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NEUROSCIENCE, GESTALT PSYCHOLOGY, RUDOLF ARNHEIM: SOME REFLECTIONS FOR A DIDACTICS OF ART EDUCATION

NEUROSCIENZE, PSICOLOGIA DELLA GESTALT, RUDOLF ARNHEIM: ALCUNE RIFLESSIONI PER UNA DIDATTICA DELL'EDUCAZIONE ARTISTICA

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Abstract
In recent years, research in neuroscience regarding visual perception and its applications in neural networks of artificial vision experimentally confirms many assumptions of the theoretical framework of twentieth-century Gestalt psychology. Evidence of its implications in art education can be found, in support of Rudolf Arheim's theoretical and didactic approach on the evolution of children's drawing developed more than half a century ago. This contribution aims to resume these aspects in light of the contributions of neuroscience and artificial vision and how they can now be used in primary school teachers' training programs.

Negli ultimi anni le ricerche delle neuroscienze rispetto alla percezione visiva e le loro applicazioni alle reti neurali della visione artificiale confermano sperimentalmente molti degli assunti dell'impianto teorico della novecentesca Psicologia della Gestalt. Questo si riflette direttamente nella educazione artistica, avvalorando l'impostazione teoretica e didattica di Rudolf Arheim, di più di mezzo secolo fa, sull'evoluzione del disegno infantile. L'intervento vuole riprenderne questi aspetti alla luce dei contributi delle neuroscienze e della visione artificiale e di come possano oggi essere utilizzati nella formazione dei docenti della scuola primaria

Key-words
Rudolf Arnheim, Gestalt, AI, visual perception, neuroscience, art education
Rudolf Arnheim, Gestalt, IA, percezione visiva, neuroscienze, educazione artistica

Introduction

> *The things of this world are basically the way they appear […] if only the weeds of secondary complication and distortion are cleared away.*
> (Arnheim, 1970, p. 36)

In the introductory essay to the Italian collection of *Thoughts on Art Education* by Rudolf Arnheim (1992)—the famous German-born art psychologist, who had a particularly close relationship with Italy, and especially with Palermo—Lucia Pizzo Russo in 2007 highlights, with brilliant wealth, the weight of Arnheim's academic legacy on the shoulders of education professionals. She addresses, as well, the fact that these professionals, including those training agencies that are supposed to train them, still struggle to master its principles.

As a visual media high school teacher in the past and as a university professor now, I have directly been able to verify Pizzo Russo's observations, especially regarding teaching methodologies in the artistic educational field and the training practices of future teachers. How can be possible, I wondered, that in Italy the Gestalt theories represent the basics in teaching visual advertisement and graphics while at the same time they are close to being ignored in arts education? The same one that is now mostly reduced to a historical catalogue of works and masters? In this scenario, Arnheim's words from 1970 echo: "The foolish notion that true art appreciation ignores the subject matter—together with equally restrictive iconological studies, discussing subject matter only—has estranged generations of students from pertinent aesthetic understanding and experience" (1986, p. 7, 1st ed. 1970).

1. Arnheim and the centrality of *visual thinking*

Moving his steps from Gestalt basics, between the 1950s and the 1980s Arnheim provided theoretical frameworks for his didactic methodology: to make artistic education the cornerstone of an integral education of the individual. In many ways, he anticipated what the early neuroscientific experiments on nerve cells were about to demonstrate, thanks to the constant improvement in observing and defining cognitive transmission and re-elaboration of sensory data. The centrality that Arnheim placed on visual thought as a *tout court* thought ("the very marrow of thought itself", as he wrote in 1969, p. 161) is confirmed not only by the prevalence in our brain of those areas specifically designed to detect visual data, but also by the pervasiveness that visual data have on those brain areas dedicated to other sensory stimuli and, nevertheless, by the analogy we can find between visual-data-related neural processes and the other senses (e.g. touch).

Not surprisingly, neuroscience studies on the visual system have found applications in the cybernetic field. Artificial vision is the sphere in which the real possibilities of "hard" artificial intelligence are experimented with in the most promising way, that means, in a silicon homologue of the human brain, hubris is no longer so science fictional: from a behavioural-Cartesian perspective, human beings are machines. "When it is argued that cognition is calculation, and mind and computer process information, the computer, more than a metaphor, works as an electronic counterpart of the mind" writes Pizzo Russo in 2007 (p. 23). Arnheim: "The machine starts out by doing exactly what the eye does: it cuts up the continuous stimulus pattern into a mosaic of discontinuous bits [...]. This is an act of so-called digital coding, which transforms the stimulus into an assembly of discrete units, each reporting the presence or absence of a particular perceptual quality. […] What, then (continues Arnheim) is the basic difference between today's computer and an intelligent being? It is that the computer can be made to see but not to perceive. What matters here is not that the computer is without consciousness but that thus far it is incapable of the spontaneous grasp of pattern—a capacity essential to perception and intelligence" (Arnheim, 1969, *passim*).

