it explained *how* learning occurs as a function of *why* it occurs. Thus, behaviorism offered a continuous line of reasoning from functional motivation back to learned structure. Many investigations of behavioral structures have demonstrated the empirical inadequacy of what could be learned according to behaviorist principles; such demonstrations motivate the hypothesis that abstract representational systems must be innate rather than learned. But no proposals have been offered in the new cognitive vein to account for the relation between motivation and how learning occurs. I have argued that humans learn the interrelations between levels of representation because doing so releases an emotional surge. The present proposal provides a way of interrelating individual motivation with the view that the levels of representation are themselves both abstract and innate.

The construction of this essay has lead me a roundabout pathway that unexpectedly reunites the motive for learning a skill with the multileveled structure of what is learned. The concept of abstract levels of representation that map the relations between other levels of representation is common in current cognitive theories of mental life. The emotional excitement of representational integration can explain why humans learn such structures at all—it is not that we cannot help it, nor that it is recognizably functional; rather, abstract representational learning is essentially *thrilling*.

Acknowledgments

This essay was written while I was a sabbatical Fellow at the Center for Advanced Study in the Behavioral Sciences, jointly supported by the Center and the Trustees of Columbia University. It started as a lecture at the Arizona conference presented in this book and was refined in an informal talk to the 1984–1985 Center Fellows, to whom I am indebted for various comments. I am particularly grateful to Margaret Omara of the Center, who turned me into a "Happy Birthday" and "Goldilocks" pseudo-scholar. I also benefited from crucial conversations on specific topics with Janet Fodor, Randy Gallistel, LouAnn Gerken, Elizabeth Kaestner, Robert Krauss, Harry Reis, and Michael Tanenhaus. This essay owes most to my colleagues, Margot Lasher and Jack Carroll, with whom the basic aesthetic theory was originally worked out and applied to the fine arts. Finally, my original debt is to David Premack, who in a casual conversation about aesthetic capacity in nonhumans, made me realize that aesthetics in humans can be approached as a scientific topic.

Appendix: The Mechanisms of Arousal in Problem Solving and Aesthetic Experience

Throughout this paper, I have been assuming that it is thrilling to solve a problem, be it an implicit one of childhood, an explicit one of adulthood, or an artistic one in aesthetic experience. My claim for the structural link between problem solving, aesthetic experience, and structural acquisition only requires that all these behaviors elicit something like an "aha" thrill. I could stop my argument there, as the text does, simply postulating that the "aha" insight experience is enjoyable and explains the consequent urge to solve problems. However, it turns out that the formal relation between the various behaviors and the abduction of motion may provide an explanation for the "aha" thrill itself. I now turn to an explanation of what causes the thrill, based on the formal analysis of the processes involved in interrelating mental representations. (I include this discussion as an appendix because it is even more speculative than the nature of the aesthetic principles in their role in learning, which I outlined in the text.)

AHA! Emotion Out of Abstract Motion and Loss of Control

Emotional theories fall into two classes—causal and interpretive. Causal theories seek to explain different emotions as a function of biological factors: on this view, particular emotions are the mental expression of particular physiological states. Interpretive theories emphasize the importance of belief systems in designating emotions. Such a view usually differentiates two processes—mechanisms of arousal and mechanisms of interpretation (Mandler 1975). It capitalizes on the independent fact that general arousal mechanisms exist and that their behavioral indices are associated with strong emotions.

Most complete theories of emotion include elements of both causal and interpretive mechanisms. The modern tradition goes back to the James-Lange view that an emotion is the interpretation that we place on instinctual mechanisms: I impute fear to myself if I notice that I am withdrawing from some danger. On this view, the basic generator of the particular behavior is instinctive: the emotional interpretation merely symbolizes the behavior for the individual. A modern classic demonstration gives greater emphasis to the interpretive than the instinctive system: if a person is aroused (for example, by a chemical stimulant), he will both report and show signs of an emotion. Which emotion he feels is influenced strongly by his immediate context; if people around him are acting happy, so will he (Schacter and Singer 1962).

