REVISITING GOTTSCHALDT: EMBEDDED FIGURES IN ART, ARCHITECTURE AND DESIGN

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In 1920, the Psychological Institute at the University of Berlin moved to the abandoned Imperial Palace, about a half-mile from the university. Its size and budget were increased, and Wolfgang KÖHLER, one of the founders of gestalt psychology, was appointed the new director (ASH, 1995, p. 205).

Under KÖHLER's supervision, along with his colleagues Max WERTHEIMER and Kurt LEWIN, the graduate students at the Institute designed and carried out their own psychological research, while serving as subjects for the experiments of fellow students. The results of their work were later published in scientific journals under the joint authorship of both student and professor (Arnheim, 1984).

Among the students was Kurt GOTTSCHALDT (1902-1991), who completed his dissertation in 1926, and was then hired as a paid assistant until his dismissal in 1929 (Ash, 1995, p. 354). In the literature of gestalt theory, GOTTSCHALDT is often mentioned because of his research of past experience in relation to the perception of game-like visual puzzles called "embedded figures," in which smaller, simpler shapes are hidden within larger, more complex designs.

In his now-famous experiment, GOTTSCHALDT showed five simple geometric figures to two subject groups for one second each, instructing the subjects to memorize the figures carefully enough that they could draw them later. These figures were shown to the one group only three times, and to the second group 520 times. Both groups were then introduced to a series of new, more complex drawings, for two seconds each, into which (unknown to the subjects) one of the earlier figures had been integrated (Figures 1-4). Initially, in both groups, fewer than 10 per cent of the subjects suspected the presence of an embedded figure; and even when instructed to search for it, only about 30 per cent were able to detect the original figure (GOTTSCHALDT, 1926).

Over the years, GOTTSCHALDT's embedded figure research has frequently been cited by psychologists and other scientists, and the issues most often debated have been the influence of experience on perception, the extent to which wholes may influence their parts, and the nature of problem-solving. In this essay, I would like to discuss embedded figures from a somewhat different viewpoint, from that of an artist, and to highlight a few of

the principal ways in which this same phenomenon has been used by artists, architects and designers.

It is conceivable that the figures used in GOTTSCHALDT's experiment were originated by him, but surely he did not come up with the idea of an embedded figure. It is more likely that comparable figures have been discovered or devised throughout human history, that they are ubiquitous visual events, examples of which can be found in all cultures and time periods.

The geometric figures in GOTTSCHALDT's experiment are reminiscent of Victorian-era parlor games, referred to by antique collectors as "put-together puzzles." Among the oldest is the tangram, which was introduced to Europe from Asia in the early 19th century, at which time it was known as the "Chinese puzzle" or "seven clever pieces" (ELFFERS, 1997; SLOCUM and BOTERMANS, 1994, p. 2ff). One can easily make a tangram by dividing two adjacent squares into seven geometric parts in a prescribed manner (Figure 5). Any number of games can be played with the pieces, but the customary challenge is to use all seven in arriving at alternative configurations, whether abstract or pictorial (Figure 6).

