

## LOOKING AT YOURSELF IN THE MIRROR: STRUCTURES OF PERCEPTUAL OPPOSITION

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### I. Looking at yourself in the mirror: a case of perceptual opposition

The most obvious frame of reference for the topics discussed in the second part of this paper is the debate concerning the so-called ‘mirror question’. Following the introductory works of BENNET (1970), BLOCK (1974), and LOCKE (1977), the study of the observer’s mirror image became an issue for discussion in the 90s (CORBALLIS 2000; GARDNER 1964; GREGORY 1989, 1996, 2001; HAIG 1993; ITTELSON 1993; ITTELSON, MOWAFY, & MAGID 1991; MORRIS 1993; NAVON 1987; TABATA, & OKUDA 2000; TAKANO 1998). All of the above references, with the exception of ITTELSON *et al.* (1991) and CORBALLIS (2000), start from the same question: ‘why does a mirror reverse left and right and not up and down?’. This question, which expresses the search for an explanation (“*why* does a mirror reverse...?”), also includes the description of an event that needs to be explained (“*a mirror reverses left and right and not up and down*”). A review of the debate regarding the mirror-question reveals that up to now it has focused for the most part on the explanatory aspects, leading to the development of different explanations for the reversal: optical (GARDNER 1964; HAIG 1993; TABATA, & OKUDA 2000), visual imagery based (GREGORY 1989, 1996, 2001; NAVON, 1987; MORRIS 1993), multiple process hypothesis (TAKANO 1998). On the contrary, we suggest focusing on descriptive aspects since, if we are to explain ‘something’, the first logical step should be to describe precisely it. For example, is the description of left-right reversal, which the mirror question assumes, a good description of what observers perceive?

In addressing this question, one must be aware of a methodological and epistemological risk: that of “stimulus error”, i.e. of confusing physical descriptions of the stimulus with their perceptual description” (BORING 1921; SAVARDI & BIANCHI 1999). We would like to emphasize that none of the arguments regarding the physics of mirrors or the physics of reflection are appropriate. Optical explanations are, on the contrary, in some way implied in the old mirror questions (which focused on ‘what mirrors do’), and are clearly endorsed by TABATA & OKUDA (2000), as giving a “simple and definitive solution to the mirror reversal problem” (p. 170). The possibility of demonstrating that a given object can coincide with its reflection by appropriate geometric operations does not make the psychological problem disappear. We agree with TAKANO’s statement (1998) that “according to this line of argument (...) one could maintain that the MÜLLER-LYER illusion, for example, is not worth investigation because the two compared lines are identical in length from a geometrical point of view. The mirror reversal problem arises from a discrepancy in recognized directions,

just as the MÜLLER-LYER illusion arises from a discrepancy in recognized lengths. From a psychological point of view, it is undeniable that the former discrepancy as well as the latter exists in reality” (p. 27). In other words, it is a question of visual perception and is independent of the physical nature of reflection.

### I.1. Past viewpoints on the description that forms the basis of the mirror question

Although all of the literature on the mirror question has concentrated on the search for an explanation of the left-right reversal, the ambiguity of the classic formulation has been repeatedly highlighted (BLOCK 1974; GARDNER 1964; ITTELSON 1993; ITTELSON *et al.*, 1991; MORRIS 1993). The reversal is generally said to arise from the confusion between different frames of reference: in the classic formulas, *left* and *right* are defined in the egocentric frame of reference (i.e. referring to the top/bottom, front/back, left/right axes of the subject) while *up* and *down* are defined in the exocentric frame of reference (i.e. referring to environmental orientation). The most common reaction to this criticism has been to conclude that the mirror-question is actually a false problem: correcting the description would make the ‘pseudo-problem’ disappear. We strongly disagree with this viewpoint, since we believe that by eliminating the linguistic ambiguity, an interesting perceptual problem comes to the fore. In this sense we, alongside CORBALLIS (2000), ITTELSON *et al.* (1991) and TAKANO (1998), share the belief that, firstly, the event under question poses a real problem to psychologists and that, secondly, the solution to this problem becomes clearer when one moves away from the classic point of view and looks at the event from a new perspective.

In their revision of the classic mirror-question, CORBALLIS (2000) and ITTELSON *et al.* (1993) shift the perspective of analysis from the recognition of left-right reversal to the more general recognition of the *differences perceived* between an object and its enantiomorphic reflection. CORBALLIS (2000) also moves the question away from the mirror itself and directs it to the perception of enantiomorphs in general, thus referring to real enantiomorphs (such as two human hands or two shoes of a pair), together with the enantiomorphs created through a reflection. His question in fact asks: ‘Why are enantiomorphs generally perceived as left-right reversals and not as reversals along some other axis?’ (CORBALLIS 2000, p. 164).

We agree with the need to move away from the classic version of the mirror-question towards a new perspective stressing relational nature of the event under study. However, we suggest starting to study observers’ direct experiences of the relationships between the real and the reflected image. More precisely, what relationship do observers perceive between themselves and their reflected image?

### I.2. A new description of the phenomenon

In the same way that ITTELSON *et al.* (1991, p. 567) argued with regard to their new perspective (“stated in this way, it presents a straightforward problem in visual perception”), we suggest that our version of the question will show that the event un-

der observation presents a straightforward problem in visual perception. The thought provoking condition arising from observers inspecting their reflected image in a flat mirror is the perception of the paradoxical unification of identity and opposition. This is the point that we consider has gone unnoticed in previous debates, preventing the identification of an interesting perceptual phenomenon.

It is worth mentioning briefly, at this point, that the present investigation concerning mirrors is part of a wider research project based on the direct perception of relationships - a topic at the core of the origins of Gestalt Psychology. More precisely, the wider research project aims to define the "rules" of perception of opposition (SAVARDI, & BIANCHI 1997; 2000; 2003). These points will be returned to in the final part of the paper.