Emotions occur in broadly labeled categories, like "fear" and "happiness." What is at issue for this discussion is the arousal mechanism underlying momentary thrills that occur when we solve a problem. We can gain some insight into this by again considering the infant. Its first forms of interaction with the world are overwhelmingly physical: the infant is carried about, rocked to sleep, and so on. In all these cases, the world is interacting with the child by some manner of moving it: motion is a primary vehicle of social interaction. In fact, one of the earliest social achievements of the child is to get adults to pick it up.

Bodily motion controlled by others can be highly arousing—this may be directly caused, as by activity of the vestibular organs. It may also be independently magnified due to fear over temporary loss of control. We can see the importance of these concepts in one of the earliest occasions for smiling and laughing induced through social interaction. A fussing infant is picked up but continues to fuss. The adult jumps up and down slightly jiggling the child in a rapid motion, perhaps chanting some rhyme; the child quiets, looks at the adult, and smiles. Even more striking is the impact of picking up an infant rapidly and throwing it slightly in the air and catching it. The importance of brief loss of control is clearly strong in this case: only if the infant knows the adult, and is clearly aware of the game, does it enjoy the experience. Under those circumstances, the infant enjoys the game inordinately, as the adult increases the height of each toss.

It is tempting to wax poetic when discussing this kind of social and physical interaction. But, we can also subject it to an elementary formal analysis: on each cycle of the tossing game, the infant is in the adult's arms, then briefly flying, falling, then in the arms again. With repeated cycles, the exhilaration reaches a peak each time, just as the infant starts to fall. This experience seems paradigmatic of all thrills: they involve a brief moment of loss of control, bounded by safe havens. The safe surround creates a bridge of situational control across the moment of apparent danger, while basic somatic mechanisms are releasing strong emergency signals.

The conclusion is that the joy results from the release of instinctive emergency signals in a safe context. Why should the infant enjoy the discharge of emergency mechanisms, even it it is under controlled circumstances? The answer to this lies in a theory of emotions that is independent of the causal and interpretive theories (and therefore a theory that may be independently correct), the "opponent process" theory. (Solomon 1980). On this view, brief experiences of intense negative arousal due to extreme loss of control are followed by a long "recovery" period of mild positive affect. A paradigm case is the emotions of amateur parachute jumpers. Although they are terrified during their early jumps, they eventually accommodate to the terror and enjoy a prolonged recovery period after each jump in which they experience confidence and joy.

We can combine our analyses of problem solving and perception with the thrill of losing control to explain how the problem-solving thrill is engendered. Consider again the phenomenon of motion perception, which has received so much recent attention—the resolution of two static images presented in time is that of an object that moves from one to the other. This is described by practitioners of the associated experimental art as "the image of a motion"; such a designation is distinguished from "the motion of an image" in order to avoid the homuncularily reductive requirement of having an internal observer who watches the image in motion (Shepard 1984; Kubovy 1983; Podgorny and Shepard 1975). The implications of this simple reformulation are tremendous—it postulates that an elementary object of perception is an abstract mental "resonance" of a physically possible movement. The perception of pure motion emerges out of an abstract movement from one stable image to the next.

The research on mental imagery and movement is based on the study of physical objects that could move in real space. Yet, the imagined movement that is evoked is in fact between two *abstract mental representations* of those objects. This demonstrates that the mental system has the capacity to form an *image of motion* between pure mental representations. I have noted that problem solving involves the formation of distinct representations and then an integrative resolution among the representations—a "leap of imagination" that allows abstract movement from one representation to the other representation. This is one source of excitement when we experience the solution of a problem—we briefly move from one representation of it to the other, via the just-intuited integrating representation. Leaps are associated with momentary loss of control and an associated excitement. When we take a dive, shutting our eyes tight, we briefly give ourselves over to unmonitored forces; like the tossed infant, between the point of loss of control and regaining it, we experience a brief thrill.

As in the infant, there is a separate, perhaps more physiological source of excitement that follows from the same basic principles. Consider, for a moment, the effect of perceived motion without the usual physically associated signals to our sense organs. It is just this that, in its extreme form, causes dizziness. The perception of motion induced by solving a problem, without proprioceptive or other cues, may elicit the same sort of disorientation, though to a much lesser degree.