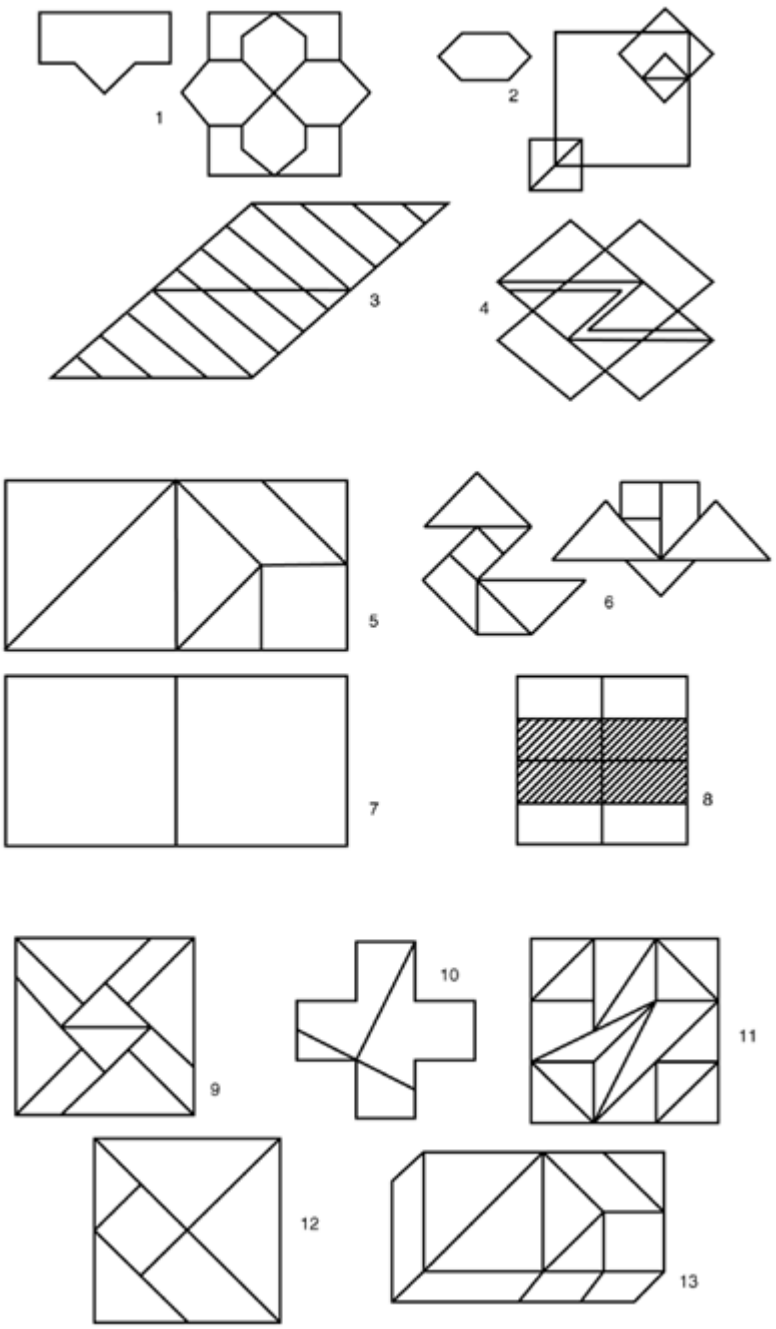
While the tangram's origin is unknown, it may be historically tied to a feature of traditional Japanese architecture, the floor mat or tatami (Figure 7). Measuring 3 feet by 6 feet, and comprised of two adjoining squares (identical to an undivided tangram), the tatami was used as the module for the floor plans of traditional Japanese houses. Each house plan was made by arranging such mats in rectangular patterns (NUTE, 1993, pp. 43-44).

I know this in part because the tatami (the shape of a domino) is a recurrent motif in the Kamerick Art Building, designed in 1985 by American architect H. Kennard BUSSARD, which is the building I teach in at the University of Northern Iowa in Cedar Falls, Iowa, U.S.A. Throughout that structure, in its windows, handrails, floor tiles, ceiling panels, and mosaic wall coverings, one finds references to tatami proportions (Figure 8).

Like the tatami, the tangram too has been widely imitated. Renditions of it were produced and distributed in Europe and the U.S. during the late 19th century and early 20th century, among them The Elzzup Puzzle (1898), The Square and Cross Puzzle (1913), The Mysterious Cross (1932), and Baffle 1 (1935) (Figures 9-12).

Among the most popular in Germany were Anchor Puzzles, including The Headcracker (Der Kopfzerbrecher, 1891), The Patience Prover (Der Geduldprüfer, 1896) and The Pipesmoker (Der Pfeifenraucher, 1913). These were apparently first produced about 1884, through the efforts of J.D. GEORGENS, a friend of Friedrich FROEBEL, who was the founder of kindergarten and who may have been the first to use wooden building blocks as educational toys (SLOCUM and BOTERMANS, 1994, p. 6; BROSTERMAN, 1997; LUPTON and MILLER, 1993). It may be more than coincidence

that FROEBEL began his kindergarten in the 1830s, while an early explicit connection between children's toys and tangrams was produced at nearly the same time in The Magic of Geometry, a set of blocks in the shape of the parts of a tangram (BROSTERMAN, 1997, p. 55) (Figure 13).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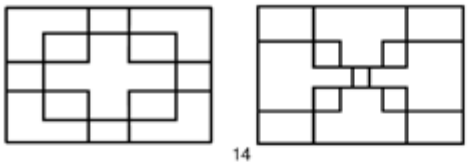

