PATRICIA D. STOKES

Creativity from Constraints: What can we learn from Motherwell? From Modrian? From Klee?

ABSTRACT

This article presents a problem-solving model of variability and creativity built on the classic Reitman and Simon analyses of musical composition and architectural design. The model focuses on paired constraints: one precluding (or limiting search among) reliable, existing solutions, the other promoting (or directing search to) novel, often opposite, ones. The primary constraint pair precludes an existing goal criterion and promotes a novel one. Other constraints — source (elements for recombination), task (how materials are used) and subject (motif, theme) — are then strategically selected to realize the goal. A brief discussion of Abstract Expressionism introduces the model, which is then applied to the painting careers of Piet Modrian and Paul Klee.

INTRODUCTION

A mechanism shared by creativity (Boden, 1994; Campbell, 1960; Perkins, 1994; Simonton, 1999) and cognitive/learning (Holland, Holyoak, Nisbett, & Thagard, 1987; Palmer & Donahoe, 1992; Stokes, 2007) models is selection from a variable substrate. The first set of models specifies selection criteria: novel always, also useful (Amabile, 1996), appropriate (Gardner, 1993), purposeful (Gruber, 1989) or goal-directed (Weisberg, 1993), and, at the highest levels, influential (Stokes, 2005) or domain-changing (Csikszentmihalyi, 1996). The second set focuses on the consequences of selection. The most critical to creativity is simple: success in meeting selection criteria reduces the variability on which creativity depends (Stokes, 2001a, 2001b). The mechanism is operant conditioning: responses that are reinforced increase in frequency. As a result, experts often get "stuck" in solutions that are successful and reliable, but not highly variable.

AUTHOR'S NOTE:
The constraint model is presented from the point of view of a painter (the author, the artists) for whom stylistic change is a visual, technical problem, not a theoretical (aesthetic, historic) one.

The current constraint model is a hybrid, using problem-solving precedents (Reitman, 1965; Simon, 1993) to study how successful creators become and remain highly variable (Stokes, 2007; Stokes & Fisher, 2005). According to Reitman (1965), paired constraints direct and limit search in a problem spaces. According to Simon (1993), for search to produce a creative solution, the problem space must be incompletely specified or ill-structured. According to the current model, paired constraints restructure existing problem spaces in ways that make them ill-structured, thus incrementing variability and facilitating creative solutions (Stokes, 2007). The following section defines the technical terms in the model.

DEFINITIONS

Problem Spaces. A problem space is defined as how a solver represents or structures a problem. It includes an initial state, a goal state with a criterion for knowing if you have reached the goal, and a set of operators. Operators take the form of "if...then..." rules: "if" specifies the condition; "then," the action. The operators are applied sequentially to form a solution path from initial to goal state. In well-structured problems, all the information needed for solution is specified (Greeno & Simon, 1988). Paint-by-number is a good example of a well-structured problem. The initial state is a numbered cartoon on a white canvas, along with numbered paints. There is one operator: "If an area of the cartoon is numbered X, then fill with the paint numbered X." Like all completely specified problems, paint-by-number requires little variability. There is one correct solution, the criterion for which is matching the picture on the paint-by-number package. Ill-structured problems do not supply all the information needed (Voss & Post, 1988), thus higher variability is required. Those in which the goal criterion is incompletely specified have multiple possible resolutions, some of which could be creative.

Constraints. Constraints structure problem spaces by limiting or precluding search in some parts of the search space, and directing or promoting search in other parts (Reitman, 1965). To produce a creative solution, these constraint pairs preclude existing responses and promote novel, often opposite, ones (Stokes, 2007). Reitman's example showed how fugal composition proceeds from main theme to counter melody: precluding the first theme promotes the second, which must be both novel and contraposed to the first. Our examples also involve constraint pairs that are highly polarized.

THE CONSTRAINT MODEL

The current model includes four kinds of constraints: goal, source, task, and subject. In painting, goal constraints are stylistic conventions. Remaining constraints — source (elements for recombination), subject (content or motif), and task (materials and their applications) — are then selected to help realize the goal (Stokes, 2005). As in Reitman (1965), each choice limits and directs search for a solution path to the appointed goal.

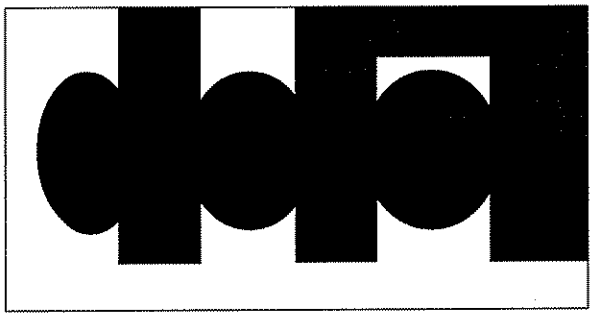

FIGURE 1. Schematic of Motherwell's *Elegy to the Spanish Republic* series.