"Thus far": Arnheim wrote these words in his evocatively entitled book, *Visual Thinking*. He argued that the eye is not limited to be a "dull" receptor organ but performs "intelligent" operations. In 1974 (p. 46), he reiterates "the same mechanisms operate on both the perceptual and the intellectual level". When Arnheim was writing, monitoring the activity of neuronal cells was still being roughly and invasively investigated by Stephen Kuffler (cf. Masland, 2020).

2. Is there any homology between artificial vision and human vision?

Nowadays, instead, Winfred's two-photon confocal microscope, as well as the ability to synthesize fluorescence protein (the so-called "neuroimaging" process) and a low-cost computing power still unimaginable few years ago (cf. Masland, 2020), allows us, on one hand, to observe with precision and without invasiveness the activity of neurons under a particular stimulus and, on the other hand, to ascertain the similarities with artificial nerve net. We now know that retinal ganglion cells (RGC) are activated and inhibited (sending or not *spikes*—

electrical impulses) depending on the type of signal they are sensitive to. In other words, they follow a binary logic, as Arnheim argued.

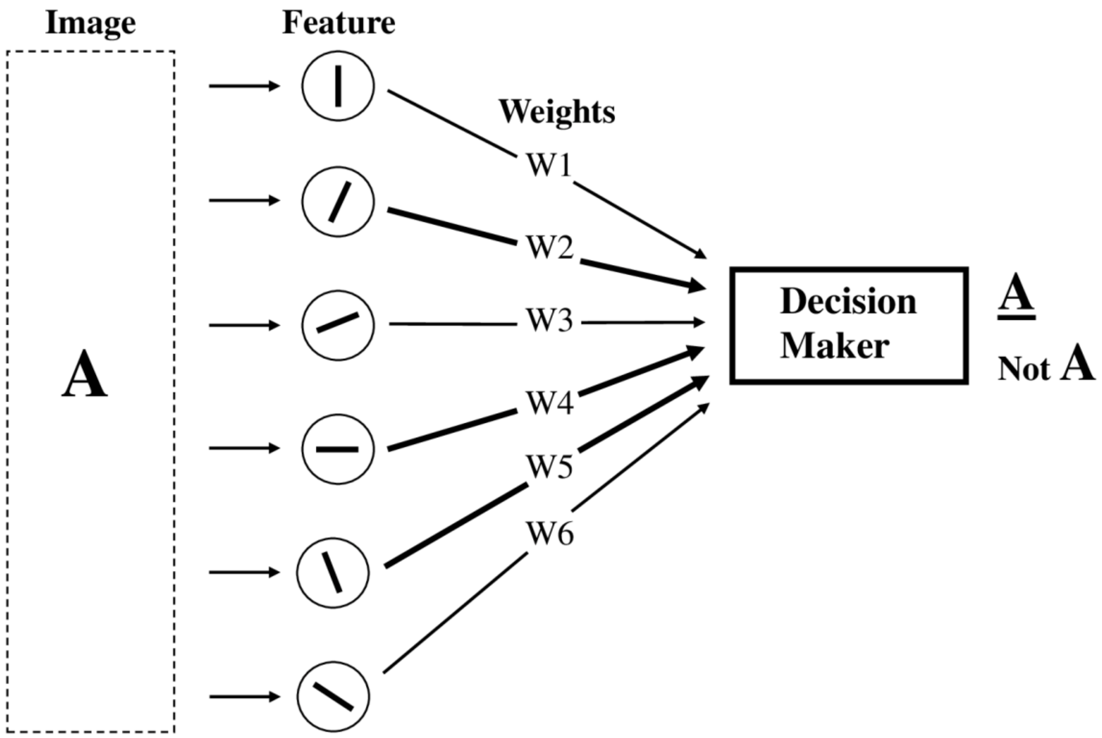

Figure 1 Basic scheme of Selfridge's *perceptron* that makes evident the binary logic by which a simple form is recognized.