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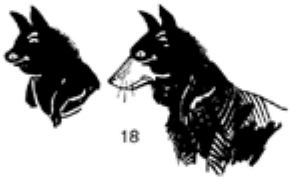

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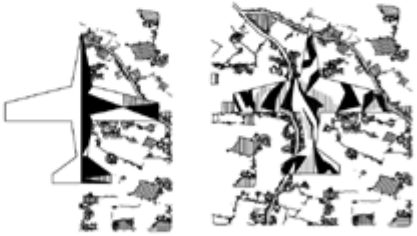

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Illustration Captions

Figs. 1-4: Examples of GOTTSCHALDT's embedded figures.

Fig. 5: Tangram, showing its standard divisions.

Fig. 6: Recombined tangram pieces (2 solutions).

Fig. 7: Tatami architectural module.

Fig. 8: Architectural motif from the Kamerick Art Building, University of Northern Iowa, USA.

Fig. 9: Elzzup puzzle (c. 1898).

Fig. 10: Square and Cross puzzle (c. 1913).

Fig. 11: Mysterious Cross puzzle (c. 1932).

Fig. 12: Baffle puzzle (c. 1935).

Fig. 13: The Magic of Geometry puzzle (c. 1830s).

Fig. 14: Esthetic line-ideas from Arthur Wesley Dow's *Composition* (1899).

Fig. 15: Comparison of one of DOW's "esthetic line-ideas" with the plan of Frank Lloyd WRIGHT's design for the Charles S. ROSS house in Lake Delavan, Wisconsin USA (1902). Based on a diagram by Kevin NUTE (NUTE, 1993, p. 89).

Figs. 16-18: Chalk talk drawings by Harlan TARBELL (TARBELL, 1924).

Fig. 19: Two nuns in a portrait of Voltaire, redrawn from a painting by Salvador DALI, titled *Slave Market with Disappearing Bust of Voltaire* (1940).

Fig. 20: Disruptive camouflage applied to an airplane. Based on a diagram by Eric SLOANE (SLOANE, 1942).

Fig. 21: Coincident disruptive patterning in the wings of a swallowtail butterfly

In tangrams as in FROEBEL blocks, the primary goal is to "put things together," to create new wholes by repositioning the same set of parts. Conversely, in embedded figure puzzles such as GOTTSCHALDT's, the goal is to "take things apart," to unearth a detail from a larger gestalt.

The literary equivalent of a put-together puzzle is an anagram, in which alternative words are produced by rearranging the same set of letters (the letters in *garden*, for example, might become *danger*, *gander* or *ranged*); while the equivalent of an embedded figure is a "word search" puzzle (the word *and*, for example, can be extracted from *gander*). In either case, one faces the same range of challenges because wholes nearly always have synergistic properties ("the whole is greater than [or at least different from] the sum of its parts"), and a part in one context may visibly change when its position is altered: A line by itself on a blank page and the same line as the

side of a figure, said Kurt KOFFKA, are “two different things” (quoted in ASH, 1995, p. 231).

The American architect Frank Lloyd WRIGHT was born in 1867, fifteen years after FROEBEL’s death and far in advance of the founding of gestalt theory. Nevertheless, by his own admission, he was substantially influenced by FROEBEL blocks (which were given to him by his mother), Japanese woodcut prints, and, very likely, such games as the tangram (NUTE, 1993). He was also very much aware of a book titled *Composition* by Arthur Wesley DOW, Curator of Japanese Paintings and Prints at the Boston Museum of Fine Arts. First published in 1899, that hugely influential book includes geometric diagrams (which DOW called “aesthetic line-ideas”) of tartan-like plans for page or picture layout schemes (DOW, 1997) (Figure 14).

At first glance, the resemblance between DOW’s and GOTTSCHALDT’s diagrams may appear only slight. But their connection becomes more compelling when we learn that a number of WRIGHT’s house plans (the first of which was designed only months after the publication of *Composition*) were apparently created by his having treated DOW’s drawings as if they were embedded figure diagrams. WRIGHT’s house plans, as architectural historian Kevin NUTE has shown, are modified extractions from DOW’s layout diagrams; they are details exhumed from a larger gestalt (NUTE, 1993, pp. 86-98) (Figure 15).