Within this framework we propose that the experience of observers facing their mirror image can be described as a singular case of direct perception of a peculiar and seemingly contradictory relationship.

### 1.2.1. The event under observation as a structure of identity

The perception we are dealing with is primarily characterized as a *relationship of identity*. We shall introduce this first argument with a simple consideration. When someone intentionally approaches a mirror in everyday life, it is in order to look at *themselves*: to shave *their* face, to see how *their* jacket fits, etc. In more general terms, when people look in mirrors they see objects, spaces, movements etc., that are immediately perceived to be in direct relation to something existing outside the mirror: reflections are always reflections of *something else*, i.e. the object reflected in the mirror. This is the first factor that leads us to argue that reflections are characterized by an intriguing visual structure, since the perceptual world existing 'outside the mirror' conforms, on the contrary, to the rule of a one-to-one correspondence between the number of unities and the number of identities (BOZZI 1969). When we look at a scene, every single item has also its own identity (e.g.: I see 5 persons in this room, a table and 4 chairs, that do in fact correspond to 10 separate identities), and vice versa. This general visual rule does not hold with reflections, which create two segregated unities (one seen in the place where the object/person is, the other in the place where the reflection is) that correspond to only one identity (there is only *one* object, or *one* person, not two).

A possible criticism would suggest that this structure of identity is not always valid, for instance when people do not immediately recognize their own reflection. But this is not in effect a valid criticism since the event under question does not constitute the perception of a reflection. When this type of event happens it is in fact because we do not recognize that we are facing a reflected image. As soon as we realize that we are looking at a mirror, the visual organization of the scene suddenly changes, and the typical structure of dual identity previously discussed is immediately perceived.

### 1.2.2. The event under observation as a structure of opposition

Describing the peculiar structure of identity does not suffice to give a complete description of the relationship between the real and the reflected object. Both COR-

BALLIS (2000) and ITTELSON *et al.* (1991) initially described the question by stating that the mirror reflection appears to be *different* from the reflected object. They consequently asked: what conditions and processes underlie the detection of this difference? In contrast, we prefer to ask what this difference between an object and its reflection consists of. How is it perceptually structured?

While our previous examination of the structure of identity (two unities - one identity) applies to reflections in general, we now need to develop our analysis with close reference to the specific object-reflection configuration. In fact, the 'differences' directly perceived in a reflection depend on how asymmetrical the object is. For instance spheres, chairs, and people, all have different degrees of asymmetry. In addition to the structure of the object reflected, there are other variables that may affect the perceived relationship between the object and its reflection; for example, the type of mirror (plane, concave, deforming) and/or its position. This will be demonstrated later in this paper.

An initial question to ask could be: what 'differences' are perceived when inspecting a sphere and its reflection (Fig. 1)? In this case it is only a 'difference' in placement.

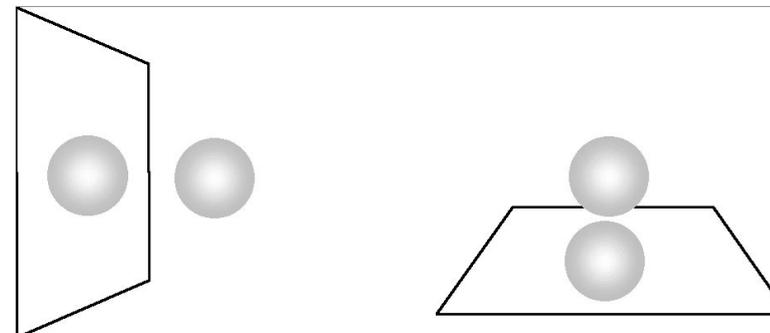


Figure 1 - Reflections of a sphere in a plane mirror, given its different positions in relation to the mirror.

Moving on, what are the 'differences' perceived when inspecting a chair and its reflection? It depends on the position of the chair in relation to the mirror: when it is side on to the mirror (Fig. 2a), one again sees only a 'difference' in placement. When it faces the mirror (Fig. 2b) or is positioned with its back to the mirror (Fig. 2c) one also perceives 'differences' in orientation. 'Differences' in placement and orientation are similarly visible when the mirror is placed horizontally and the chair is over it (Fig. 2d).

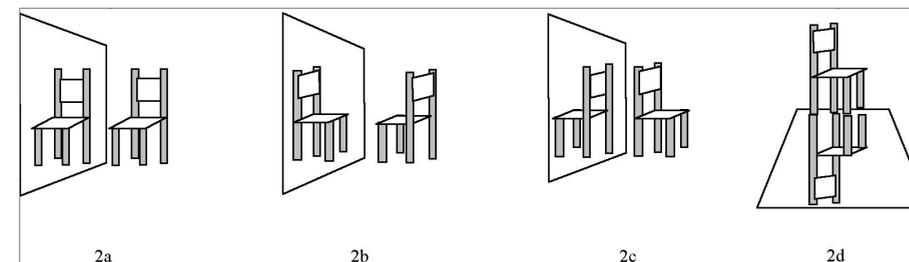


Figure 2 - Reflections of a chair in a plane mirror, given its different positions in relation to the mirror.

Finally, what are the 'differences' perceived when inspecting human beings and their reflections (Fig. 3)? Once again, we could describe 'differences' in placement when the person is side on to the mirror (Fig. 3a); 'differences' in placement and back-front orientation when the person is facing the mirror (Fig. 3b), or positioned with their back to the mirror (Fig. 3c); 'differences' in placement and gravitational orientation when the person is standing above the mirror (Fig. 3d). In all of the above conditions the structural left-right reversion found at the core of the mirror-question is also present.