The same principle explains the core concepts of a *perceptron* (Fig. 1), "the granddaddy of seeing computers (you might as well call them thinking computers)" (Masland, 2020, p. 153), invented by Selfridge in the late 1950s: each *demon* (i.e. "perceptual elements" in Selfridge lingo) is not able to recognize the object, but what it can detect compared to another "silent" *demon* will give it greater weight in the final choice of the perceptron (decision maker) (cf. Masland). The process of "thickening" (decision-making weight) of the axons of neurons, developed with practice activities, is similar: if the response to a certain stimulus is "correct", the synaptic pathways that produced it will "thicken" and become prevalent (this also explains the *trompe l'oeuil* effect: the synaptic habit can mislead us).

In this perspective, replacing "retina" with "perceptron" and "visual areas of the brain" with "decision maker" doesn't seem to overcome the logic of the "dull eye" and the "sentient brain" that Arnheim rejected. However, the difference between the "ancient" perceptron and a modern artificial nerve net is that the latter does not need a supervisor to educate itself on the quality of its response. This is due to two reasons: firstly because the (pavlovian) *reinforcement learning*—which is generated by some specific algorithms that allows the computer to "play against itself" and reward itself every time it "wins"—reinforces the synapses/circuits of its neural network/nerve net. Secondly, through the mechanism of the *backpropagation* (invented by Hinton and later exploited in modern nerve net by Sejnowski starting from the 1980s): the computer compares the incoming data with the one that has already been gathered and stored, and then provides its own "answer". The brain itself implements these same processes. Eagleman (2015, p. 71) writes: "In fact, the brain generates its own reality, even before it receives information coming in from the eyes and the other senses. [...] This is known as the *internal model*." The words of Eagleman echo those of Arnheim: "[Vision is] a creative activity of [the] human mind" (1974, p. 46). As the neuroscientist Michael Herzog said in the latest *Kanisza Lecture*, "The percepts are mind dependent; they are not in the external world … Objects are the outputs of perception, not the inputs … Gestalts rule human perception, but in an idiosyncratic fashion, depending on brain wiring and unconscious processing."[1]

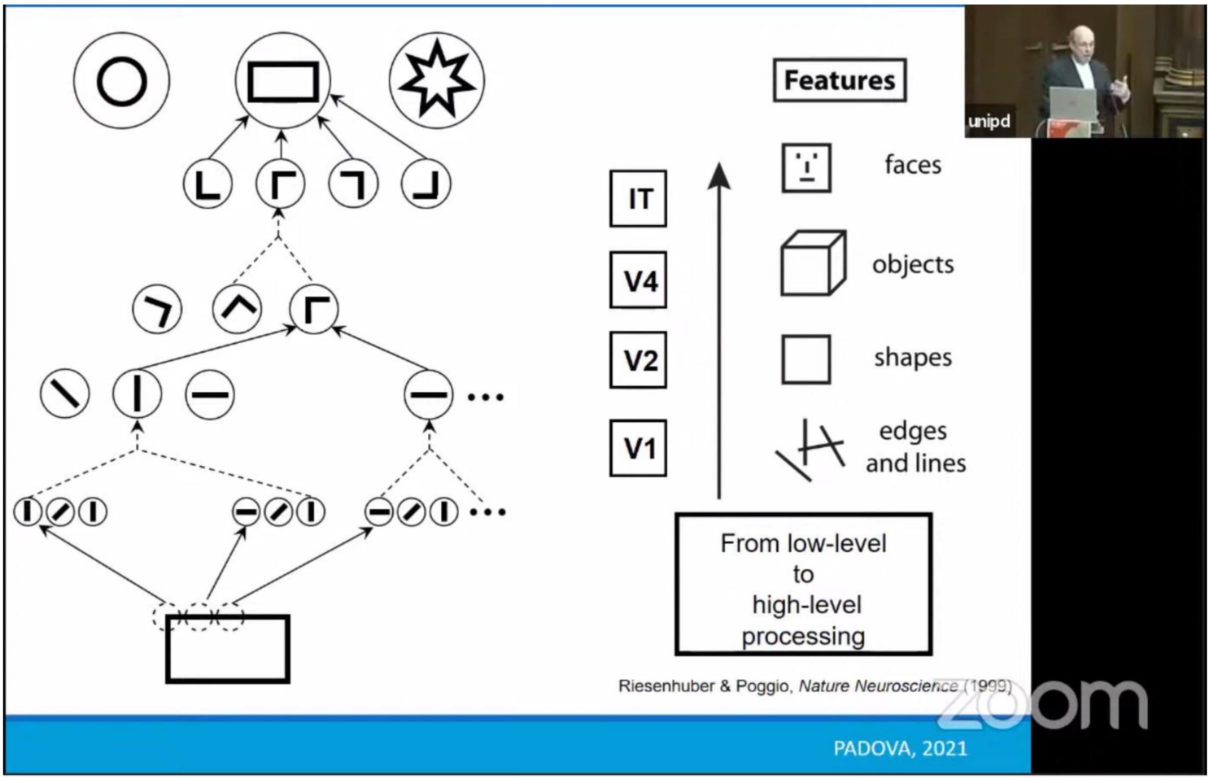

Figure 2 Frame from M. Herzog, *The irreducibility of vision*, 29th Kanisza Lecture, Padua, 2021.