Constraints related to Robert Motherwell's *Elegy to the Spanish Republic* series[1] will serve to introduce the model. Figure 1 presents a schema for the series, whose source constraints included two earlier masterpieces, reproductions of which hung on the artist's studio wall (Gluck, 1984). One was Matisse's *Bathers by the Stream* (1916) with its dark and light rectangular bands and round ovoid figures. According to Motherwell, this painting influenced the *Elegies* "more than anything else" (Gluck, 1984, p. 74). The other was the similarly composed, albeit realistically painted, *Flagellation of Christ* by Pierro della Francesca.

Early in his career, the artist described his goal or "primary concern," as "express[ing] the felt nature of reality" (1944/1992, p. 31). Much later, he expanded on that idea by quoting Mallarme: "You don't represent the object, you represent the *effect of the object*" (1974/1944, p. 217). Restated as paired constraints, Motherwell's goal promoted an emotional, and precluded a perceptual, response to reality. Table 1 rephrases these as the initial and goal states of a hypothetical (and oversimplified) problem space.

TABLE 1. Possible paired constraints for Motherwell.

	Description	
Initial State	Current domain goal criterion: paint the thing	
Subject and Task Constraint Pairs	Preclude	Promote
	1. Realism	→ Abstraction
	2. Changed motif	→ Series with shared motif
	3. Perceptual armature	→ Pictorial armature
	4. Local color	→ Symbolic color
	5. Controlled brushwork	→ Dynamic brushwork
	6. Easel-sized canvases	→ Mural-sized canvases
Goal State	New goal criterion: paint the effect the thing produces	

[1] All paintings referred to in the text can be easily seen on Google images.

Instead of operators, Table 1 suggests constraint pairs that produced the operators. For example, replacing realism with abstraction would generate an operator like "If determining elements for a motif, then select abstract/non-representational ones." Subject and task constraints that met the initial criterion (paint the thing) are listed under "preclude"; those selected as substitutes for realizing the new criterion (paint the effect the thing produces) are listed under "promote." The first two pairings are subject constraints. Abstraction replaces representation; a series of paintings using a similar, limited set of elements (the hovering black ovals and bands) replaces changes in subject. The others are task constraints. The pictorial armature that replaces a perceptual one (what the painter is looking at) is based on the compositions of della Francesca and Matisse. Local color refers to the hues seen on objects (leaves are green); symbolic color evokes events and emotions: "Black is death, anxiety; white is life, éclat" (Flam, 1991, p. 9). The fifth and sixth task constraints preclude precision and concision. Abstract Expressionism demanded the dramatic — in the application of the paint and the size of the painting.

The following sections cover, in greater detail, the constraints selected by two artists who shared a common compositional armature, the grid.

CONSTRAINTS IN MONDRIAN'S PAINTINGS

Mondrian's three major stylistic phases are closely related, each borrowing from and building on its predecessor. The close relationship comes from the constant goal; the shifts from the evolving specification of its criterion.

TABLE 2. Possible paired constraints for Mondrian.

	Description		
Initial State	Current domain goal criterion: manner of nature		
Subject and Task Constraint Pairs	Preclude		Promote
	1. Changes in motif	→	Series with single motif or set of equivalents
	2. The particular	→	The universal
	a. natural forms, objects	→	abstract, equivalent forms
	b. local color	→	limited palette, primary colors
	c. figure-ground relationship	→	grid with balanced relations between forms and space[2]
Goal State	New goal criterion: manner of art		

[2] Figure-ground relationships give primacy to objects. Mondrian's grid gave equal emphasis to form (figure) and space (ground).Source Constraints.

Mondrian first attained mastery in Dutch landscape, maintaining always its strict horizontal/vertical composition. Later influences were Monet's series paintings (in which a motif is kept constant in order to produce variations of it) and Cubism's compositional grid (which makes the spaces between objects as important as the objects). Mondrian's first mature phase combined the two: the tree as subject, the focus on the spaces between its branches. Constraints common to all phases appear in Table 2.

Goal Constraint

Mondrian wrote extensively about his goal, contrasting what he intended to preclude (the manner of nature) and to promote (the manner of art). "Painting", he said, "can express the absolute in two ways: determinately, as it does *not* appear in the external world, or veiled in form and natural color, as it is expressed in nature. In the first, style appears entirely in the *manner of art*; in the second, it always appears more or less in the *manner of nature*" (Mondrian, 1917/1986, p. 32)[3]. Yve-Alain Bois (1994) called this goal a "kind of high-stakes redefinition" (p. 314) which precludes any specific "perception" in order to promote perceiving the "essence" of painting. To achieve it, the artist developed that he called the *nieuwe beelding* or the new structuring. We follow this development from his source constraints to its final realization in the *Broadway* and *Victory Boogie-Woogies* (1942-1944)[4].

