Chapter 3
The perception of space and what we learn from this about the link between perception and contraries

From this chapter on, we will be looking at the results of some experimental studies on perceptual experience which demonstrate that contrariety is a basic perceptual relationship. The search for evidence confirming this hypothesis moves now from the domain of pre–experimental phenomenological observations to the domain of the Experimental Phenomenology of Perception.

You might ask why, in trying to establish a link between perceptual experience and the experience of contraries, we start with the Ganzfeld. The Ganzfeld can be considered the most primitive visual stimulation condition and so the perception associated with it can be considered the simplest visual perception. Thus we need to discover whether contraries are present in this case to or if their connection with perceptual experiences emerges only when ecological (and therefore richer and more complex) conditions are considered. As there are absolutely invariant conditions at the level of stimulation in the Ganzfeld, one might expect to find a lack of any perceived variations and above all a total lack of any form of contrariety. Because of this, we considered it an interesting place to start.

We will then move on towards more complex perceptual conditions in order to determine whether they are also based on certain primitive contraries. This will form the basic mapping of the contraries which are intimately linked to the rules of perception and we will be using them to perform a phenomenological analysis of the structure of these pairs in the following sections of this chapter.

We propose a new way of defining the structure of each pair of contraries, not in terms of their linguistic structure, but in terms of their perceptual shape. We will discover that some properties have a single structure, while others can vary within a range of different states; that for some pairs the passage from one property to its contrary is abrupt, while for others it is more spread out and covers an extended range of variations; that the unidimensionality of the two contraries representing the poles of a dimension cannot be taken for granted and lastly that the contrariety between two properties might be better described in terms of multivariate contrariety than a single dimension of opposition. We will analyze all these points with respect to the set of properties which have emerged as primitive spatial contraries, but our proposal goes well beyond this. The phenomenological psychophysics of contrariety – as Kubovy (2002) has proposed naming it – is, we believe, extendable to every perceptual domain and to any pair of properties which might be described as contraries.

This is the other side of the coin in a cognitive analysis of contrariety. This is what has been missing in the research on opposition within the field of Psychology up to now and what a shift in perspective (from linguistic to the perceptual structure on which language is grounded) will bring to the forefront. It might also be worth considering whether what we discover about the internal structure of contraries has direct implications in term of the way language works.

3.1 Primitive contraries

To understand whether adult observers perceive contrariety in the Ganzfeld, we analyzed the results of Metzger's pioneering experiment (1930).

In Metzger's experimental setting (see Koffka, 1935, p. 114), the observers sat in front of a carefully whitewashed wall of 4x4 sq. m., at a distance of 1.25 m. Since the dimensions of the wall were not sufficient to fill the entire visual field in either direction, wings were added on both sides, care being taken that the inhomogeneities thereby introduced were reduced to a minimum. The observer was asked to stare at an area at a height of about 1.50m. Homogeneous illumination was supplied by a projection lantern with a specially constructed set of lenses. It is worth noting that the experimental apparatus varied, even significantly, in subsequent studies (see, for instance Avant, 1965; Cohen, 1956, 1957; Gibson & Waddel, 1952; Hochberg, Triebel & Seaman, 1951; Miller & Hall, 1962; Miller & Ludvig, 1960), but this did not lead to significant changes in the perceptual experiences reported. Basically, subjects see space–filling fog and they feel as if they were "swimming in a mist of light" which becomes denser at an indefinite distance (Metzger, 1930, p. 13). In textbooks on the Psychology of Perception, the description of the subjects' reports usually ends here and is used to demonstrate that a three–dimensional space (filled with fog which is thinner close to the observer and thicker at distance) is perceived even when ecological distance cues have been deleted from the optical flow. The fact that this primitive experience is a *spatial* experience is interesting: if it could be demonstrated that contrariety is present here, this would constitute an initial confirmation of our hypothesis that there is a basic link between the perception of contrariety and the perception of space. Intriguingly however, this would also shed new light on Presocratic and Aristotelian intuition that contrariety was primarily founded on space (Bianchi & Savardi, 2002).

But what exactly did observers see in the Ganzfeld? Three different spatial experiences were described (see Koffka, 1935, p.114): 1) an indefinite foggy mass surrounds the observer; when the light is gradually increased, this fogginess dissipates somewhat and the sensation of pressure decreases; some also report a feeling of expansion of space; 2) when the illumination is further increased, the fog becomes condensed into a regular curved surface which surrounds the observer on all sides; its appearance is filmy like the sky, without a solid surface and slightly flat in the center; 3) if the light then becomes even brighter, the surface flattens out and may appear to recede into the distance.

If one considers that the *range* of illumination used by Metzger varied from absolute darkness to just under the threshold of unbearable brightness, one can conclude that the three spatial structures described in Metzger's experiment cover all the possible perceptual outcomes of white isoluminant light stimulation.

Metzger himself emphasized that, of the three experienced described, the perception of an indefinite fog is what properly corresponded to an absolutely homogeneous condition of stimulation. The perception of a curved (experience 2) or vertical (experience 3) surface in fact emerged at higher levels of illumination when the microstructure of the distant stimulus object (the wall) started to be visible.

In experience 1, observers said that the fog was thick and heavy at a distance and became progressively thinner and lighter as it moved closer to them, ending up as a transparent empty space. This empty space was described as similar to the space that usually separates objects from an observer in normal daily illumination conditions. This three–dimensional mass was said to be indefinite in size, given that no definite boundaries were perceived. Participants however estimated its depth as ranging from 40 to 125cm.

The brightness perceived was not perceived as inert, but as "pushing" towards the observer (this was expressed in terms of "insistency", "impressiveness" or "aggressiveness"). Without introducing any change in the stimulation and simply as a result of staying in the Ganzfeld, participants then started to perceive local perturbations (namely extended cloudy configurations or little spots of light in motion) as well as global perturbations (i.e. gradual or abrupt, continuous or repeated variations in the total amount of light perceived).

The perception corresponding to complete invariance in the level of stimulation was thus characterized by the following basic spatial variations: near versus far; empty versus filled; figures in motion versus unmoving fog; extended cloudy masses (in motion) versus little spots of light (in motion); decreasing versus increasing extension of space; gradual versus abrupt changes and continuous versus repeated changes.

If one extends the analysis to experiences 2 and 3, further variations emerge: a flat, solid surface, perceived with higher levels of illumination, as opposed to a soft, curved, flexible surface, perceived with medium levels of illumination.

At high levels of illumination, when illumination was further increased or decreased or simply with a prolonged stay in the Ganzfeld staring fixedly, the surface was perceived to recede from the observer (when the light increased) or to move closer (when the light decreased) while changing its compactness into a fluffier, more fluid consistency (the same consistency as whipped cream).

With low levels of illumination, an increase in brightness was associated with a change in perceived pressure (the fog become lighter and observers felt they could breathe more easily) and an increase in the sensation of space expansion. The fog also appeared to become brighter and to condense into a curved surface of a soft and fluffy consistency. Conversely, a decrease in illumination was associated with the sensation of the fog becoming heavier and darker and with a sense of more restricted space.

Thus, increase and decrease in illumination were associated, respectively, with an increase or decrease in space extension, with a change in perceived pressure (the fog becomes lighter, the observer feels he can breathe easily versus the fog becomes heaviest and the observers feels they can hardly breathe) and in brightness (the fog, after becoming lighter also becomes brighter; after becoming heavier, also becomes darker), and color density (when the illumination increases, the color filling the space recedes and compresses itself into a fluffy, foggy, concave surface).