In short, from the perceptor's viewpoints onwards, things become more complex but substantially they maintain the same logic. Just like we see in Herzog's chart (Fig. 2), in which different brain areas dedicated to vision are shown, distinguished by level of complexity (V1, V2, etc.), the more neurons (thus the computing power) increase, the more the process refines itself. Then, accordingly, within each area, a "micro-consciousness" (Zeki) operates: "there is no such thing as a 'unitary' visual consciousness. There are instead many visual consciousnesses that are distributed in time and space" (Zeki, 2009, p. 39).

[1] Excerpts from Michael Herzog lecture: *The irreducibility of vision: Gestalt, crowding and the fundamentals of vision*. 29th Kanisza Lecture, 2021/11/29, Padua (IT). Streaming video recording: https://youtu.be/rpUoeLD85GE

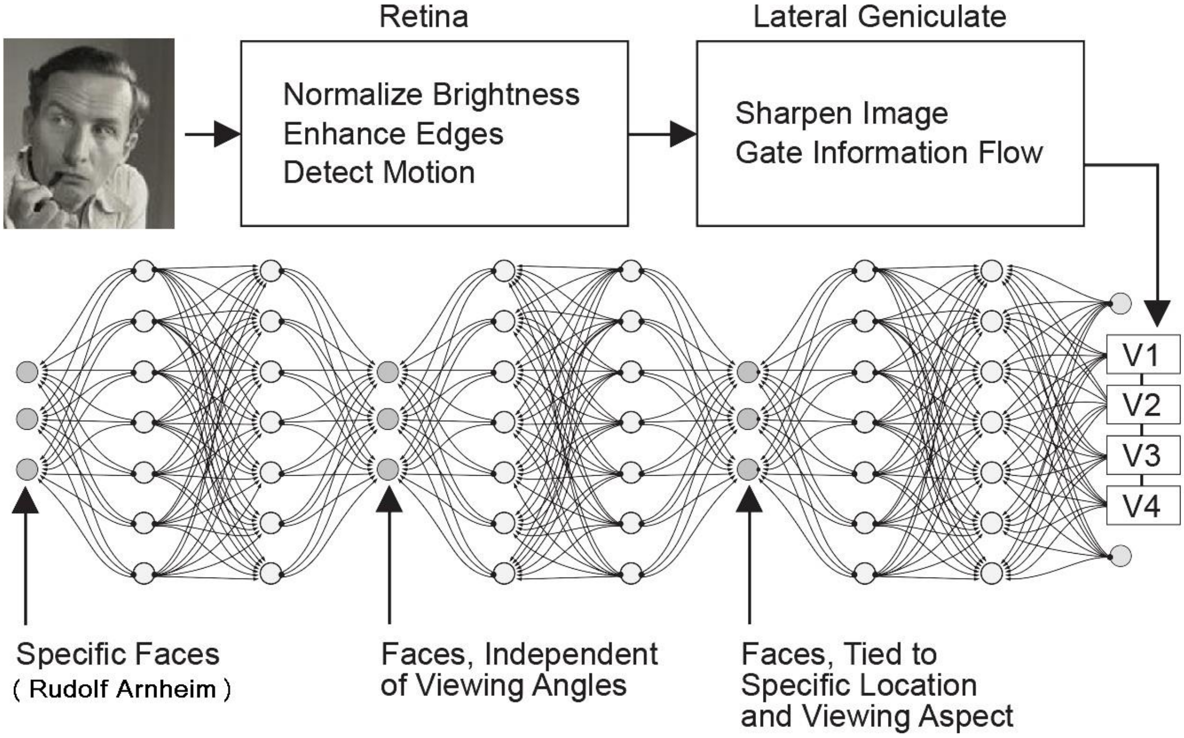

Figure 3 Retina-Brain paths as an artificial nerve net (adapted from Masland, 2020)

As we see in Figure 3, both in AI and in our brain we find the face of Rudolf Arnheim consciously at the end of a complex path. And both in AI and in the brain, the traces by which a precise identity can be given to that face are lost—they are lost in the latency (the thousands of interconnections/data) between inputs and outputs, just as Herzog points out (~400 "unconscious" milliseconds).