First Phase: Natural Referents, the 1910s

To substitute the universal for the particular required developing a set of "plastic" or painterly equivalents for natural forms, colors, and their relationships. Mondrain's subject constraint, which (like Monet) precluded changes in motif, promoted series based on trees, church facades, waves and piers. His task constraints (like Cubism) promoted a palette limited to grays and earth colors, simplified forms, and critically, the grid format. Figure 2 is my rough approximation of how Mondrian began turning the branches of an apple tree into the armature of a picture. (The trunk is at the bottom center).

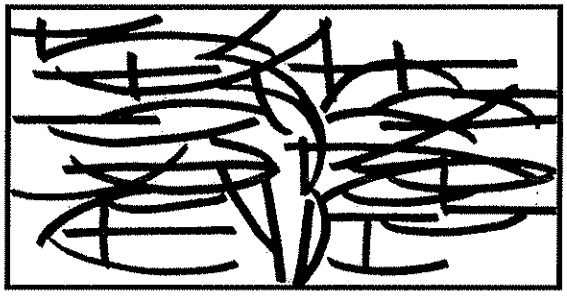

FIGURE 2. Schematic of tree branches becoming a grid.

[3] The "manner of nature" is representational; the "manner of art" replaces representation with relationships between purely painterly elements like color and space.

[4] All titles and dates for Mondrian's paintings are from Bois, Joosten, Rudenstine, & Janssen (1994).

Mondrian's *Gray Tree* (1911) was the start of his "new structuring." Its palette is monochromatic; its brushstrokes move rhythmically to emphasize the now-important, between-branch, proto-grid, openings. The paintings that follow — including *Flowering Appletree* (1913), which is suggested by Figure 2 — progressively change the curved lines of the branches into the straight lines of the grid. By 1913, a black grid predominates, the spaces between it are restricted almost entirely to gray and ochre toned rectangles. The tree now provides the structure of the painting, not its subject. The subsequent *Pier and Ocean* (1914-1915) series, with its longer horizontals and shorter verticals (vestiges of waves) culminates in complete abstraction. All that remains in *Composition in Line* (1916/1917) are scattered black plus (+) and minus (-) signs that appear co-extensive with the white field that fills the spaces between them.

Second Phase: Static Equilibrium, the 1920s

In this period, which followed the disruptions of World War I, Mondrian's goal criterion was altered to preclude movement and promote repose. The equilibrium among his elements was to be static. Having eliminated all specific perceptions (the manner of nature), Mondrian now concentrated entirely on composition, color and line (the manner of art). His forms were completely abstract, orthogonal black lines and colored planes between them. In place of naturalistic color, his palette was limited to three primaries (blue, red, yellow) and two "non-colors" (white, gray). The static equilibrium specified by his modified goal criterion required exact, completely balanced relations of lines and planes.

Third Phase: Rhythmic Referents/Dynamic Equilibrium, the 1930s

In ten years, the expected time between breakthroughs (Gardner, 1993; Hayes, 1989; Weisberg, 1999), Mondrian's goal constraint shifted from a static to a dynamic equilibrium. Repetitions, layerings, weavings appear in the paintings. As indicated by his titles, lines were doubled (*Composition with Yellow, Blue, and Double Line*, 1933), and colored (*Lozenge Composition with Four Yellow Lines*, 1933). An external referent appeared, indicated by new titles, no longer *Compositions* but place names, names of throbbing, dynamic, jazzy places: *Place de la Concorde* (1938), Paris, *Trafalgar Square* (1939-43), London, and the triumphant finale, the New York City series. *New York City 1* (1941-42) looks like a street grid with overlapping, interwoven equally intense yellow, blue, and red lines, enclosing 156 rectangular spaces of varying size. The interweaving prevents any color from moving before (figure) or behind (ground) any other. The eye bounces from color to color and space to space, all on the surface, and all rhythmically, dynamically related to each other. *Broadway Boogie-Woogie* (1942-43) eliminates the overlapping. Instead, the lines consist of multi-colored squares and rectangles; larger planes with shapes inside their shapes abut the lines. *Victory Boogie-Woogie* (1942-43) further fragments the planes, some mimic the multi-colored lines on which they impinge. Figure 3 schematically shows how the lines and "planes" are woven together.