When small illumination discontinuities (just above the JND threshold) are introduced, observers perceive localized sparks of light: a local region of the field becomes brighter and this brightness expands in all directions.

By introducing a small area with different illumination into the field, Metzger expanded his analysis from the most primitive perception to a primitive figure–ground organization. Metzger limited himself to projections of small squares and small rectangles of light, but we will see later on what happens with more complex variations.

Even if the alteration was minimal, when Metzger introduced a small area with different illumination this triggered a series of changes. These involved:

1) the consistency of the geometrical forms and the background: the former appeared to be dense and taut, the latter (i.e. the foggy background), softer and less resistant;

2) spatial localization: the geometrical form was seen *in front* of the foggy mass when the form was more illuminated than the background, while it was seen *behind* the foggy mass when the form was less illuminated than the background.

To summarize, what did the Ganzfeld experiment prove with regard to our hypothesis? Koffka commented: «thus we see that primitive space lacks the articulation that normal space possesses» (Koffka, 1935, p. 116). This is certainly true, but we feel that in reality this primitive space does not lack articulation. For example our analysis showed that:

a) even when spatial experience is not yet an experience of objects, it is still an experience of spatial properties and relationships between non–identical properties, namely, distances (near–far), space extension (broad–restricted), space density (sparse–dense fog), consistency (compactness and fluidity or softness), shapes (flat–curved surfaces), weight (sensation of weightlessness–heaviness), brightness (brighter or darker), mutual localizations (in front of – behind) and state and directions of movement (still–moving, receding–advancing);

b) all these cases represent variations between contrary perceptual features or at least variations which move towards extremes; this is true *not in terms of the words* used in the reports, *but in terms of the perceptual features* described as characteristics of different parts of the environment.

In 1989, in a very interesting piece of writing on the role of natural language in the phenomenologically based science of perception, Bozzi (pp. 60 ff) used the Ganzfeld as a starting point in order to demonstrate the contents and the principles underlying a "minimum vocabulary". By "minimum vocabulary" he meant a set of words, all of which referred to discernible states and objects, where the addition of any new term is justified only by the need to label a new discernible state. It is easy to see why the Ganzfeld represented a very effective scenario for showing this process of emergence of new perceptual states and the corresponding urge to find new terms for these states.

We do not need to look at the Ganzfeld to realize that natural language comprises a wide range of terms mapping contrary states, verbs, adjectives and adverbs which reflect the recognition of actions, properties and states that are opposite to each other. The existence of dictionaries of synonyms and antonyms for all major languages is probably the most striking proof of this. However, what an analysis of Metzger's paper (1930) might add to this consideration is that the need for terms to refer to discernible contrary states is not the result of the complex structure of the ecological world. On the contrary, the need for terms describing opposite features emerges in the most primitive human perceptual experiences. Even the most basic vocabulary (i.e. confined to the discernible states perceived in the poorest perceptual scenario) is from the very beginning one that refers to contrary features.

Primitive contraries in ecological space

What happens if we replace this totally homogeneous field with an ecological field – in other words, if we let the world enter the Ganzfeld? If we ask our subjects to report on the resulting spatial experience, what variations ("discernable states") would they describe?

To answer this question, we asked a group of adults to describe their experience of space using everyday language (in this case Italian), focusing on as many different spatial experiences as possible (Savardi & Bianchi, 2000a, 2000b; Savardi, Bianchi & Kubovy, submitted).

Given that we were interested in a general description of the perceptual articulation of ecological space, the analysis needed to be based on a broad set of spatial experiences. For this reason, throughout the study, participants were asked to focus on as many different spatial experiences in daily environments that they could think of. In order to avoid variability in results due to the fact that participants might refer to different "samples" of the ecological world, we used groups of participants (composed of 3 people) rather than individual subjects, in accordance with the inter–observational method (Bozzi, 1978; Bozzi & Martinuzzi, 1989; Kubovy, 1999). Participants were first asked to share with the other members of the group as many experiences of objects or environments as they could for a certain property (e.g.: inside) with reference to the space around them (e.g.: "if you look at the space that is inside this room...") or by verbal reference (e.g.: "think of the experience of being closed inside a small lift...."). In this way all the members of the group could "recollect" the same experience directly from the surrounding environment or from memory. This initial phase was followed by a second phase where participants tried to reach a common description of the spatial experiences recollected in the first phase, each time according to instructions.

What emerged from this study is that, when asked to produce a consensual list of as many spatial properties as possible without being redundant, adult observers (57 participants, undergraduates at the Milan Institute of Technology) were able to come up with a list of 60 to 80 terms.

After collating synonyms, we discovered that a list of 74 terms appeared on at least 15 out of the 18 lists (80%) produced by the groups. These were for the most part adjectives or adverbs. They were divided by participants into 4 groups: spatial properties concerning shape, amount, localization and orientation. More interestingly, an examination of the 74 words revealed that each had its contrary within the set; stated differently, the 74 words could be organized in 37 pairs of contraries (see Tab. 1).

Table 1. The list of primitive spatial contraries referring to ecological environments.

Shape	Amount	Localization	Orientation
convex – concave	thick–thin	above–below	ascending–descending
rounded–angular	near–far	in front–behind	upright–upside down
straight–curved	broad–restricted	left–right	vertical–horizontal
unbounded–bounded	fat–thin	floating–sunken	standing–lying down
open–closed	high–low	top–bottom	moving–still
symmetrical–asymmetrical	wide–narrow	beginning–end	
obtuse–acute	long–short	inside–outside	
regular – irregular	large–small	supported–unsupported	
simple–complex	shallow–deep		
complete – incomplete	full–empty		
ordered–disordered	dense–sparse		
convergent–divergent	many–few		

As we verified in successive informal observations, whatever the ecological scene observers are looking at, almost all the features described in this list are perceived as characteristics of the scenario. You can easily verify this by seeing just how many of the spatial features in the list can be used to describe "space" around you. You will also notice that you rarely find one of two contrary properties without the other being present. You perceive height, but also lower areas and low objects; you find straight lines, but also curved ones; you see narrow spaces, but also wide open areas. Let us remember that we are referring to ecological environments, i.e. "stimuli" which have the articulation that spatial experiences normally possess (see for example Figures 18a–c).

a

b

c

Figure 18 a–c. Three ecological scenes. We invite the reader to look carefully to see how many of the spatial properties described in tab. 1 are recognizable in each scene.

3.2 The perceptual structure of contraries

What are we referring to when we say that we perceive something as curved, or straight, high or low? We designed two experiments to study the structure of contraries, based on what one could call qualitative "just noticeable differences" (JNDs) between variations of the properties belonging to the pair, e.g. large and small (Savardi & Bianchi, 2000a, 2000b; Savardi, Bianchi & Kubovy, submitted). This idea of *qualitative* JNDs – rather than the more familiar *quantitative* JNDs, typical of psychophysical research – can be easily understood considering a simple example.

Take two ants: an adult ant and a small one. If you were asked to describe whether you see a difference in size between the two ants (and given that their physical difference is greater than what in terms of classical psychophysics we would call the JND threshold) you would say that yes, one of the two is bigger than the other. What you are indicating, here, is a *quantitative* difference between the two.