This offers an explanation of why humans like to solve problems, even useless ones: we get a little thrill each time because the mechanisms of problem formation and resolution induce an inner percept of motion from one representation to another, with a momentary sensation of loss of control. It is a satisfying result of this proposal that the "aha" reaction to solving a problem occurs primarily just at the moment of initial intuition that one understands the solution. By hypothesis, it is at this point that one has arrived at an overarching representation that bridges the conflicting one. The image of motion from one representation to the other is emotionally effective until the structure of the integrating bridge becomes explicit—as one checks out the solution to the problem intuited in the resolving representation, the image of uncontrolled motion fades as the conflicting representations are explicitly integrated.

Coda—The Specific Emotions in Different Aesthetic Experiences

High art often elicits emotions of characteristic kinds. I suggested that problem solving is intrinsically thrilling because it evokes a feeling of inner motion on a freshly evoked dimension and a momentary loss of control. On this analysis, aesthetic experiences evoke the same mental mechanisms as problem solving and therefore the same emotional arousal. What remains is to explain the particular emotion that is felt—in problem solving, it is clear enough that we ultimately feel a mixture of pride and relief at having solved the problem. But what is the nature of the emotion evoked by aesthetic experiences, in which the "problem" exists only as a stimulus for the problem-solving activities themselves? That is, why do aesthetic experiences elicit emotions of particular kinds?

On the general theory of emotion, interpretive systems play a role in determining the emotion assigned to an aroused state. The everyday aesthetic objects shape the emotion as a function of their explicit or social content. Upon hearing the "shave and a haircut" tatoo, we experience a recognition that somebody wants our attention; the golden rectangle elicits a concept of "two-ness" and depth in a third dimension; "Happy Birthday" is a vehicle for saluting somebody else; "Goldilocks" tells an explicit story with the child's place in a family as the clear moral. Many high art

works have even more explicit content: representational painting, literature, and theater use the interplay between structure and content to guide the audience's particular feelings.

Some kinds of art lack such content, yet evoke strong emotional responses. We can obtain the clearest picture of how the formal structure of aesthetic experience elicits and allows for the control of emotions by examining such cases. Art-music is a striking example, since it has almost no semantic structure and yet can release turbulent feelings. There are several other notable facts: the same piece of music evokes different emotions in different people, and it evokes different emotions in the same person at different times.

There are several sources of the emotional arousal in response to music. First, music can directly excite the somatic and autonomic nervous systems via orienting and startle responses; Haydn exposes this in the "surprise" symphony, with loud chords at (expected) unexpected points. A gong in the middle of a quiet passage has the same effect: the blood races, the mind blanks out while the "fight or flight" system reaccommodates. Second, there is a rhythmic alternation of outer attention and inner mental processing paced by the perceptual analysis of each musical "phrase" (see Tan, Aiello, and Bever 1981; Bever, Lasher, and Carroll, in press). Finally, an effective musical work is one that elicits representational forms that fulfill the aesthetic principles, thereby stimulating the abstract image of motion, as discussed above.

Music has these three powerful mechanisms that can increase arousal and mental movement. But we must also account for the fact that not just general excitement but particular emotions are often felt, emotions such as elation and deep sorrow. First, there are a few conventions that depend on cultural motives—a march with a snare drum indicates a military image, whereas parallel fifths continually convey an oriental aura. Some of the motivic conventions are understandably related to basic physiological mechanisms, for example, different tempos: the perceived tempo of a piece can itself directly recruit rhythmic activities in a listener, as reflected in a tapping foot or nodding head. Once the rhythm is induced, it can resonate with different classes of emotions; for example, a quick tempo is unlikely to be perceived as lethargic and sad, whereas a harmonically slow-moving piece is unlikely to be perceived as energetic and happy. In addition, minor changes in the rhythm of the variation in processing load and attention may mimic some formal properties of emotional states.

Beyond conventional and physiological determinants of the emotion, a listener has his own prior emotional states as well: a person who is already depressed may take almost any piece of music as an occasion for sorrow. The very fact that music only vaguely guides the emotional content may account for its releasing power—the individual listener is free to attach his antecedently available emotions to the experience, thereby making it far more personally powerful than the usual response to an art work with explicit content.

This brief consideration of the sources of emotion in music outlines the kinds of factors which may play a role in other art forms, both high and low. Most important, it also highlights some emotional forces that can play a role outside of aesthetic experiences—most notably in problem solving and cognitive growth.

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