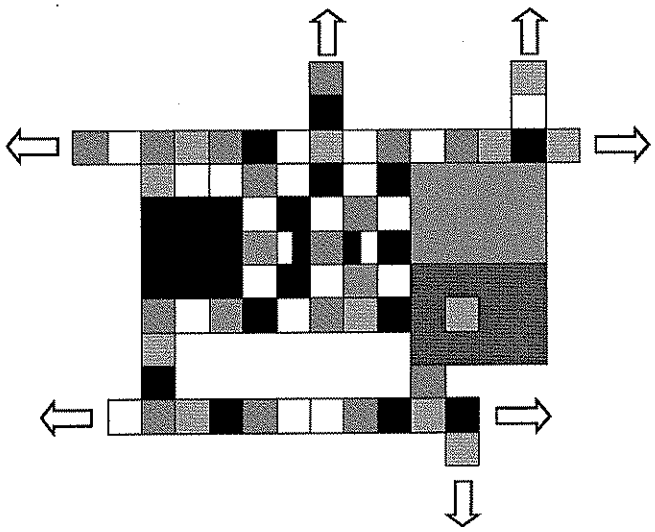

FIGURE 3. Schematic of interwoven lines and planes in *Victory Boogie-Woogie.*

Arrows indicate directions in which the lines continue. The surface of *Victory Boogie-Woogie* is a constant state of shift. I purposively use the word "surface." Mondrain's final goal constraint precluded the static and promoted the dynamic. However, his task constraint precluding figure-ground relationships still held. The relationships between planes and space are rhythmic, but remain rule-fully "exact."

CONSTRAINTS IN KLEE'S PAINTINGS[5]

The grid served as both structure and subject for Mondrian. For Klee, its pupose was structural and specifically so, providing an armature for expression.

Source Constraints

The exaggerated graphics of artists like Breughel and Grunewald were the sources of Klee's self-proclaimed "bent for the bizarre," already apparent at nine, when he recalled picking out "human grotesques" from the "labyrinth of lines" in a marble table top (Klee, 1880-1895/1964, p. 8). Graphic and grotesque, his early output depended on draftsman's skills devoted to the expressive powers of distortion.

Two trips were seminal in the switch from satire to poetry. On the first, to Paris in 1912, Klee saw Robert Delaunay's *Windows,* a series of canvases divided by Cubist grids into rectangles and triangles of luminous, autonomous (non-local, non-representational) colors. The pictures were, in Delaunay's words, "no longer a simulacrum of natural colors, but... 'color' [itself] (Delaunay, 1920/1978, p. 58). On the second trip, to Tunisia, Klee proclaimed himself "possessed by color"

[5] I do not discuss the paintings based on surrealism, child or primitive art.

(Klee, 1914/1964, p. 297). Once dedicated to its permutations, other sources become available to the artist: Byzantine mosaics with their brilliant colors and outlines; the "miniscule, intricate brilliance of thin line, glowing, winking, jewel-like color" that resulted from the crossing peasant and Gothic urban art in the late Middle Ages (Greenberg, 1950/1993, p. 4); music (an area in which Klee, a violinist, was already expert) with its rule-fully derived modulations and variations.

Goal Constraint

Klee, like Mondrian, wrote constantly, in his diary, in his notebooks. A prescient formulation of his goal — to "bring architectonic and poetic painting into a fusion" (Klee, 1902/1964, p. 125) — appeared earlier than the means to achieve it. Achieving it meant precluding the current goal criterion in painting (reproduce the visible) with a new criterion (make visible). What Klee wanted to make visible was the universal (the intuitive and poetic), contained within the object (the architectonic and iconic). Like traditional sonnets, his "poems" were highly structured. Table 3 presents Klee's strategically selected constraint pairs.

TABLE 3. Possible paired constraints for Klee.

	Description		
Initial State	Current domain goal criterion: reproduce the visible (the world)		
Subject and Task Constraint Pairs	Preclude		Promote
	1. Natural anatomy	→	Compositional anatomy a. the armature b. its permutations
	2. Local color	→	Autonomous color
	3. Realistic imagery	→	Iconic imagery
Goal State	New goal criterion: make visible (the poetry)		

The "promote" parts of the pairs were derived directly from his sources. Compositional anatomy depended on the armature provided by the Cubist grid, and the permutations possible in music. Autonomous color originated with Delaunay's *Windows*, which showed how color "applied to a fixed structure" could make "its presence unfold . . . without being representational" (Duchting, 2004, p. 23). An everyday example of "autonomous color" is white light broken up into the seven hues seen viewed in a prism or a rainbow. The iconic imagery was Klee's own, derived at a distance from Northern graphic traditions[6]. I have adopted examples from Klee's notebooks to show how his grid-based paintings were constructed.

[6] Delaunay had also included imagery in his *Windows* series: parts of Parisian streets, the Eiffel Tower, and a ferris wheel can be seen in *The Three Windows, the Tower and the Wheel* (1912).

The Armature

The armature is Klee's word: "One may speak of the specific anatomy of the picture . . . First one builds an armature on which the picture is to be constructed. How far one goes beyond this armature is a matter of choice . . ." (Klee, 1908/1964, p. 231). Klee's armature was not a static grid, but a dramatic, dynamic one which emphasized direction (in the size of its areas) and weight (in its tonalities and colors). Klee varied his armature in multiple ways, borrowing ideas from both music and mathematics. In early paintings like *Red and White Domes* (1914), he elongated the grid vertically, with the largest and lightest areas towards the bottom and the smallest, densest areas near the top. Like Delaunay, he applied his paint in washes, the borders between the areas of color flowing into each other. Finally, he added iconic elements, visual cues indicating the dome of a minaret and vegetation.