However, if you were asked to answer the question taking into account the *qualitative* differences in size for the whole set of objects ranging from the smallest thing that you can see (e.g. a grain of sand) and the biggest one (e.g. a very high, wide wall, covering almost entirely the visual field of the observer) then you would likely answer the question about the ants by saying that they have the same "qualitative size". The first noticeable qualitative difference in the set of variously small things would likely be that between the size of ants and that of butterflies or nuts. Yet again, between a butterfly and a nut one can see a *quantitative difference*, but in terms of *qualitative differences* they are more or less the same size.

It was made clear to the adult participants who took part in the studies that they had to consider this interpretation of the term "difference". Thus, when analyzing, for instance, the various gradations of "small", they had to ask themselves: "Do I really perceive the size of this object as being smaller than this other one, despite the fact that I recognize that it is only some millimeters smaller?". Or for instance, when analyzing various gradations of "open", they had to compare different apertures of a door by asking: "Do I really perceive this door (which is, let's say, about 60 degrees open) as being open in a qualitatively different way than a door open 65 degrees? If I keep opening the door by small amounts, at what point do I start seeing that the door is open in a qualitatively different way from before?". These questions have to be answered by looking at concrete examples, referring to what appears to the naked eye and not to the physical characteristics of objects. For instance, it doesn't matter that we *know* that the stars or the moon are very big, we *perceive* them as being small (very small in the case of stars: i.e. the same "qualitative size" as a pinhead…).

We used two different studies in order to establish the phenomenological psychophysics of the 37 spatial pairs presented in table 1.

In the first study, participants (70 undergraduates at the Milan Politecnic) were presented with scales of gradation composed of two bars one above the other (see Fig. 19). They were told that the total length of the bars represented the whole range of variations of visual experiences in between the two poles (e.g., for the pair "near–far", from the nearest to the farthest). They were asked to mark on the top bar the boundary that separates the two poles, i.e. the proportion that they considered expressed gradations (qualitative differences) of for example "near", and the proportion which expressed gradations (qualitative differences) of "far". If they considered these variations to be the same size for the two poles, they had to mark the boundary exactly in the middle of the top bar (see Fig.19a); if they considered one of the two poles to be richer than the other in terms of the amount of qualitative variations, they had to shift the boundary towards one of the two poles in order to reflect this difference (see Fig. 19b and c).

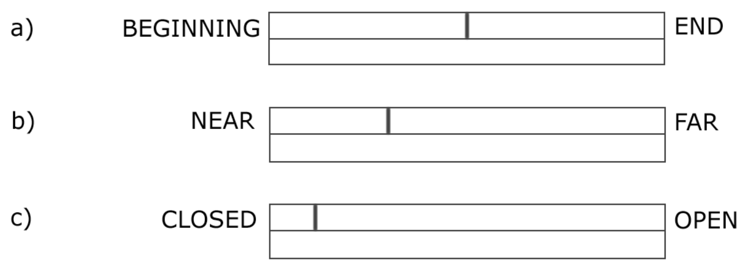

Figure 19. Example of the bars used in study 1, for 3 different pairs of contraries. The thicker lines on the top bar simulate participants' responses to the first part of the task.

They were then asked to mark on the bottom bar the range of things that were "neither pole A nor pole B" (e.g. "neither beginning nor end"; "neither near not far"; "neither open nor closed") and to refer this area to the mark on the top bar by deciding how much of the intermediate space to ascribe to one pole and how much to the other. As in the first part of the task, the size of the area had to be described in proportion to the whole sample of visual experiences in between the two poles (Fig. 20).

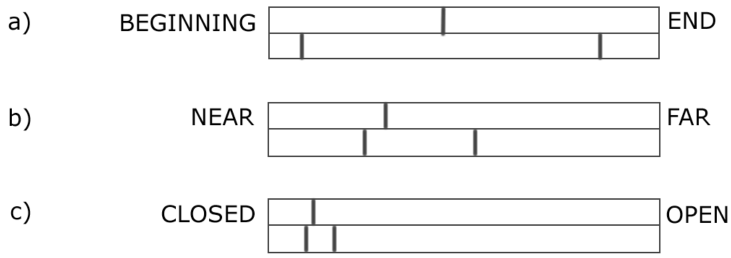

Figure 20. Example of the bars used in experiment 1, for 3 different pairs. The region between the thicker lines, on the bottom bar, simulates participant's responses to the second part of the task.

The second study was designed to integrate results from study 1 concerning the area covered by the three components (the two poles and the intermediate region) with qualitative data.

In particular, the basic distinction we were interested in was between poles and intermediates consisting of single properties and poles or intermediates with many different gradations of a given property. Again the point can be easily explained by means of examples.

Consider, for instance, the dimension closed–open. Participants were asked to decide whether something could be visibly "closed" at various degrees and if something could be open at various different degrees. If you look at a door which is open, let's say, approximately 30°, you perceive it as being open. If you now open it to around 90° degrees, do you perceive it as being open in a different way? And if you then open it wide, do you perceive it open in a even more different way? If the answer is yes, then this means that the "open" pole refers to a range of variations. You can do the same with "closed", starting from a closed door. Can you change something in order to see the door as being closed in a different way? If the answer is no, then we should conclude that the "closed" pole consists of a single property and not a range (of course one could lock the door, but this does not correspond to *seeing* the door closed differently).

Bearing in mind this distinction, one can further distinguish between ranges which have a final state, i.e. with the property at a maximum possible degree and thus a final boundary of the pole (e.g., a wide open door) and ranges where this final state is not present and the range is thus unbounded.

Similar questions can be asked for intermediates, i.e. "neither A nor B". Intermediates lie in between the two poles and hence necessarily have final states on their two sides. They can never have unbounded ranges. However, they can either have bounded ranges or single properties. Let's take for example a box that looks as if it is “neither near nor far”. Can the distance of the box be changed (increased or decreased) in such a way that you will still perceive it as being “neither near nor far”, while still however perceiving that you are now looking at a more distant gradation of intermediateness? If so, “neither near nor far” admits a range of variations. Now, if you put the box right in front of you so that you perceive it to be “neither to the left nor to the right” of you, can you change its position within the left–right dimension and still perceive it as being “neither to the left nor to the right” of you? If not, this means that the intermediate area consists of a single property. Consider also “neither still nor moving”. Can we see an object as being neither still nor moving? If not, this constitutes a pair with no intermediates.

To summarize, participants (54 of the 70 undergraduates involved in study 1) were asked to make the following distinctions:

a) for the two poles, the distinction between single experiences and ranges of experiences and, in the latter case, between bounded ranges (i.e. ranges having a “final state”, showing the property at the maximum possible degree) and unbounded ranges (i.e. ranges where this “final” state is not identifiable);

b) for the intermediates, the distinction between the existence or non–existence of properties which are “neither one pole nor the other”. If these properties existed, participants were then asked to distinguish between intermediates referring to ranges of experiences (even very limited ranges) or to a single experience.

By means of these distinctions regarding poles and intermediates, we were better able to interpret the findings about the area covered by the poles and the intermediate regions which emerged from the first study.

We need to bear in mind that in both studies, participants were asked to base their responses on as many objects or environments as they could. They did this by referring to areas in the space around where a particular property was visible, but also by thinking of spatial objects or environments not directly under observation at that moment.