Another Victorian-era practice that may have prompted WRIGHT, DOW and GOTTSCHALDT to become interested in embedded figures is a form of public speaking called a “chalk talk” (TARBELL, 1924). The term refers not only to a lecture given with the aid of a chalkboard. It also implies a sequential, simply-drawn cartoon in which (to the surprise of the audience) one picture is hidden within another and, as the talk progresses, the first drawing is magically transformed into the second. A duck, for example, may evolve step-by-step into a farmer, a hunter into the hunted, or a prey into its predator (Figures 16-18). Chalk talks were popular in the 1920s (coincident with GOTTSCHALDT’s dissertation), but I recall from childhood that they were still occasionally used by speakers in the 1950s.

Hidden pictures, like those in chalk talks, have long been used in visual art. There is a rider in the clouds in Andrea MANTEGNA’s painting of St. Sebastian (c. 1460), a face in a rock in a landscape by Albrecht DÜRER (c. 1495), and two nuns in a portrait of VOLTAIRE by Salvador DALI (1940) (Figure 19). In *Art and Illusion*, art historian E.H. GOMBRICH reproduces a photograph of a prehistoric sculpture on a cave wall in France that appears to have come from the shape of a rock in which the artist saw the embedded figure of a horse. Similarly, GOMBRICH suggests, constellations might also be regarded as embedded figures in the night sky (GOMBRICH, 1969, pp. 105-109).

Embedded accidental shapes (or "chance images") are mentioned in a famous passage in Leonardo DA VINCI's *Treatise on Painting*, in which he advises that a sure way to produce new ideas is to "look at certain walls stained with damp, or at stones of uneven color." If in need of a background while painting, he writes, "You will be able to see in these the likeness of divine landscapes, adorned with mountains, ruins, rocks, woods, great plains, hills and valleys in great variety; and then again you will see there battles and strange figures in violent action, expressions of faces and clothes and an infinity of things which you will be able to reduce to their complete and proper forms. In such walls the same thing happens as in the sound of bells, in whose stroke you may find every named word which you can imagine" (quoted in GOMBRICH, 1969, p. 188).

Among those who advocated similar techniques were the British artists Alexander COZENS, who wrote a book about the use of accidental ink blots as points of departure, and Aubrey BEARDSLEY, who said of his own method, "I make a blot upon the paper and begin to shove the ink about and something comes" (GOMBRICH, 1969). Even more astonishing are the experiments of the French novelist Victor HUGO, who made drawings and paintings not only from ink blots, but from soot, black coffee, mulberry juice, burned onion, cigar ash, fingerprints, fingernails, matchsticks, stencils, sprays of water, lace and cloth impressions. He even signed and dated stones (RODARI, 1998).

Chance images are not always desirable. There is a wonderful story about Pablo PICASSO and Georges BRAQUE, the co-founders of Cubism, for example, who were painting in ways that were largely abstract. One day, as PICASSO was looking at BRAQUE's latest painting, "he became aware that there was a squirrel in the picture, and pointed it out to Braque, who was rather abashed at this discovery. The next day Braque showed him the picture again, after reworking it to get rid of the squirrel, but Picasso insisted that he still saw it, and it took another reworking to banish the animal for good" (JANSEN, 1973, p. 352).

Embedded figures such as GOTTSCHALDT's, wrote KÖHLER in 1947 in *Gestalt Psychology*, are comparable to "the puzzle-pictures which years ago amused the readers of magazines…" They rely on the same principles as camouflage, he continued, which in modern wars has been used "to make objects such as guns, cars, boats, etc., disappear by painting upon these things irregular designs, the parts of which are likely to form units with parts of their environment" (KÖHLER, 1947, pp. 92-93).

A step-by-step procedure for concealing an object in its surroundings was demonstrated in 1942 by American artist Eric SLOANE in *Camouflage Simplified* in a section on "The Disruptive Pattern" (SLOANE, 1942). By cutting up the object (a building, airplane or whatever) with lines and shapes that contradict (are "not in harmony with") the attributes of the figure, a camou-

flage artist can prevent it from being seen as a single, segregated object, and, at the same time, can blur the distinctions between the object and its surroundings (Figure 20).