Figure 4 illustrates the progression from what Klee called the "norm or motionless base picture" to a structure "moving in two directions" (Klee, 1961, p.144): the movement comes from altering the grid to make larger and smaller internal shapes. The third step involved adding color (hue) and tonality (value), and finally — my addition to the artist's example — iconic elements (domes, palms) similar to those in *Red and White Domes* (1914)[7].

[7] Dates and titles for Klee's paintings are taken from Duchting, 2004, and Klee, 1961.

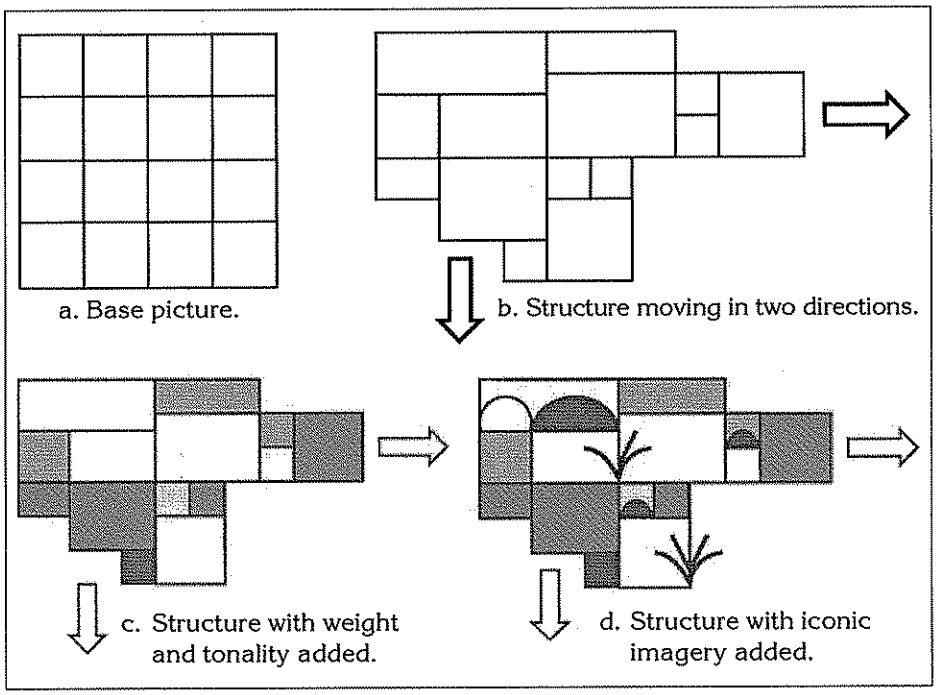

FIGURE 4. Development from base grid to painting with imagery.

The Permutations

The clearest demonstration of how Klee used constraints comes from his notebooks, with their detailed analysis of how directionality and tonality were to be determined. The means were mathematical, and by analogy, musical. Hue was analogous to key. The choice of hues depended on a self-constructed 'Canon of Tonality' (Klee, 1961, p.489), a circular model of relationships between primary and secondary colors which parallels the cycle of fifths, Bach's canon that determined modulations between keys. Rhythm emerged via the directional patterns in the grid; melody from the sequencing of hues; harmony from the simultaneous presence of multiple color layers, one thin wash showing through another.

Directed movement

The simplest type of movement demonstrated by the artist was unidirectional (Klee, 1961, p. 373). One drawing showed a four by four section of a large otherwise empty grid filled with the tonalities indicated by another, numbered grid. The numbered rows indicated which value of a 5-step gray scale was to be painted in each square (left panel, Figure 5). Since number 1 indicated white and number 5, black, the eye would move downward and to the right (right panel).

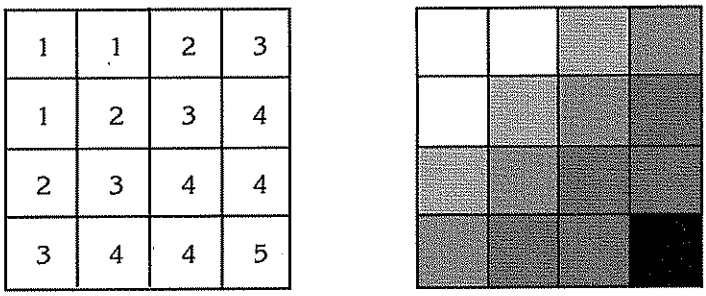

FIGURE 5. Squares with increasingly darker colors indicated by numbering.

The musically term for this tonal progression is *crescendo*, an increase in value from lightest to darkest.

Divided strata

Another mathematically determined grid appeared in paintings like *Monument in a Fertile Country* (1929). The pattern, reminiscent of the topography of Egypt seen by Klee during a 1928-29 winter visit, is built in horizontal strata, divided according to the following formulae. First, whenever a vertical line crosses a horizontal, the strata on one side of the vertical are halved, while those on the other are doubled. Second, the most intense colors occupy the smallest strata. Notice how the linear divisions echo those of musical notation: a whole note is divided into 2 halves, each of which is divided into 2 quarters, etc.