The results of the second study will be discussed in one of the following sections (*Typical patterns*, p.70). Let’s now look at what we discovered in the first study.

The polarization of contraries

Before going on to look at our findings, it’s better if we explain exactly what the terms we refer to mean. Figure 21 shows how the data we are discussing were calculated based on subjects’ responses; it also helps to clarify the significance of the data in terms of the characteristics of the pairs of contraries.

The first characteristic we are going to consider is the degree of polarization in each pair. Using the bottom bars of each pair (see Fig. 21), we established the area covered by the intermediate region (m) and conversely the area covered by the polarized properties, i.e. properties perceived as gradations of one or the opposite pole (AA+BB).

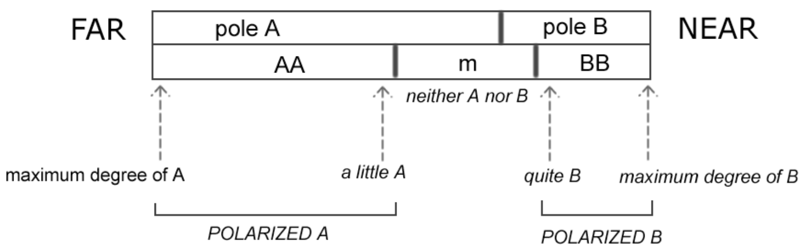

Figure 21. Diagram showing the results of participants' responses. On the top bar: areas assigned to pole A and pole B (used to define the degree of symmetry/asymmetry of the pair, see following paragraph). On the bottom bar, the area covered by properties perceived as "neither A nor B" (m) and the area covered by polarized properties (AA for pole A, BB for pole B), i.e. the properties perceived as *gradations* of one or the other pole.

Since, in our list of 37 pairs, the order of the two poles was arbitrary, we conventionally established A as the bigger of the two poles and re–ordered the data matrix accordingly. The degree of polarization characterizing each pair is shown in Table 2.

What did we discover about the polarization of the 37 pairs? The results showed that experiences of space consist of more properties relating to one pole or another rather than intermediates. In fact, on average, 78% of the space in between the two extremes was attributed to polar properties, while only 12% of properties were perceived as being neither one nor the other pole. This, as we said, is what we found "on average". However, differences emerged between the 37 pairs (see Tab. 2). Based on a hierarchical cluster analysis (method: average linkage between groups; measures: Euclidean) the 37 pairs turned out to be clustered into three main groups:

– *Strongly polarized contraries*: for 19 of the 37 pairs (51.3%), most of the scale (on average 88%) consists of gradations of one or the other pole (see cluster 1).

– *Moderately polarized contraries*: for 13 pairs (35.1%), the intermediate area is greater than in cluster 1, but less than 35% of the entire scale. The polarized area covers on average 66% of the entire scale (see cluster 2).

– *Weakly polarized contraries*: the intermediate area is greater than the area relating to one pole or the other in only 5 pairs (13.5%). For these pairs the polarized area covers on average 41% of the entire scale (see cluster 3); the intermediate area accounts for the remaining 59%.

Table 2. Proportions of polarization resulting from a hierarchical cluster analysis, based on the proportion occupied by gradations of one or the other pole, without intermediate regions.

Strongly polarized (cluster 1)	***M***	***SD***
moving–still	0.971	0.086
convex – concave	0.963	0.117
supported–unsupported	0.955	0.105
unbounded–bounded	0.950	0.254
divergent–convergent	0.945	0.109
in front–behind	0.932	0.129
inside–outside	0.901	0.130
right–left	0.900	0.106
angular–rounded	0.878	0.112
open–closed	0.865	0.121
curved–straight	0.863	0.099
ascending–descending	0.861	0.101
asymmetrical–symmetrical	0.860	0.126
upright–upside down	0.857	0.175
obtuse–acute	0.848	0.150
incomplete – complete	0.833	0.262
disordered–ordered	0.805	0.122
above–below	0.798	0.148
irregular–regular	0.776	0.258
$M_{\text{cluster 1}}$	*0.882*	*0.021*

Moderately polarized (cluster 2)	***M***	***SD***
many–few	0.733	0.128
thick–thin	0.701	0.108
far–near	0.687	0.185
broad–restricted	0.681	0.099
fat–thin	0.681	0.141
high–low	0.672	0.180
wide–narrow	0.664	0.129
long–short	0.661	0.100
large–small	0.656	0.140
vertical–horizontal	0.638	0.251
complex–simple	0.612	0.174
dense–sparse	0.600	0.144
deep–shallow	0.574	0.153
$M_{\text{cluster 2}}$	*0.658*	*0.034*

Weakly polarized (cluster 3)	***M***	***SD***
lying–down– standing	0.460	0.112
full–empty	0.413	0.113
sunken –floating	0.410	0.119
top–bottom	0.407	0.091
end–beginning	0.377	0.113
$M_{\text{cluster 3}}$	*0.413*	*0.039*

Note. Mean (*M*) and standard deviation (*SD*) reported refer to the area covered by poles A and B (i.e. the entire scale, minus the intermediate area). The cluster number refers to the order of segregation resulting from cluster analysis.

This predominance of polarized pairs suggest that in ecological spatial conditions observers would identify their experiences as belonging to one or other of the opposite properties and would less frequently identify them as intermediates. To be precise, this does not mean that, for example, in the pair large–small, we *usually* meet enormous or minuscule objects. It means rather that the sizes of objects which are in between minuscule and enormous are usually perceived as polarized sizes, i.e. belonging to nuances of small or big.

This could be a possible explanation as to why subjects, when initially asked to describe the primitive qualities of ecological environments (see 3.1), naturally referred to 74 opposite properties and no intermediate states. It also supports the hypothesis that opposition is a commonly given relationship within spatial domains: if the experience of space is fundamentally based on properties which are well characterized in terms of one or the other pole, then the recognition of contrariety between objects, properties or different parts of the environment becomes a common condition. In other words, these data prove that spatial properties are widely polarized. We also understand from this that this constitutes a necessary condition for contrariety to be easily perceived when comparing different aspects of visual scenes.

The asymmetry of contraries

A second interesting finding is that the 37 pairs revealed variously asymmetrical structures rather than symmetrical structures (Tab.3). The symmetrical or asymmetrical nature of each pair was indicated in the responses given in the top bar of Fig. 19, by observing the difference between the proportion of the scale covered by pole A and, conversely, pole B.

– *Very strongly asymmetrical pairs* (cluster 1): these pairs (18.9% of the 37 analyzed) are characterized by having one of the two poles three times more extended than the other pole (cluster1 mean: pole A = 0.242; pole B = 0.758). For instance, the gradations of “irregular” were found to be three times those of “regular” and a similar case was seen in the gradations of “curved” with respect to the gradations of “straight”. Many of these dimensions concern shape.

– *Strongly asymmetrical pairs* (cluster 3): less asymmetrical than the previous category (t = –7.288; df = 40, p < .000), this structure is still characterized by clear asymmetry, one pole being twice as extended as the other ($cluster_3$ mean: pole A = 0.717; pole B = 0.283). All the pairs grouped in this cluster (18.9%) refer to amount. What the asymmetrical structure describes is that there are around twice as many gradations of “broad” as opposed to “narrow”, just as for “high” as compared to “low”, “thick” versus “thin” and “long” versus “short”.