The result of course is a variety of embedded figure, an effect that was given the suitable name of “coincident disruptive coloration” by British zoologist and scientific illustrator Hugh B. COTT, who was also a camouflage artist in both world wars. On the one hand such forms are disruptive, said COTT, because “they appear to break up what is really a continuous surface” (the figure); while, at the same time, they are also coincident because they “unite [visually] what are actually discontinuous surfaces” (the figure and ground) (COTT, 1940, p. 70). As COTT illustrates, coincident disruption in nature occurs not only between a figure and its surroundings; it also takes place in relations among distinct regions of the same figure, as shown by the misleading bands that result when a frog’s legs are folded up or a butterfly’s wings are unfurled and aligned (Figure 21).

During World Wars I and II, hundreds of soldiers (French, British, German, American, Russian and others) who had been artists in civilian life were assigned to camouflage (BEHRENS, 1998a). What enabled those artists to be well-suited for concealing objects (or at least to assume that they might be) was their understanding of innate grouping tendencies or “laws of visual organization” (similarity, proximity, good continuation and closure) that WERTHEIMER proposed in a paper he wrote in 1923. Titled *Untersuchungen zur Lehre von der Gestalt*, that essay was fondly referred to among students at the Berlin Psychological Institute as WERTHEIMER’s *Punktarbeit* or “dot paper” because its visual examples were abstract patterns made of dots (ARNHEIM, 2000). It is those same grouping tendencies or “unit-forming factors” (a term borrowed from Fritz HEIDER) that determine the ease or the challenge with which one can solve an embedded figure problem (cf. BEHRENS, 1998c).

As the leading proponent of Prairie School architecture, one of Frank Lloyd WRIGHT’s main goals was the “destruction of the [impenetrable architectural] box,” which he did by embedding his buildings within their physical surroundings: No house should ever be on a hill, he said; instead, it should be of a hill. The purpose of an architectural structure, said WRIGHT, is “to afford protection against storm or heat,” but also “to bring the outside world into the house, and let the inside of the house go outside” (NUTE, 1993, p. 62).

Just as camouflaged objects and WRIGHT’s buildings may remind us of embedded figures, the same is also often true of artworks and the page layouts of graphic designers. One reason for this is that skilled artists and designers, like architects, nearly always play up the connections between a figure and its background, a text and the page it resides in, or a building and its surroundings, for the purpose of what is traditionally called “esthetic uni-

ty." In a well-designed house in its setting, said WRIGHT, "everything has a related articulation in relation to the whole and all belongs together; looks well together because all are speaking the same language" (cf. BEHRENS, 1998b).

A further reason why art, architecture and design tend to resemble GOTTSCHALDT's embedded figure puzzles is that the finest, most lucid examples combine clarity with implicitness. They provoke closure—the act of completing an incomplete form in the very process of perceiving it—and provide for what GOMBRICH describes as "the beholder's share" (GOMBRICH, 1969, p. 183ff), and what Arthur KOESTLER calls "infolding," the purpose of which "is not to obscure the message, but to make it more luminous by compelling the recipient to work it out by himself—to re-create it" (KOESTLER, 1964, p. 337).

Summary

This paper recalls the research in 1926 by gestalt psychologist Kurt Gottschaldt (1902-1999) of the influence of past experience on the perception of game-like visual puzzles called "embedded figures." It discusses the historic use and significance of such figures from the viewpoint of an artist, and highlights a few of the principal ways in which this same phenomenon has been used by artists, architects and designers.

Zusammenfassung

Die 1926 publizierten Forschungsarbeiten des Gestaltpsychologen Kurt GOTTSCHALDT über den Einfluss vergangener Erfahrungen auf die Wahrnehmung spielähnlicher visueller Puzzle ("eingebundene Figuren", engl. "embedded figures") wird vorgestellt. Der Autor diskutiert den historischen Nutzen und die Bedeutung solcher Figuren vom Standpunkt eines Künstlers. Es werden einige der prinzipiellen Möglichkeiten dargestellt, wie diese Figuren von Künstlern, Architekten und Designern genutzt wurden.

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