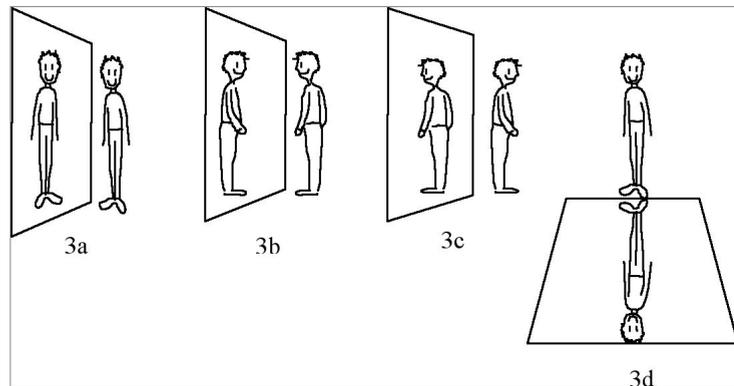


Figure 3 - Reflections of a person in a plane mirror, showing different positions in relation to the mirror.

We suggest that these three kinds of 'differences' (in placement, orientation and structure) are enough to operationalize the observed spatial variability between objects and their reflections, given any ecologically possible configuration. We would like to emphasize that the 'differences' we are referring to are not generic differences, but more precisely opposites. Thus:

a) with respect to placement, the observer-reflection relationship is always characterized by the reflected image being localized over/under, on the right of/on the left of, in front of/behind the observer.

b) given the natural structure of the human body with its two main axes of orientation (the one structured by the line of sight, the other structured by the gravitational orientation), the 'differences' in orientation, when present, are also strictly opposites. So, in relation to the line of sight, when the observer faces North, the reflection could face North too (Fig. 3a, 3d) or alternatively could face in the opposite direction, i.e. South (Fig. 3b, 3c), depending on the position of the mirror. With respect to the gravitational orientation, when the observer is standing upright, the reflection could be upright too (Fig. 3a, 3b, 3c) or alternatively it could be upside down (Fig. 3d). In both cases the orientation is visually organized in terms of identity or opposition. In the latter case, sometimes the result is divergent (Fig. 3c, 3d) and at other times it is convergent (Fig. 3b).

c) In the case of the third 'difference', the structural difference or "the crux of the problem" as CORBALLIS (2000) defines it, we again argue that it is not a general difference but more specifically a case of opposition: the observer's body is structurally 'opposite' (right-left) its reflection.

At this point it is useful to notice that actual differences can also be present in

the mirror image: for example, when a reflection is created by a partially reflecting surface, one might see an image as flatter and blurred or that colors are less pure. However, these differences need not always be present; on the contrary, the three oppositions in placement, orientation and structure inevitably exist whatever the reflecting surface may be.

### I.3. Experimental observations

Given that all the above oppositions analytically characterize the visible relationship between observers and their mirror images, we may ask if people notice any variation, reversal or contradictory element in their reflected image or if they simply perceive the reflection as identical to themselves. If they see any variations, what do they refer to? Do they relate to the left-right reversal or to the opposition between their real and virtual front-back orientation, or to their real and virtual gravitational orientation? How do these variations, if noticed, affect the perceived relationship? Would they say that the reflection is in any case identical to themselves, or would they describe it as similar, different, or opposite? It may be noted that in the old version of the mirror question, the front-back and gravitational orientation variations were never considered. Is this because they are not part of the visual scene or is it simply because they are not as intriguing to researchers as the left-right reversal?

Moreover, given that the left-right reversal is perceived by participants, how would they demonstrate that, although *their* left arm is *the* right arm in the mirror, it *is* however the image of *their* left arm? In other words, can they show which geometrical transformation of their body (rotation, movement of translation...) would prove that their body and its mirror image coincide?

*Experimental conditions.* Various experiments were devised to answer these questions, using experimental apparatus set up in the Psychology Department Laboratory at the University of Verona. This consists of an open mirror room made of four mirrors (2.5 x 2.5 m) composed of two sides, the ceiling and the floor of the room, set next to each other and meeting at right angles. The mirror room has been built to allow participants to stand on the mirrored floor. In this way participants can see many images of themselves, some of them showing the left-right reversal, others not.

Without going into details at this point regarding the experiments which were carried out (BIANCHI, SAVARDI & DE LOTTO 2003), the common factor in all the experiments was that participants were asked to give verbal reports. For instance, they were asked to describe what they could see in terms of 4 different aspects, sameness, opposition, difference, and/or similarity. General questions were asked, e.g. "do you see your image as identical, similar, opposite to you or different from you?" This was done in order to understand the general relationships that people perceive with regard to their own reflections. We also asked questions focused on local aspects of the scene, e.g., after being invited to stretch out their arms, participants were asked: "what would you say about the stretched out arm in the reflection: do you perceive it as the same arm as yours, or as the opposite arm?". Different reflections, different gestures, and static or dynamic conditions were used.

### 1.3.1. Main results and discussion.

A) *Perceived relationships.* With regard to the first series of questions concerning which relationship participants perceived between themselves and their mirror image, we found that they rarely referred to the left-right reversal, but at the same time they did not always describe their reflection as being “identical to themselves”. They noticed variations within the allocentric frame of reference, namely, they usually described the orientation variation in terms of similarity when referring to back-front variations in orientation (as occurs in every frontal reflection) and of opposition when reflections showed an upside-down gravitational reverse orientation (with mirrors lying horizontally on the floor). When they noticed the left-right reversal, it was usually when they were asked to focus on their arm. However even in this case they more frequently described their arm as identical. Moreover, when participants noticed the left-right reversal, it usually happened with reflections that were visible in frontal or lateral mirrors, i.e. with upright reflections, but not when the reflections were upside-down.