– *Moderately asymmetrical pairs* (cluster 4): the pairs falling in this group (13.5%) show a clear predominance of the extension of one of the two poles ($cluster_4$ mean: pole A = 0.645; pole B = 0.355). This structure again characterizes dimensions concerned with amount (large–small, wide–

narrow, many–few…). The significant difference between the extension of the poles in the present cluster as compared to the previous one ($t = 9.243$, $df = 4$, $p < .001$) suggests that the difference between "many" and "few", or between "large" and "small" is however not as great as the difference between "long" and "short", or "high" and "low";

Table 3. The *asymmetry of the pairs, resulting from a hierarchical cluster analysis, based on the proportion of the entire scale occupied by pole A.*

Very strongly asymmetrical (Cluster 1)	***M***	***SD***
open–closed	0.869	0.061
moving–still	0.84	0.040
incomplete–complete	0.804	0.074
curved–straight	0.752	0.041
irregular–regular	0.737	0.115
disordered–ordered	0.667	0.041
asymmetrical–symmetrical	0.637	0.051
$M_{\text{cluster 1}}$	*0.758*	*0.035*

Strongly asymmetrical (Cluster 3)	***M***	***SD***
broad–restricted	0.762	0.050
dense–sparse	0. 751	0.043
deep–shallow	0.736	0.043
high–low	0.709	0.090
full–empty	0.699	0.042
thick–thin	0.698	0.056
long–short	0.661	0.043
$M_{\text{cluster 3a}}$	*0.717*	*0.020*

Moderately asymmetrical (Cluster 4)	***M***	***SD***
many–few	0.667	0.072
large–small	0.664	0.083
wide–narrow	0.652	0.068
fat–thin	0.650	0.086
obtuse–acute	0.613	0.064
$M_{\text{cluster 3b}}$	*0.645*	*0.051*

Weakly asymmetrical (Cluster 5)	***M***	***SD***
top–bottom	0.619	0.039
far–near	0.610	0.052
ascending–descending	0.598	0.045
in front–behind	0.598	0.062
complex–simple	0.594	0.054
above–below	0.589	0.065
divergent–convergent	0.579	0.052
upright–upside down	0.578	0.041
convex–concave	0.570	0.057
vertical–horizontal	0.569	0.113
$M_{\text{cluster 3c}}$	*0.590*	*0.053*

Slightly symmetrical (Cluster 2)	***M***	***SD***
right–left	0.520	0.033
bounded–unbounded	0.520	0.124
supported–unsupported	0.508	0.044
inside–outside	0.502	0.058
standing–laying down	0.484	0.072
rounded–angular	0.449	0.048
floating–sunken	0.448	0.039
beginning–end	0.429	0.064
$M_{\text{cluster 2}}$	*0.494*	*0.058*

Note. Mean (*M*) and standard deviation (*SD*) reported refer to the extension of pole A (we arbitrarily established pole A as the pole with the greater extension). The number of the cluster reflects the order of segregation resulting from cluster analysis.

– *Weakly asymmetrical pairs* (cluster 5): these pairs (23.8%) have a structure that is less asymmetrical than that of the pairs grouped in the previous cluster ($t = 5.787$, $df = 40$, $p < .001$). Many pairs describing orientation fall in this cluster (4 out of the 5 used in the experiment), together with pairs describing localization (the remainder are in cluster 2). The emergence of asymmetry for this last group of dimensions (e.g.: horizontal–vertical, top–bottom, ascending–descending) is particularly interesting, since it would be tempting to assume that they were symmetrical. Data revealed, on the contrary, that "vertical", "top", "ascending", "above" and "in front" are properties that have more perceptual gradations then their respective contraries ($cluster_5$ mean: pole A = 0.590; pole B = 0.410).

– *Roughly symmetrical pairs* (cluster 2): these pairs (21.6%) have the most symmetrical structure among those which emerged in the present analysis ($cluster_2$ mean: pole A = 0.494; pole B = 0.506). Examples belonging to this set are floating–sunken and rounded–angular: the gradations of "sunken" are neither more nor less than those of "sunken"; the gradations of "angular", neither more nor less than those of "rounded". Five out of the 8 pairs having this structure refer to localization.

The finding of generalized asymmetry contrasts the assumption of symmetry shared by statistical methods based on scales of opposites, such as the semantic differential (Osgood, Suci, & Tannenbaum, 1957) or the Likert scales (1932).

In semantics and linguistics, the counterpart of the asymmetrical aspect of the two poles can be found in the definition of the term "marked" in antonymous pairs (e.g. Lehrer, 1985). This is however based on an ambiguous mixture of morphological, grammatical and cognitive criteria. For this reason, the outcomes of perceptual definitions of asymmetries do not necessarily confirm the linguistic definition of the term "marked". However, whether the description of the structures we came up with in the present study could contribute to psycholinguistic analyses of asymmetries in antonyms would be an interesting point to investigate.

The asymmetry of intermediates

Intermediates came out as a precise component of a dimension. The study demonstrated that they can be defined with high accuracy, both in terms of their extension and of their balanced or unbalanced proximity to the two poles.

A series of comparisons between intermediate regions described as belonging to pole A or pole B (paired sample t tests) revealed that these regions are distributed with no significant difference between the two poles in only 6 out of the 37 pairs (16%). In all the other cases, the intermediate area was not at an equal distance from the two contrary properties and thus closer to one of the two. This result challenges the idea that intermediates are neutral with respect to the two poles and confirms that in most cases they are perceived as being more related to one or another of the two properties (anisotropic characterization).

A few examples will make this concept clear.

If something is oriented in a position which is “neither vertical, nor horizontal”, it was said to belong more to “vertical” (m ⊂ pole A[1] = .270 on the total extension of the pair vertical–horizontal) than to “horizontal”(m ⊂ pole B = .092). What does this mean? Take a pen and put it in front of you, in a vertical position. Then lower it to such an extent that you perceive it as no longer vertical but rather “neither vertical nor horizontal”. Now look at it and consider whether, if forced to decide one way or the other, you would say it is more vertical or horizontal. Then keep moving the pen, gradually (using the qualitative JNDs we are now familiar with), to exhaust the range of positions that you would describe as “neither vertical, nor horizontal” until you reach a horizontal orientation. You can do the same starting from a horizontal orientation and moving to a vertical one. Consider how often when looking at these “neither vertical nor horizontal” conditions, you would say – if forced to decide – that you recognize the orientation of the pen as being vertical rather than horizontal. You will discover that this happens for the most of the intermediate steps.

A similar asymmetry emerged with “neither empty nor full”. Do the same exercise taking into account the intermediate steps between “full” and “empty”, referring to a bag, a bottle, a drawer or a room (full or empty of people). Again, explore all the various ways of being “neither full nor empty”. How many times, if forced to say whether the intermediate state you are looking at (and which, as first choice, you would describe as “neither full nor empty”) is closer to one of the two poles, would you say that it appears closer to “full” than to “empty”? You will discover that this happens most of the time. The intermediate region “neither full nor empty” tuned out to be positioned more towards “full” (m ⊂ pole A = .406) than “empty” (m ⊂ pole B = .181).