Figure 6 schematically depicts patterning near the bottom of *Monument in a Fertile Country* (1929). The actual painting is more dynamic (some of the verticals are angled) and lush (the white in Figure 8 is bright lemon yellow), but this is true of all Klee's work: each grid provided the armature for a poem.

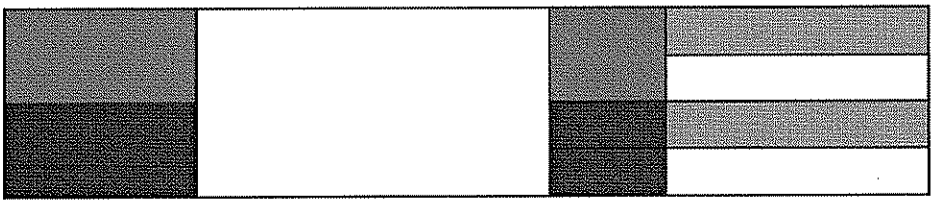

FIGURE 6. Mathematical division of grid strata.

CONSTRAINT COMPARISONS: MONDRIAN, KLEE AND THEIR PROGENY

Despite the fact that Mondrian and Klee were contemporaries (their life-spans ranged from the 1870s to the 1940s; their breakthroughs both occurred c. 1914), the grid is the only apparent commonality in their paintings. The differences arise from the uses to which each put the grid. For Mondrian, the grid was an armature for the absolute, purified, rarified, absolutely balanced — at first serenely, at last dynamically — and always on the surface. For Klee, it was an armature for the musical and the poetic, nuanced, layered, always lush (with or without the flora of his tropical gardens).

The goal criteria that each precluded sound similar: the "manner of nature" could be restated as "reproduce the visible". However, the goal criteria each promoted were completely divergent: the "manner of art" was confined by Mondrian to equilibrated arrangements of primary colored lines and planes; "make visible" led to Klee's mathematically arrived at arrangements, elaborated with multi-hued washes, jewel-like embellishments, recognizable fragments of reality.

CONCLUDING QUESTIONS

Is there corroborating evidence that constraints increase variability and creativity?

Yes, both experimental work (Finke, 1990; Mumford, Reiter-Palmer, & Redmond, 1994; Ward, Patterson, & Sifonis, 2004; Yokochi & Okada, 2005) and performance accounts (Cunningham, 1994; Hodier, 1986; Lesschave, 1985) support the contention that paired constraints increase the variability on which creativity depends.

Finke, Ward, & Smith (1992) predicted that greater choice would promote conventional thinking, and conversely, that less choice would preclude it. Choices in their study involved either parts (e.g., wire, tube, wheels) or categories (e.g., furniture, games, tools). Inventions devised by students with no choice were judged more creative that those by students who could select both parts and inventive category. In terms of the current model, fewer choices precluded/limited reliable responding and promoted/directed search for more variable, original solutions.

The choreographer Merce Cunningham echoed the idea that experts getting "stuck" in successful solutions. "The danger with acquiring a technique," he wrote, "is that it can constrict you, can make you think that's the way you have to do it...." (Cunningham, 1968, p. 56). To preclude constriction, Cunningham uses chance methods to determine the order in which sets of predetermined movements would appear. For example, two coins are tossed together to determine each performance of a 1953 ballet, *Untitled Solo* (Lesschave, 1985). The coin tosses precludes repetition and promotes variability; the movement set precludes chaos and promotes continuity.

The composer Igor Stravinsky (1997) also wrote about the need for constraints: "If everything is permissible . . . if nothing offers resistance, then any effort is inconceivable," noting (in the same paragraph) that resistance resided in the "seven notes of the scale and its chromatic intervals" (Stravinsky, 1997, p. 104). In other words, the tonal system of Western music precluded chaos, permitting the shift from harmonic to rhythmic primacy that promoted variability and creativity (Stokes, 2005). Finally, in jazz, players improvise on the first chorus, "composed of either 12 or 32 bars . . . [which] constitutes a perfectly circular, never-changing path" (Hodier, 1986, p. 84). The chorus precludes chaos, the improvisation promotes variability.

Where does this leave "artistic freedom?"

According to the constraint model "artistic freedom" consists solely in the choosing and using of one's own constraints (Stokes & Fisher, 2005). Novices cannot do this successfully for two related reasons. One is that they have not yet mastered the stylistic constraints that define their domains. Second, due to this skill/knowledge deficit, they don't recognize when something "new" in their work is old in their domain. In short, the constraints they use are not their own. This leaves artistic freedom to those experts who self-select and self-impose constraints on their currently successful solutions. Not all experts do. Not all can.

Can choosing and using constraints be taught?