3. The intelligence of the eye

A total homology between "hard" AI and the brain is still science fiction (but with quantum computers, who knows); also because, as Masland (2020) writes, the powerful nerve net of Google's *Alphazero* computer runs at a power of about one million watts and its hardware is a whole lot bigger—I quote Masland freely—"than the brain of my 4-year-old nephew who uses scarce 20 watts to do the same things" (*passim*, p. 196).

However, what has been explained so far, via the contribution of neuroscience and AI, confirms what Arnheim wrote in unsuspecting times about the "intelligent" activity of the retina and also confirms his theoretical approach to visual thinking. This is corroborated by what Zeki (2009) writes in relation to the Gestalt overturning of the generalization process: it is the general concepts that precede the perception of single cases (*triangularity* in relation to single triangles), and not the other way around. That, quoting Arnheim (1974, p. 58), "overall structural features are the primary data of perception". Zeki reiterates this when he highlights how the brain cells specialized in a given stimulus are, at the same time, capable of generalizing, meaning "abstracting" that particular stimulus. Indeed, "What I mean by abstraction is the emphasis on the general property at the expense of the particular. […] [For example, an] orientation-selective cell that responds to vertically oriented lines only will respond to a pencil if held vertically, or to a ruler, or to a white/black boundary. It will respond as well to a vertically oriented green line against a red background or vice versa. […] Perhaps paradoxically, specification and abstraction are two sides of the coinage of acquiring knowledge" (Zeki, 2009, *passim* pp. 13–19). Arnheim, (1986, p. 60, 1st ed. 1967): "Abstraction is the indispensable means by which all visible shapes are perceived, identified, and found to have generality and symbolic significance. For, if I may rephrase Kant's pronouncement, vision without abstraction is blind; abstraction without vision is empty."

Moreover, Zeki (2009, p. 21) seems to quote Arnheim's words when he writes about inherited perceptual concepts and acquired ones: "The inherited concept […] organizes the signals coming into the brain so as to instil meaning into them and thus make sense of them. The acquired concepts are generated throughout life by the brain and make it significantly independent to the continual change in the information reaching the brain. […] It is not as if perceptions lead to abstractions and concepts, but the other way round: we form our percepts from abstractions and concepts." The results achieved by the intertwining of neuroscience and artificial vision, which I have tried to exemplify here, end up confirming Arnheim's theoretical framework and showing evidence today of his assumptions as even more didactically valid in regard of the evolution of "child art" starting from simple gestalt structures the child, as well as a "naive" artist, adapts to the medium he uses: "Children and primitives draw generalities and nonprojective shape precisely because they draw what they see. But this is not the whole answer. Unquestionably, children see more than they draw" (Arnheim, 1974, p. 167).

Conclusions

I conclude where I began, by advocating didactics starting from visual thinking taken as teaching not only art education but teaching *tout court*. It has been established by neuroscience that the areas dedicated to vision are prevalent in the brain and also pervade the areas in it dedicated to other sensory perceptions. In Arnheim's way of thinking (see his *A plea for visual thinkin*g, 1st ed. 1980, now in Arnheim 1986, pp. 135–152), this means that visual thinking substantiates perceptual thinking. Therefore: "If all good thinking involves perception, it follows that the perceptual base of the student's and the teacher's reasoning must be explicitly cultivated in all areas of learning" (ibid. p. 146).

This is a perspective that breaks down the illusory barriers between scientific and humanistic disciplines, between intellect and intuition, both equally active and useful in every educational sphere. "Quite obviously, the two resources of human cognition, perceptual intuition and the intellectual standardization of concepts, require each other. The scientist must preserve a fresh view of the phenomena he is investigating to protect his concepts against 'premature closure'. The artist, in turn, must understand the general significance of the objects and events he is depicting so that his work may amount to more than an accidental apparition. […] This interdependence of intellect and intuitive perception is of fundamental consequence for general education. It demands not just that in the curriculum the subjects cultivating the intellect must be properly balanced against others that train intelligent vision. More importantly, it demands that in the teaching and learning of each subject both the intellect and intuition should be made to interact" (Arnheim, 1992, p. 29).

To try to establish an island of visual literacy
in an ocean of blindness is ultimately self-defeating.
Visual thinking is indivisible.
(Arnheim, 1974, p. 206)

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