The same was found for “neither beginning nor end”, which was positioned nearer to “end” (m ⊂ pole B = .440) than to “beginning” (m ⊂ pole A = .183): interestingly, when something is no longer located at the beginning and is in between the beginning and the end (of a road, a corridor, a path), it is literally “neither at the beginning nor at the end” and soon starts to be perceived as closer to the “end” rather than “the beginning”.

One might observe that all the examples we have given refer to moderately polarized pairs, i.e. to pairs which have a very extended

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[1] “m ⊂ pole A” and “m ⊂ pole B” refer to the proportion of the intermediate region (m) which is included in the area covered, respectively, by pole A and pole B. See the diagram represented in Fig. 21 for better understanding.

intermediate region (Table 2, cluster 3). We might ask ourselves whether this asymmetry in the characterization of intermediates only holds in this condition.

An asymmetrical proximity towards one of the two poles was found also for moderately polarized pairs (Table 2, cluster 2). “Neither near nor far” was described as being closer to “far” (m ⊂ pole A = .276) than to “near” (m ⊂ pole B = .041); “neither broad nor restricted” was closer to “broad” (m ⊂ pole A = .230) than to “restricted” (m ⊂ pole B = .103); “neither high nor low” was said to be closer to “high” (m ⊂ pole A = .230) than to low (m ⊂ pole B = .090); “neither many nor few” was considered more as “many” (m ⊂ pole A = .235) than as “a few” (m ⊂ pole B = .032).

When a symmetrical distribution of the intermediate region was found, it was always for strongly polarized pairs, i.e. for pairs having a very restricted intermediate region. For instance “neither right nor left” would describe something which is aligned directly in front. Now, if you look at something aligned in front of you and you are forced to say whether it is closer to one of the two poles (“right” or “left”), what will you say? You would agree with our participants that it is not closer to either of the two poles (right = .051; left = .049). You would conclude the same when considering “neither in front nor behind”, which in fact was symmetrically ascribed to “in front” (m ⊂ pole A = .037) and “behind” (m ⊂ pole B = .031), or “neither convergent nor divergent” (i.e. parallel), which was symmetrically related to “convergent” (m ⊂ pole B = .030) and “divergent” (m ⊂ pole A = .025). So is this the rule for all pairs where intermediates are very restricted? In fact it isn’t.

Being “neither open nor closed” was ascribed more to “open” (m ⊂ pole A = .110) than “closed” (m ⊂ pole B = .026). Think of a door which is ajar: people see it as being “neither open nor closed”, but when forced to decide if this intermediate state is more related to “open” or “closed”, they decide for the former.

The same was found for what is perceived as being “neither regular nor irregular”. For example a geometrical figure that is not perfectly regular, would not be described as “irregular” at a first glance, as its irregularity is almost unnoticeable. If you draw it and then look at it, you might spontaneously describe it as “neither regular nor irregular”. But what if you were forced to decide one way or another? Our subjects were inclined to refer to it as “irregular” (m ⊂ pole A = .159) rather than “regular” (m ⊂ pole B = .065).

Another way to investigate these asymmetries is to start from a condition that participants agree as being intermediate (e.g. emptying a bag until it shows a prototypical state of “neither full nor empty”, or putting boxes one on top of the other until they form a pile that appears to be “neither high nor low”). Another group of participants is then asked what they would consider to be “the contrary” of these conditions. What is the contrary of a pile of boxes which is “neither high, nor low”: a very high pile or a very low pile? And what is the contrary of a bag which is “neither full nor empty”: a bag full to its limits or a visibly empty bag? We are carrying out a series of experiments (Savardi & Bianchi, in preparation) which may reveal that responses are randomly distributed towards the two poles only in special cases. Most of the time participants resolve the task by consistently choosing one pole or the other.

Are these asymmetries simply reflections of the overall symmetry–asymmetry of the two poles? In other words, were subjects reproducing, within the intermediate region, the same asymmetrical or symmetrical structure they had described in the first part of the task, when drawing the boundary separating the two contraries (the response given in the top bar of Fig. 21)?

No correlation was found (r = 0.18, *ns*) between the values for the asymmetry between pole A and pole B and the values for the asymmetry of polarized regions (another way of looking at the attribution of the intermediates to the poles). This suggests that the asymmetry/symmetry of the overall structure of the poles and the asymmetry/symmetry of the intermediate region (or, conversely, of the polarized regions of the poles) do in fact refer to different characteristics of the pairs.

Typical patterns

As shown in the previous pages, a significant amount of information about the internal structure of the pairs can be derived from three basic indexes expressing various aspects of the relative extension of the two poles and of the intermediate region:

a) The symmetrical or asymmetrical structure of the pair;

b) The extension of the polarization of each pole for each pair

c) The degrees of asymmetry between the polarized regions.

By means of a second study (see p. 62), we have been able to qualitatively reinterpret the data of the study just presented, with respect to both the poles and the intermediate region.

In particular, we have been able to distinguish which of the intermediate regions should be considered as cases of a first or second type of “intermediateness”. These two types have been proposed (Savardi & Bianchi, 2000a) in order to distinguish between two different conditions of intermediateness. The first refers to those conditions where the property does not belong to either of the two poles – for instance “parallel” is neither an experience of “convergent”, nor an experience of “divergent”, but “neither convergent nor divergent”. A similar condition characterizes the experience of being, for instance, “halfway down” a street, where the property in question is not an experience of being at the “beginning” or the “end” of the street. A corresponding condition is not possible for pairs like “open–closed”, for instance. When we experience something as not “closed”, it is because it is “open”. However, it is also a fact that a door that is ajar is not perceived as wide open; it appears, on the contrary, to be much closer to “closed”. We refer to this latter condition as a second type of intermediateness. By comparing participants’ descriptions of the intermediate component in study 1 and 2, we could differentiate between two types of intermediates for the 37 dimensions.

Let us remember that participants (54 of the 60 undergraduates who had participated in study 1, organized into 18 groups of 3) were asked to classify the component of each dimension (pole A, intermediate area, pole B) by choosing from three possible structures for the two poles: single property (S), bounded (B) or unbounded range of properties (U) and if an intermediate area existed to choose from single property (S) or bounded range of properties (R); in the case of non–existence of the intermediate region they were to classify the intermediate component as “none” (N).

We believe that the most interesting result (shown in Fig. 22) is that various typical patterns emerged after a hierarchical cluster analysis was carried out (method: average within group, chi square measures). The analysis was performed on the frequencies of the 3 levels of description for each of the 3 components (pole A, intermediate region, and pole B).

I) UBB (*pole A unbounded range, intermediate region bounded range,* pole B *bounded range*). In this structure, all three components refer to ranges of experiences. One of the two poles is unbounded (study 1 told us it is the one covering a greater area), while the other (covering between 23–39% of the dimension) is bounded. Results from study 1 also show that the range of intermediate experiences covers around 35% of the whole dimension (see Tab. 2, cluster 2). This structure seems to be typical of dimensions referring to amount (length, height, thickness…). These are consistently characterized by: 1) many gradations for the pole which refers to the “smaller” end of the scale (e.g.: thin, narrow, low, short, few…); 2) many gradations which are “neither one pole nor the other” and 3) many more gradations referring to the “large” end of the scale. This latter is the *unbounded* pole. This means that subjects perceive that there is no “final” state representing the limit to these dimensions.