We believe that our results show that the old version of the mirror question describes something that is interesting for researchers rather than for observers facing their mirror image. This is not because they don't see any difference between themselves and their reflections but because the differences they notice are concerned with allocentric rather than egocentric aspects. The difference in importance between these two frames of reference in terms of structuring the scene is maybe the reason why observers accept the paradox of left-right reversal. If left-right reversal was an accepted fact about “what mirrors do,” participants would refer to the reversal just because they know about it and there would be no reason for the differences we found which depend on various other conditions.

In other words, we propose that people don't see any paradoxes not because they know or because are familiar with mirrors, but because although mirrors violate a definition of identity based on an egocentric frame of reference, at the same time they conform to an allocentric definition of identity. This second factor is probably even more important than egocentric non-correspondence in influencing our visual experience of the “correctness” in the correspondence between people and their images.

B) *The “sameness” between reflected images and real bodies.* With regard to the question concerning the strategies that participants used to prove the correspondence between their body and its reflected image, results revealed a preference for two strategies. The first strategy involved direct translation with the person moving towards the mirror and touching the surface. In the second case, participants visualized a simple rotation that would move their body into the same place and position as the reflection. All participants noticed the impossibility of eliminating the element of opposition from the scene.

In fact, the experience of identity, although evident, is at the same time impossible to prove perceptually. The correspondence between 3D objects and their relative reflections can be geometrically demonstrated by point-by-point correspondence, or by a rigid transformation within the 4<sup>th</sup> dimension<sup>1</sup>. Neither of these two transformations can be imagined by participants. On the subject of direct phenomenological solutions,

the most direct approach when searching for proof of correspondence is to imagine the person's body rotating so it coincides with its reflection, as is suggested both by the literature (BLOCK, 1974; GARDNER, 1964; GREGORY, 1989; NAVON, 1987; MORRIS, 1993) and by our results. However this transformation leads to the exact opposite result: it highlights left-right reversal. Another method suggested in the literature is to imagine ourselves ‘squashed’ back to front. Using TABATA & OKUDA's (2000) words: “your mirror image has the structure of your body which has suffered such a physical transformation that the front of your body has pushed back through the other side” (p. 170), a hardly conceivable solution, and in fact so confusing that TAKANO (1998) presents it as if he was proposing an exercise in imagination.

In conclusion, it is impossible for an observer to eliminate the perceived opposition, leaving only an experience of pure identity. In the same way, it is impossible to eliminate a strong sensation of identity, leaving only the experience of pure opposition. Optical explanations, on the other hand, a part from being epistemologically and methodologically incorrect for the researcher (as we discussed in the introduction), are completely useless for observers. CROUCHER, BERTAMINI and HECHT's recent work (2002) on naïve beliefs about mirror reflection demonstrates that, despite the fact that observers often have correct knowledge regarding the laws of reflection, they do not use it to solve easy geometrical predictions about what they would see in a mirror in familiar situations.

## II. Structures of perceptual opposition

As mentioned in part I of this paper, we consider that the study of the properties characterizing the perceived relationship between observers and their mirror image is part of a broader study of the structures that opposition, a type of directly perceived relationship, takes on in direct perceptual experiences.

When observers are looking at a scene, they directly perceive not only objects and properties but also the relationships between them. This idea can be considered to be the basis of the Gestalt theory (KOFFKA, 1935; KÖHLER, 1938; WERTHEIMER, 1912). It was not only at the heart of EHRENFELS' definition of “Gestalt qualities” (1890), but also referred to those relationships - perceived between two (or more) objects or properties - *that result from judgments of similarity, identity, etc....* These relationships allow us, for example, to assert that two colors are the same or different. It was MEINONG's *Hume Studien II: Zur Relationstheorie* (1882) that took the discussion of direct perception of relationships from the philosophical theories of English empiricists (such as LOCKE, HUME, etc.) to the experimental investigation

<sup>1</sup> Rigid transformations are a way of moving a figure without changing its size or shape. They are also called isometries because they preserve the same measures for length and angles. To reflect a line (geometrically 1D) by a rigid transformation, we need to move it into the second dimension (in the plane), around the axes of symmetry. Similarly, to reflect a 2D body (e.g. a square), we need to move it around the third dimension. To reflect a 3D body by a rigid transformation, we need to move it around the axes of symmetry into the fourth dimension. It is hard to picture the fourth dimension in our minds; if we were to consider a fourth dimension (x,y,z,t), it would have to be a new perpendicular direction in addition to the three directions we have free movement in. A hypercube is an example of a 4D object.

of psychology emerging at the end of the 19th century. EHRENFELS himself referred to MEINONG's viewpoint when discussing Similarity, Equality, Identity, Causality, and Opposition as direct perceived relationships.

If we look at these very early beginnings in the perceptual analysis of relationships, we notice that the notion of opposition was discussed by both MEINONG (1882, sect. 5) and EHRENFELS, alongside identity, similarity, diversity, and causality. Neither, however, treated opposition as a relationship of comparison (as they did with the other relationships) but instead regarded it as a relationship of incompatibility ("Widerspruch"). Opposition was identified only with respect to the condition of *co-presence* of two attributes in the same place and at the same time (e.g.: a table cannot be round and square in the same place and at the same time). In other words, they were examining perceptual opposition through the keyhole of the principle of non-contradiction. This would appear logical but they redefined it as a psychological experience of impossibility and failed to examine the other ways in which opposition may be perceived in terms of the comparison of two objects or aspects of the properties of those two objects.

It is of note that the principle of incompatibility was extolled by those who were endeavoring to avoid arguing in terms of logic and were, on the other hand, attempting to define a theory of phenomenal experience. A vast panorama of experiences of opposition involving comparison between objects, between parts of objects, and between properties of the same or of various objects was left outside, waiting at the doorstep. This may be the reason why a survey of the main research topics reveals that much experimental work was done on the perception of relationships such as identity (WERTHEIMER 1912; TERNUS 1926/55; von SHILLER 1933; BURKE 1952), causality (MICHOTTE 1946), and similarity (GOLDMEIER 1936; PALMER 1978), while these works do not consider the case of opposition at all (see, BIANCHI & SAVARDI 2003).