Yes, but only to a degree. In professional art and design schools, this happens directly and indirectly. One direct way involves dissecting, as this paper did, the development of domain-changing work. What did it reject? What did it promote? What changes in task constraints, media and technique, did it involve?

Indirect ways include practicing what I call "constraint-finding" (Stokes, 1999). Constraint-finding involves ill-defined or ill-structured problems. Recall that in this kind of problem, some thing or things required for solution are not included in its presentation. Among the missing elements may be the constraint pairs that structure the solution path, or — more critically — the goal criterion for recognizing an acceptable solution. Since there is no single solution, there are numerous solution paths, negotiable only by imposing constraints that preclude and promote search in different parts of the problem space.

An example from Gabriel Latterman's painting class at Pratt involved "seeing" in a pile of stuff (plaster busts, shoes, paint cans, rags, etc.) something interesting enough to paint. What we saw depended on what we knew, i.e., our source constraints. If we knew about Paul Klee, we might have constructed a grid in which to place icons of the objects. If we knew about Robert Motherwell, dramatic blacks and whites could have dominated our canvases. Knowing includes both what these painters saw and how they realized what they saw. Unfortunately, at the time, most of us didn't know enough about either.

What conclusions can be made?

While some constraints (e.g. do it the same way) and some problems (e.g., well-structured ones) indeed preclude variability and creativity, multiple studies support the idea that paired constraints (which preclude low-variability, reliable responses and promote higher-variability, novel, often opposite ones) are integral to creativity. Recognizing, choosing and using constraints can be taught (and must be taught for novices to acquire expertise) but only to some degree. The caveat "to some degree" reflects the rarity with which an individual — a Motherwell, Mondrian, or Klee — pursues a novel goal and in the process of realizing it enlarges a domain.

REFERENCES

AMABILE, T. M. (1996). *Creativity in context.* Boulder, CO: Westview Press.

BODEN, M. A. (1994). What is creativity? In M.A. Boden (Ed.), *Dimensions of creativity*, pp. 76-117. Boston: MIT Press.

BOIS, Y-A. (1994). The iconoclast. In Y-A. Bois, Y-A., J. Joosten, J. A.Z. Rudenstine, & H. Janssen (Eds.) *Piet Mondrian, 1982-1944* (pp. 313-372). New York: Leonardo Arte.

CAMPBELL, D. T. (1960). Blind variation and selection in creative thought as in other knowledge processes. *Psychological Review, 67*, 380-400.

CSIKSZENTMIHALYI, M. (1996). *Creativity: Flow and the psychology of invention.* New York: Harper Collins.

CUNNINGHAM, M. (1968). *Notes on choreography.* NY: Something Else Press.

DELAUNAY, R. (1920/1978). Three notes on the differences between Delaunay's art and Impressionism and Expressionism. In A.A. Cohen (Ed.), *The New Art of Color: The Writings of Robert and Sonia Delaunay* (pp. 56-61). New York:Viking.

DUCHTING, H. (2004). *Paul Klee: Painting music.* Munich: Prestel.

FINKE, R. A. (1990). *Creative imagery: Discoveries and inventions in visualization.* Hillsdale, NJ: Erlbaum.

FINKE, R. A., WARD, T. B., & SMITH, S. M. (1992). *Creative cognition: Theory, research, and applications.* Cambridge, MA: MIT Books.

FLAM, J. (1991). *Motherwell.* NY: Rizzoli.

GARDNER, H. (1993). *Creating minds.* New York: Basic Books.

GLUCK, G. (1984, Dec. 2). The mastery of Robert Motherwell. *The New York Times Magazine* (pp. 66-86).

GREENBERG, C. (1993). An essay on Paul Klee. In J. O'Brian (Ed.), *Clement Greenberg, The collected essays and criticism: Affirmations and refusals 1950-1956* (pp. 3-13). Chicago: The University of Chicago Press.

GREENO, J. C., & SIMON, H. A. (1988). Problem solving and reasoning. In R.C Atkinson, R.J. Herrnstein, G. Lindzey, & R. Duncan Luce (Eds.), *Stevens' handbook of experimental psychology, Second edition, Volume 2: Learning and Cognition* (pp. 589-672). NY: Wiley.

GRUBER, H. E. (1989). The evolving systems approach to creative work. In D.B. Wallace & H.E. Gruber (Eds.), *Creative people at work: Twelve case studies* (pp. 3-24). NY: Oxford University Press.

HAYES, J. R. (1989). Cognitive processes in creativity. In J.A. Glover, R.R. Ronning, & C.R. Reynolds (Eds.), *Handbook of creativity* (pp. 135-145). New York: Plenum.

HODIER, A. (1986). *Toward jazz.* NY: DaCapo.

HOLLAND, J. H., HOLYOAK, K. J., NISBETT, R. E., & THAGARD, P. R. (1987). *Induction: Processes of inference, learning, and discovery.* Cambridge, MA: MIT Press.