II) USU (*pole A unbounded range, intermediate region single property, pole B unbounded range*).With the exception of one single state that is perceived as being “neither one pole nor the other” all the experiences belonging to these dimensions are identified as gradations of one or other of the two contrary properties. These dimensions are characterized by the fact that the ranges of experiences at the two poles do not have a final experience showing the property at its maximum possible level. For example, all the experiences belonging to the dimensions "above–below" and "in front–behind" (except the single state of being "aligned") are perceived as ways of being "above" or "below", or of being "in front" or "behind". However none of these experiences is such that it would not be possible to extend it further, i.e. it is always possible to find something that is more "in front " or more "behind", more "above" or more "below". Both the dimensions falling in this cluster refer to spatial localizations.

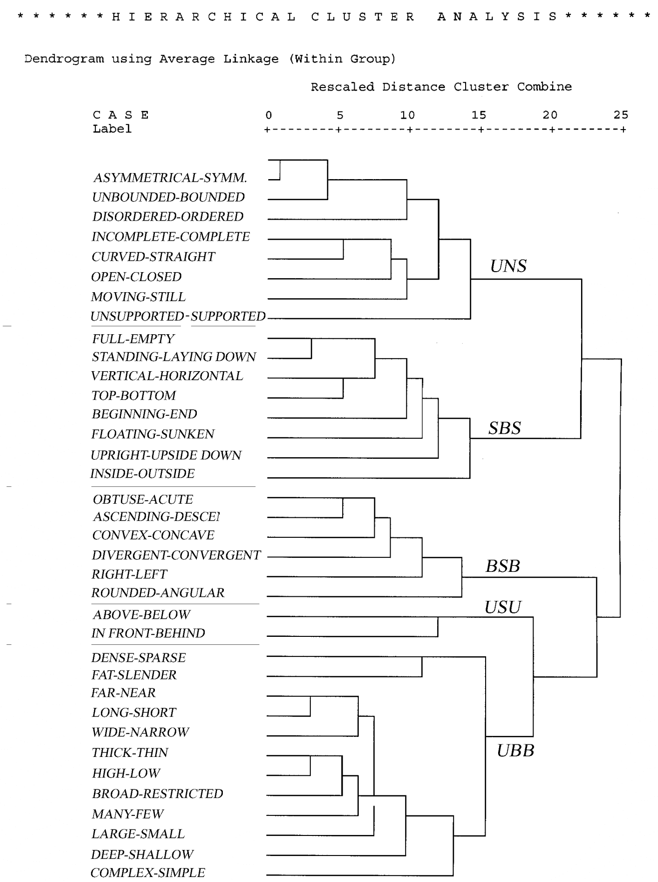

Figure 22. Typical patterns of the 37 spatial dimensions, based on the qualitative description of the three components: pole A, intermediate area, pole B (for the explanation, see text). **U=unbounded range, B=bounded range,S=singular(Point)**

III) BSB (*pole A bounded range, intermediate region single property, pole B bounded range*). Basically similar to the previous category, these dimensions are distinguished by unbounded poles. All the experiences belonging to these dimensions are perceived as variations of one or the other pole, except for the single state that is perceived as being "neither one pole nor the other". For instance, with the exception of "being parallel", all other experiences belonging to the "divergent–convergent" dimension are perceived as either degrees of convergence or divergence. The same goes for "obtuse–acute" and "left–right": apart from the precise state of "being a right angle", all other experiences are perceived as variations of "being acute" or "being obtuse"; apart from the state of being "aligned", all other experiences belonging to the left–right dimension are variations of being "on the left" or "on the right". The dimensions with this type of structure were among the strongly polarized group (see study 1, Tab. 2, cluster 1). In this cluster there are dimensions referring to shape, localization or orientation, while dimensions referring to the amount of space are excluded.

IV) SBS (*pole A single property, intermediate region bounded range, pole B single property*). Somehow inverted in relation to the two previous categories, this type is characterized by the fact that both poles have a single property and that all variations are perceived as gradations of "neither one pole nor the other". Many dimensions referring to localization and orientation are of this type. For instance, all the different ways of being oriented between vertical and horizontal are perceived as being "neither vertical, nor horizontal"; similarly, all states that are not at the "beginning" of something or at the "end" (or else at the "top" of something or at the "bottom" of it) are perceived as intermediates. All the dimensions that in study 1 were found to be weakly polarized, with intermediates occupying around 60% of the dimension (see Tab. 2, cluster 3) are of this type. There are however three dimensions in this category ("vertical–horizontal", "upright–upside down", "inside–outside") that in study 1 came out as having strong polarization (with the intermediate region covering less than 10%).

V) UNS (*pole A unbounded range, no intermediates, pole B single property*). The dimensions with this structure have one pole consisting of a single property while all other experiences are perceived as variations of the contrary pole (with no limits to the range). These dimensions have no intermediates. Examples of dimensions with this structure are "asymmetrical–symmetrical" and "irregular–regular". Despite the existence of different formal definitions of symmetry and regularity, subjects perceive "being regular" and "being symmetrical" as single states: when a variation in regularity or symmetry is perceived, it is already experienced as a gradation of irregularity or asymmetry.

There are two more general observations we would like to mention. They concern, respectively, the structure of the poles and of the intermediate region.

1) None of the 3 structures of the poles (single property, bounded range and unbounded range) can be considered typical of the 74 spatial properties studied: an analysis of the most frequent description (mode) for each properties revealed that 26 of them (35.1%) were described by most of the subjects as single (S), the same number of properties were described as bounded ranges (B) and 22 properties (29.7%) were unbounded ranges (Chi square = 0.457, *df* = 2, *p* = .796). These data also show that 64.9% of the 74 properties analyzed are gradated into ranges of experiences, independently of the presence or absence of a "final" state and refer less frequently to single experiences.

2) In the second experiment, 11 of the 37 dimensions (29.7%) were recognized as having no intermediate state. Comparing these results with those of the first study, we can see however that a small region of intermediates was assigned for all of these 11 dimensions (they fell into cluster 1, Tab. 2, i.e. highly polarized dimensions). For these pairs, intermediates are "second type", while for the remaining 26 dimensions, they are "first type".

Intermediates of the first type covered, on average, up to 35% of the total dimension in 13 of cases (mainly those describing amount, see Tab.2, cluster 2), while for other 5 which concern localization or orientation, this region covered up to almost 60% of the whole dimension (see Tab. 2, cluster 3). For the remaining 8 dimensions (21.6%), the experience of being "neither pole A nor pole B" refers to single experiences (S). It is worth noting that in a phase of the research that we are not going to deal with here (see Savardi & Bianchi, 2000, pp. 93–98), the existence of specific linguistic labels was found for many of these properties.

Typical patterns, fuzzy functions

We investigated to see if it was possible to describe the structure of contrary pairs by means of fuzzy functions, expressing both the qualitative description of the three components and their qualification.