However, a broader perspective on opposition was suggested by another original branch of experimental psychology, Wundtian psychology, but very little experimental investigation was carried out. In his *Outlines of Psychology* (1897), WUNDT introduced opposition as one of the three general psychological laws of relation, which were as follows: the law of psychical resultants, the law of psychical relations, and the law of psychical contrasts.

The law of psychical contrasts was based on what WUNDT defined as the subjective components of experience, such as feelings and emotions. He considered that feelings and emotions were arranged in opposite affective directions - pleasurable and unpleasurable, exciting and depressing, stressful and relaxing feelings - and that, as they change, they obey a law of intensification through contrast. Furthermore, he extended the law of opposites to apply also "in the case of certain sensations, such as those of sight, and in the case of spatial and temporal ideas" (WUNDT, 1897, p. 326). In fact, he studied opposition between colors (cit., p. 45, pp. 52-53), tones, rhythms, sizes, smells and tastes (cit., pp. 66-69). His extension of the law to cover sensations and ideas can be understood by keeping in mind that WUNDT thought that ideas and their elements were always accompanied by feelings (cit., p. 326). By "feelings", he meant, in general, the subjective aspects of experience.

The fact that the law of psychical contrast may be generalized and extended to cover other areas and that WUNDT acknowledged it as a basic law recalls a similar approach found in Pre-Socratic and Aristotelian empirical theories. If re-worked into a framework of psychological perception, it also represents the point of view developed by the authors in more recent times (BIANCHI & SAVARDI 1997; 2000).

Within this briefly described frame of reference, *i.e.* focusing on the direct experience of relationships in general, and opposition, in particular, this paper proposes that the perception of reflected human bodies is an intriguing phenomenon, showing a peculiar structure of opposition. We say "peculiar" because of its being embedded in a simultaneous strong experience of identity. Even though the coexistence of contrasting descriptions of the same visual stimulus is typical of other well-known phenomena (reversible figures, illusions, impossible figures), the visual structure discussed in the present paper does not fall under any of these categories. In fact, this structure is not a case of a reversible figure (RUBIN 1921), since identity and opposition are simultaneous experiences. Neither is it a case of illusion (e.g. MÜLLER-LYER, ZÖLLNER, POGGENDORF...), since the paradox is not a consequence of changing the 'instruments' used to describe the same event (direct perception vs. metric measurements; descriptions of the perception vs. descriptions of the stimulus). It cannot even be said to be a species of impossible figure (e.g. PENROSE triangle) as it does not exhibit the typical incongruity that makes these kinds of figures 'impossible' in their spatial structure.

Other "structures of opposition" have been found by SAVARDI & BIANCHI (1997, 2000, 2001) by means of an extensive series of experiments carried out using different types of perceptual stimuli. Since our hypothesis was not supported by previous experimental work and assumes that the perception of opposition is a general "law" in the organization of perceptual experience, the theoretical and experimental analysis has been extended to cover various aspects of experience. We investigated the perception of opposition in simple geometric figures, in natural objects, in the experience of space, in music, in simple motor tasks, in the perception of odd and even ratios (referring to the geometrical patterns used by the Pythagoreans to define odd and even numbers) and in symmetrical patterns.

Methodologically, the experiments take into account four different kinds of task:

- a) production tasks: participants were presented with a series of figures (or objects or gestures) and asked to express the opposite by means of drawing or physical movements;
- b) recognition tasks: participants were shown pairs of figures and they were asked to describe the degree of opposition perceived when looking at the pair (in a min-max scale; ranking task)
- c) classification tasks: participants were presented with a series of pairs of figures and were asked first to classify the pairs as opposite, similar or different, then to rank the couples within each class;
- d) phenomenologically psychophysical tasks: participants were asked to analyze scales of opposites by identifying the ratio between polarized and intermediate states and their reciprocal relationship to the range of dimensions as a whole (see Kubovy 2002).

These experiments demonstrated, in the first place, that opposition has a particular place in the set of “perceptual relationships”, alongside similarity and diversity.

Secondly, some regularities were found in the “structures of opposition”, not only within each field, but also between different fields. We chose to describe these regularities in terms of “Principles”. Here the term Principles indicates solely “a general description” of the behavior of opposition, a “law” in a phenomenological sense (see WERTHEIMER’s Principles of perceptual organization, 1923).

The “perceptual laws of opposition” we discovered during our experimental work are as follows. Let us emphasize that our purpose here is simply to present the reader with a draft of this “phenomenological theory of opposition”. In the following list of Principles, EuO refers generically to “Event(s) under Observation”, where “under observation” are events (I), or properties ( $\dot{i}$ ). Moreover, when the symbol  $^{>c}$  is used, it defines the opposition of that element (I or  $\dot{i}$ ) with respect to the one it is compared to (eg: I, I $^{>c}$ ).

P1) *The Principle of direct perception of Opposition*: Opposition is directly perceivable as a relationship between events or properties.

A necessary condition for opposition to be perceived is the duality of the EuO. In other words, the perception of opposition requires the presence of:

a) two events (I, I $^{>c}$ ) strictly under observation; e.g.: two cars crashing into each other; a high tone and a low tone, a good smell and a bad smell...;

b) two elements of the same event ( $\dot{i}$ ,  $\dot{i}^{>c}$ ) under strict observation e.g. the black and the white squares of a chessboard; the keys of the low and high notes of a piano, the right shoe and the left shoe of a pair of shoes, the inside and the outside of a pullover;

c) an event or property (I,  $\dot{i}$ ) under strict observation, and its opposite (I $^{>c}$ ,  $\dot{i}^{>c}$ ) not under strict observation; e.g. the cold that one experiences when going outside on a winter day is the opposite of the warmth that one experiences when staying inside; the silence that one experiences on moving to a deserted place is the opposite of the noisy environment left behind.