KLEE, P. (1961). *The notebooks of Paul Klee. Vol 1: The Thinking Eye, Vol. 2: The Nature of Nature.* J. Spiller (Ed.). London: Lunt Humphries.

KLEE, P. (1880-1895/1964). Memories of childhood (Bern in the eighties). In F. Klee (Ed.), *The diaries of Paul Klee, 1898-1918* (pp. 3-21). Berkeley: University of California Press.

KLEE, P. (1902/1964). Recapitulation. In In F. Klee (Ed.), *The diaries of Paul Klee, 1898-1918* (pp.125-126). Berkeley: University of California Press.

KLEE, P. (1908/1964). Munich, 1908. In In F. Klee (Ed.), *The diaries of Paul Klee, 1898-1918* (pp. 220-234). Berkeley: University of California Press

LESSCHAEVE, J. (1985). *The dancer and the dance: Merce Cunningham in conversation with Jacqueline Lesschaeve.* NY: Marion Boyars.

MONDRIAN, P. (1917/1986). The new plastic in painting. In H. Holtzman & M.S. James (Eds.), *The new art – The new life: The collected writings of Piet Mondrian* (pp. 27-74). Boston: G.K. Hull & Co.

MOTHERWELL, R. (1974/1992). Interview with Robert Wagener, 14 June 1974. In S. Terenzio (Ed.), *The collected writings of Robert Motherwell* (pp. 214-220). New York: Oxford University Press.

MOTHERWELL, R. (1944/1992). The modern painter's world. In S. Terenzio (Ed.), *The collected writings of Robert Motherwell* (pp. 27-35). New York: Oxford University Press.

MUMFORD, M. D., REITER-PALMER, R., & REDMOND, M. R. (1994). Problem construction and cognition: Applying problem representations in ill-structured problems. In M.A. Runco (Ed.), *Problem finding, problem solving, and creativity* (pp. 91-122). Norwood, NJ: Ablex.

PALMER, D. C., & DONAHOE, J.W. (1992). Essentialism and selectionism in cognitive science and behavior analysis. *American Psychologist, 47*, 1344-1358.

PERKINS, P. N. (1994). Creativity: Beyond the Darwinian paradigm. In R.J. Weber & D.N Perkins (Eds.), *Inventive minds: Creativity in technology* (pp. 238-250). NY: Oxford University Press.

REITMAN, W. E. (1965). *Cognition and thought.* New York: Wiley.

SIMON, H. A. (1993). The structure of ill-structured problems. *Artificial Intelligence, 4*, 181-201.

SIMONTON, D. K. (1999). *Origins of genius: Darwinian perspectives on creativity.* New York: Oxford University Press.

STOKES, P. D. (1999). Learned variability levels: Implications for creativity. *Creativity Research Journal, 12*, 37-45.

STOKES, P. D. (2001a). Variability, constraints, and creativity: Shedding light on Claude Monet. *American Psychologist, 56*, 355-359.

STOKES, P. D. (2001b). Constraints and creativity: Experiments in art and psychology. In S.Nagel (Ed.), *The handbook of policy creativity, Volume III* (pp. 33-48). New York: Nova Science Publishers.

STOKES, P. D. (2005). *Creativity from constraints: The psychology of breakthrough.* New York: Springer.

STOKES, P. D. (2007). Using constraints to generate and sustain novelty. *Psychology of Aesthetics, Creativity, and the Arts.* (in press).

STOKES, P. D., & FISHER, D. (2005). Selection, constraints and creativity case studies: Max Beckmann and Philip Guston. *Creativity Research Journal, 17*, 283-291.

STRAVINSKY, I. (1997). Poetics of music. In F. Barron, A. Montuori, & A. Barron (Eds.), *Creators on creating: Awakening and cultivating the imaginative mind.* (pp. 189-194). NY: Putnam.

VOSS, J. F., & POST, T. A. (1998). On the solving of ill-structured problems. In M.T.H. Chi, R. Glaser, & M.J. Farr (Eds.), *The nature of expertise* (pp. 261-286). Hillsdale, NJ: Erlbaum.

WARD, T. B., PATTERSON, M. J., & SIFONIS, C. M. (2004). The role of specificity and abstraction in creative idea generation. *Creativity Research Journal, 16*, 1-9.

WEISBERG, R.W. (1999). Creativity and knowledge: A challenge to theories. In R.J. Sternberg (Ed.), *Handbook of creativity* (pp. 226-250). New York: Cambridge University Press.

WEISBERG, R. E. (1993). *Creativity: Beyond the myth of genius.* NY: Freeman.

YOKOCHI, S., & OKADA, T. (2005). Creative cognitive process of art making: A field study of a traditional Chinese ink painter. *Creativity Research Journal, 17*, 241-255.

Patricia D. Stokes, Psychology Department Barnard College, Columbia University, 3009 Broadway, New York, New York 10027. Email: pstokes@barnard.edu