Two fundamental concepts of the fuzzy set theory (Zadeh, 1965; Zimmermann, 1991; see also Klir &Yuan, 1996) seemed in fact to be adequate for describing the structure of perceptual dimensions:

a) the assumption of fuzziness of meaning: with respect to the issue of space, this means that the words used in natural language to describe spatial properties (e.g. "open", "regular", "ascending" etc.) would refer to classes of different perceptual experiences in which the transition from membership to non–membership is gradual rather than abrupt. More specifically, within each dimension, this means that the transition from states belonging to the poles to states belonging to intermediate regions is better described by areas of overlap than by crisp boundaries; the non–neutrality of intermediates in relation to the two poles clearly shows that certain states are simultaneously experienced as belonging to the set of states which are "neither one pole nor the other" and to the set of variations of one of the two poles, to different degrees.

b) the degree of membership: the membership function is defined by the idea that the set of experiences of a certain property is composed of elements belonging to the set to different degrees. The degree of membership is expressed by a number in the interval [0,1] with 0 representing non–membership and 1 representing full membership. Within our frame of reference, the membership values express various degrees of polarization of the experiences at the two poles of the dimension and various degrees of salience for intermediates in being perceived as "neither one pole nor the other". For instance, in the dimension "open–closed", the range of states of being "open" expresses to different degrees the experience of "open" (a wide open door is perceived as being more open than a door which is ajar).

Thirty–seven fuzzy structures (relating to the 37 dimensions) were drawn from the data. Three curves described each dimension: two of them referred to the functions of the opposite poles and the third to the function of the intermediate region (see Fig. 23). We decided to use a new function for intermediates and not to describe them as an intersection of the two poles since the phenomenological description of intermediates does not fit in with the idea of an intersection of poles. When we experience an intermediate property, we are not experiencing both "one pole and the other", but "neither one pole nor the other". Moreover, intermediates in theory should never achieve maximum membership value, but this is however phenomenologically possible.

The functions assume that:

– the x axis represents the range of experiences belonging to a dimension (corresponding to the bipolar scale used in study 1).

– the domain of each function in the x axis expresses the fraction of the dimension belonging to each of the three components and their overlap (derived from the results of experiment 1).

– the values of the membership function range from 0 to 1 for each function.

The curves were drawn by applying what can be called an indirect method to obtain membership functions, where the curves of the functions are derived from the distribution of frequencies (see Hersh & Caramazza, 1976; Hersh, Caramazza & Brownell, 1979; Rubin, 1979; Wallsten, Budescu, Rapoport, Zwick & Forsyth, 1986, p. 349). Stated in brief, the algorithm (Bianchi, Savardi & Tacchella, 2002) was used to calculate, for each point of the x axis, the frequency of responses assigning the corresponding point on the bars to pole A (Fig. 19), the frequency of responses assigning it to pole B and the frequency of responses assigning it to the intermediate region. In the latter case, since responses regarding the area covered by the intermediate region were constrained by where the boundary between pole A and B was drawn (see the task used in the first study), the above mentioned computation was preceded by a preliminary operation which aimed at standardizing responses with respect to the boundary marked on the top bar (see Fig. 19, p. 60).

So, what do these curves show about the structure of the dimensions?

If we compare, for instance, the structure of "high–low" (Fig. 23, top left) with the structure of "open–closed" (Fig. 23, top right), we notice that the two dimensions share an asymmetrical structure, but also that the latter is more asymmetrical. The intermediate region covers a smaller area in "open–closed" and almost entirely overlaps the curve of "open" – as we noted earlier, a door which is ajar is perceived as being already open. Being "neither high nor low" is mainly perceived as being a degree of "height", but it is sometimes recognized as being closer to "low".

The structure for "full–empty" (Fig. 23, bottom right) is very different. It is again asymmetrical, but with the intermediate region asymmetrically distributed inside the two poles and covering more than half of the entire dimension. "Supported–unsupported" (Fig. 23, centre left) offers an example of a somehow very similar structure (the two poles are in both cases single properties), but it has no intermediate region.

"Ascending–descending" and "above–below" (Fig. 23, centre right and bottom left) are further variations of the previous structures: the "ascending–descending" dimension has two poles which consist of ranges of properties (both bounded) and a single property intermediate state. This second feature also characterizes "above–below", but in this case the two poles are unbounded (not bounded) – the curves in fact do not reach but only approach a membership value of 1 in an asymptotic way).

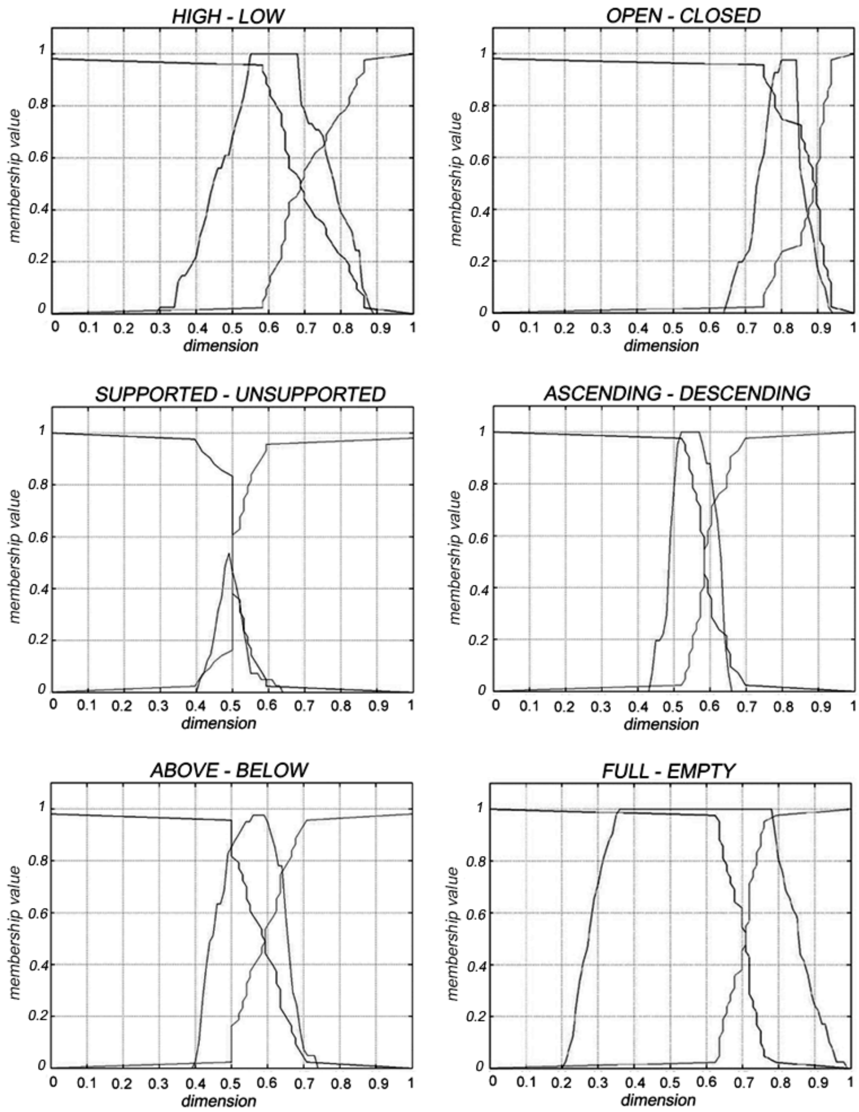

Figure 23. Fuzzy functions of dimensions, based on the three components: pole A, intermediates, pole B. The extension of each curve in the x axis expresses the proportion covered by each component. The shape of each function (reaching 1 or close to 1 in the y axis) represents whether they are single properties or bounded or unbounded ranges of properties. For the intermediate component, the shape indicates whether it consists of single properties or bounded ranges or is an intermediate of the "second type"). For more complete explanation see text.