Opposition is perceivable on two levels:

I°) two EuO can be perceived as opposites in a “self-evident” sense, in the same way that two EuO can appear identical, similar, or different (Gestaltic properties);

II°) two EuO can be perceived as opposites by means of analysis of their properties, despite appearing similar or different when viewed as a whole and not in detail. The second level of analysis implies that, given two non-identical events, it is always possible to find at least one aspect of opposition ( $\dot{i}$ ) between their identities (I) - see P2.

P2) *The Principle of General Opposition*: Given any kind of EuO, it is always possible to find a perceivable experience of opposition, both between the given EuO and another EuO, and within the same EuO. More specifically, the principle may be expressed in terms of:

P2.1) *The Principle of General Opposition between two EuOs*: Given any kind of EuO it is always possible to find another EuO opposite to the former.

For instance, for all objects (I) with a direction of orientation (intrinsic or extrinsic), a self-evident opposite obtained through the inversion of the orientation direction is always guaranteed.

P2.2) *The Principle of General Opposition within an EuO*: Within any given EuO opposite properties are perceivable.

For example, the top is opposite to the bottom, the front is opposite to the back, and the left is opposite to the right.

P3) *The Principle of mutual exclusion of opposites*: an event, object, property or proposition cannot generally coexist at the same time and in the same place as its opposite.

This principle of logic, when applied to phenomenology, loses its universal validity and admits the possibility of rare exceptions to the general rule.

Exceptions to the general mutual exclusion condition are experiences perceived as “both  $\dot{i}$  and  $\dot{i}^{>c}$  (e.g. a cold-hot fever..., the bitter-sweet of an apple).

P5) *The Principle of state*: Any perceived property belongs to a Dimension. A dimension is the range of the perceivable variations of a property. The opposites are the poles (extremes) of a Dimension.

E.g.: *temperature* is the Dimension composed of all the possible perceivable temperature variations from cold to hot and vice versa. A Dimension is defined perceptually (a range of experiences), independently of the existence of corresponding linguistic terms (a range of terms)

P6) *The Principle of intermediates*: For any Dimension at least one property between the two poles exists.

From a phenomenological point of view, intermediate properties are not perceived as *both one pole and the other* ( $\dot{i} \wedge \dot{i}^{>c}$ ), but as *neither one pole nor the other* ( $\neg \dot{i} \wedge \neg \dot{i}^{>c}$ ). E.g.: warm is “neither cold nor hot”, not “both cold and hot”. The Principle is defined perceptually by means of experience, independently of the existence of corresponding linguistic terms. E.g.: the experience of being neither cold nor hot has a corresponding linguistic term (warm), while the experience of being neither heavy nor light does not have such a term even if we can identify not only one property but a range of properties that we perceive as neither heavy nor light.

The Principle is evident for those Dimensions in which the variation from one pole to the other appears to be continuous. The “big-small” Dimension consists of a continuous series of properties, going from very big, to big, to quite big, to neither big nor small, to quite small, to small, to very small. The Principle applies similarly for the “dark-bright” Dimension, the “heavy-light” Dimension, or the “hot-cold” Dimension.

For other Dimensions (dichotomous Dimensions) one pole appears to change directly to the other one, with no intermediate stages, e.g. we don’t have experience of properties that are neither  $\dot{i}$ , nor  $\dot{i}^{>c}$  in the cases of: closed-open, regular-irregular, stationary-moving, finished-unfinished...

The Principle recognizes that at least one experience can be considered an intermediate of at least one pole. E.g.: a door that is ajar is an experience of being a degree of

“open” (and in this sense it is not “neither  $i$ , nor  $i^{>c}$ ”), but it is also perceived as an intermediate of what we properly identify as being open and being closed.

P8) The *Principle of anisotropy of Dimensions*: The structure of a Dimension is anisotropic.

The counterpart of this principle in cognitive psychology is the definition of the asymmetrical behavior of *antonyms* in comprehension and memory tasks and the definition of antonyms in terms of marking. However, the definition of linguistic asymmetry does not necessarily correspond to the definition of perceptual anisotropy of a Dimension. E.g.: When looking at an *irregular* surface, do we directly perceive its irregularity or do we derive this experience from the experience of *regularity*?

The anisotropy of Dimensions can be perceptually defined in a non-linguistic way, for instance, by taking into account a quantitative and qualitative description of the “structure” of the two opposite properties and their intermediates.

P9) The *Principle of task conditions*: Given an event or a property, the identification of its opposite depends on the identity of the EuO and on the degree of freedom of the specific task.

A comparison of the relative degrees of freedom for recognition and production tasks provides a paradigmatic example of the principle. For recognition tasks, the EuO is a pair of figures ( $I, I'$ ) with a visible relationship. The relationship between the two figures is under observation as are the properties of each individual figure. For production tasks the EuO is a single given event ( $I$ ) and the observer chooses which of its properties needs to be modified to obtain a new event, opposite to the given one.

P10) The *Principle of invariance*: A necessary condition for two events under observation to be perceived as opposites is evident invariance.

The invariance between the two EuO takes two forms: A) When two EuO are objects ( $I, I^{>c}$ ), the observed identity of each one needs to reach a certain level of invariance for them to be perceived as opposites. B) In order to be perceived as opposites, the properties of two EuO ( $i, i^{>c}$ ) must belong to a common Dimension.

In its quantitative aspect, the principle of invariance is guaranteed by the Principle of non-additivity [P11]

P11) *Principle of non-additivity*: The opposite of a given EuO is not that achieved by transforming all its properties into their own opposites.

If the second event,  $I^{>c}$ , differs from the given event,  $I$ , by having too many opposite properties, it cannot be perceived as an opposite. E.g.: if we start with a still, small, white, equilateral triangle and we change all its properties into the opposite ones, we will not obtain a figure perceived as opposite to the first one,

The two non-identical events have to demonstrate maximum opposition to be perceived as opposites. Therefore the single property or few properties of  $I^{>c}$  which are opposites of  $I$  have to extend their oppositeness from the specific property ( $i^{>c}$ ) to the whole event ( $I^{>c}$ ).

P12) The *Principle of “requiredness”*: In production tasks, the properties which make up the identity of the EuO differ in their degree of requiredness to be transformed into the opposite property.

The term “requiredness” (KÖHLER 1938; METZGER 1941) expresses the strength of a property’s “request” to be transformed. The requiredness of each single property may be seen in production tasks when a given identity ( $I$ ) is under observation and the observer has to decide which property to modify in order to obtain an opposite ( $I^{>c}$ ). The degree of requiredness measures the perceiver’s tendency to modify some properties more frequently than others, regardless the high or low degree of oppositeness that the transformation shows.

P13) The *Principle of the degree of adequacy*: Given a constant number of transformations, the properties defining the identity of any event differ in their adequacy to produce a high or low degree of opposition when changed into their own opposite.

We can refer to this aspect as a more or less “local” effect demonstrated by the degree of necessity to explicitly attribute the perceived opposition to the transformed property. E.g.: When looking at a white and a black triangle both pointing up, the need to specify that they are opposites “in terms of color” is stronger than the need to specify that two black triangles pointing respectively up and down are opposites “in terms of direction”. The degree of necessity to specify the reference of the transformation to the transformed property is a sort of inverse indication of the degree of adequacy.

The degree of adequacy may be seen in recognition tasks, *i.e.* when variations are perceived in the direct comparison between EuOs.

P14) The *Principle of the Anisotropy of the Direction of Transformation between two Poles*. The transformation of a property in the two directions permitted within the Dimensions (e.g. from big to small and from small to big; from regular to irregular and from irregular to regular, etc.) does not necessarily produce an equal degree of opposition.

For more information about the experimental work that these principles are based upon, see SAVARDI & BIANCHI (2000).

### Summary

A mirror optically reverses the axis that is perpendicular to its surface. The psychological implications of this stimulus transformation have been discussed thus far in the literature under the title of the 'mirror question'. From the earliest to the most recent discussions, authors have always begun by describing a given perception (the left/right reversion) and then attempted to explain the lack of correspondence between optical and perceptual transformations.

Our study, in contrast, focuses on the descriptive aspects of the mirror question, by approaching it through the Gestalt paradigm of the direct perception of relationships between objects and properties and by means of various ecological experiments. Naïve observers were asked a series of questions concerning different aspects of the relationship they perceived between themselves and their reflection (general perceived relationship, orientation relationship, left-right reversal, gestural relationship etc.).

The results are discussed by focusing on the interesting contradictory structure of identity-opposition in mirror images. Moreover, the reference in the present analyses to a broader investigation into the perception of opposition, currently being conducted by the authors, is touched upon in the final part of the paper.

### Zusammenfassung

Ein Spiegel dreht optisch die zu seiner Oberfläche senkrechte Achse um. Die psychologischen Implikationen dieser Stimulus-Transformation wurden bisher in der Literatur unter dem Titel „Spiegel-Problem“ diskutiert. Von den frühesten bis herauf zu den jüngsten Diskussionen zu diesem Thema begannen die Autoren stets mit der Beschreibung einer gegebenen Wahrnehmung (der Links-Rechts-Umkehrung) und versuchten dann das Fehlen der Entsprechung zwischen den optischen und den Wahrnehmungs-Transformationen zu erklären.

Unsere Studie hingegen stellt die deskriptiven Aspekte des Spiegel-Problems in den Mittelpunkt und nähert sich ihm, von der gestaltpsychologischen Auffassung der unmittelbaren Wahrnehmung der Beziehungen zwischen Objekten und ihren Eigenschaften ausgehend, mit Hilfe verschiedener ökologischer Experimente. „Naiven“ Beobachtern wurden eine Reihe von Fragen über verschiedene Aspekte der Beziehung gestellt, die sie zwischen sich selbst und ihrem Spiegelbild wahrnehmen (allgemeine wahrgenommene Beziehung, Beziehung hinsichtlich der Orientierung, Links-Rechts-Umkehrung, Beziehung hinsichtlich von Gesten usw.).

Die Ergebnisse dieser Experimente werden vor allem unter dem Gesichtspunkt der interessanten widersprüchlichen Struktur von Identität und Gegensatz bei Spiegelbildern diskutiert. Im letzten Teil des vorliegenden Beitrags werden Bezüge zu breiter angelegten Untersuchungen der Wahrnehmung von Gegensätzen hergestellt, mit denen sich die Autoren zur Zeit beschäftigen.

### References

- BENNET, J. (1970): The Difference between Right and Left. *American Philosophical Quarterly*, 7, 175-191.
- BIANCHI, I., SAVARDI, U., & DE LOTTO, M. (2003): La percezione del proprio riflesso: tra identità e contrarietà. [Perceiving our own mirror reflection: from identity to opposition] *DiPAV, Quadrimestrale di psicologia e antropologia culturale*, 7, 97-123.
- BLOCK, N. J. (1974): Why do mirror reverse Left/Right but not Up/Down?. *Journal of Philosophy*, 71 (9), 259-277.
- BORING, E. G. (1921): The stimulus Error. *American Journal of Psychology*, 32, 449-471. Republished in E. G. BORING (1963). *History, Psychology, and Science: selected papers*. New York and London: John Wiley and Sons, Inc.
- BOZZI, P. (1969): *Unità, Identità, causalità. Una introduzione allo studio della percezione* [Unity, Identity, Causality. An introduction to the study of perception]. Bologna: Cappelli.

- BURKE, L. (1952): On the tunnel effect. *Quarterly Journal of Experimental Psychology*, 4, 121-138.
- CORBALLIS, M. C. (2000): Much ado about mirrors. *Psychonomic Bulletin and Review*, 7 (1), 163-169.
- CROUCHER, C. J., BERTAMINI, M., & HECHT, H. (2002): Naive Optics: Understanding the Geometry of Mirror Reflections. *Journal of Experimental Psychology-Human Perception and Performance*, 28 (3), 546-562.
- EHRENFELS, VON C. (1890): Über Gestaltqualitäten. *Vierteljahrsschrift für wissenschaftliche Philosophie*, 14, 242-292.
- GARDNER, M. (1964): *The ambidextrous Universe*. New York: Charles Scribner's Sons.
- GOLDMEIER, E. (1936, 1972): Similarity in visually perceived forms. *Psychological Issues*, 29, Whole No.
- GREGORY, R. L. (1989): Mirror Reversals. In GREGORY (Eds), *The Oxford companion to the mind* (491-493). Oxford: Oxford University Press.
- GREGORY, R. L. (1996): *Mirrors in mind*. Oxford: Oxford University Press.
- GREGORY, R. L. (2001): Seeing oneself. *Perception*, 30, 903-904.
- HAIG, N. D. (1993): Reflections on inversion and reversion. *Perception*, 22, 863-868.
- ITTELSON, W. H. (1993): Mirror reversals: real and perceived. *Perception*, 22, 855-861.
- ITTELSON, W. H., MOWAFY L., & MAGID, D. (1991): The perception of mirror rotated objects. *Perception*, 20, 567-584.
- KOFFKA, K. (1935): *Principles of Gestalt Psychology*. New York: Harcourt Brace.
- KÖHLER, W. (1938): *The place of value in a world of facts*. New York: Liveright Publishing Corporation.
- KUBOVY, M. (2002): Phenomenology, psychological. In L. Nadel (Ed.), *Encyclopedia of Cognitive Science* (pp. 579-586). Houndmills, Basingstoke, Hampshire, UK: Macmillan.
- LOCKE, D. (1977): Through the looking glass. *Philosophical Review*, 86, 3-19.
- METZGER, W. (1941): *Psychologie*. Darmstadt: Dietrich Steinkopff.
- MICHOTTE, A. E. (1946): *La perception de la causalité*. Louvain: Publ. Universitaires de Louvain.
- MORRIS, R. C. (1993): Mirror image reversals: Is what we see what we present?. *Perception*, 22, 869-876.
- NAVON, D. (1987): Why do we blame the mirror for reversing left and right? *Cognition*, 27, 275-283.
- PALMER, S. E. (1978): Structural aspects of visual similarity. *Memory & Cognition*, 6 (2), 91-97.
- RUBIN, E. (1921): *Visuell wahrgenommene Figuren*. Copenhagen: Gyldendalske.
- SAVARDI, U., & BIANCHI, I. (1997): *I luoghi della contrarietà* [Grounding Opposition]. Torino: Upsel.
- SAVARDI, U., & BIANCHI, I. (1999) (Eds): *Gli errori dello stimolo* [The stimulus errors]. Verona: Cierre.
- SAVARDI, U., & BIANCHI, I. (2000): *L'identità dei contrari* [The Identity of Opposition]. Verona: Cierre.
- SAVARDI, U., & BIANCHI, I. (2001): La percezione della forma dei gesti identici e contrari [The perception of Identical and Opposite gestures]. *DiPAV Quaderni, Semestrale di psicologia e antropologia culturale*, 1, 135-168.
- SAVARDI, U., & BIANCHI, I. (2003): Fenomenologia sperimentale della contrarietà: origini e sviluppi [Experimental Phenomenology of Opposition: its origin and development]. In: U. Savardi & I. Bianchi (a cura di). *Le Relazioni Empiriche. Per una scienza delle Relazioni in Psicologia* [Empirical Relationships. Toward a Science of Relationships in Psychology]. Milano: Franco Angeli (pp. 101-128).
- SHILLER, von P. (1933): Stroboskopische Alternativversuche. *Psychologische Forschung*, 179-188.
- TABATA, T., & OKUDA, S. (2000): Mirror reversal simply explained without recourse to psychological processes. *Psychonomic Bulletin and Review*, 7 (1), 170-173.
- TAKANO, Y. (1998): Why does a mirror image look left-right reversed? A hypothesis of multiple processes. *Psychonomic Bulletin and Review*, 5 (1), 37-55.
- TERNUS, J. (1955): The problem of phenomenal identity. In W. D. ELLIS (Ed. and Trans.), *A source book of gestalt Psychology* (pp. 149-160). London: Routledge and Kegan Paul. (Original work published 1926).
- VICARIO, G. B. (1975): Some observations on gestalt principles of organization. In G. B. FLORES D'ARCAIS (Ed.), *Studies in perception. Festschrift for Fabio Metelli* (pp. 67-80); Milano-Firenze: Martello Giunti.

WERTHEIMER, M. (1912): Experimentelle Studien über das Sehen von Bewegung. *Zeitschrift für Psychologie*, 61, 161-265.

WERTHEIMER, M. (1955): The general theoretic situation. In W. D. ELLIS (Ed. And Trans.), *A source book of Gestalt psychology* (pp. 71-88). London: Routledge & Kegan Paul. (Original work published 1923).

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