(Inter)Subjectivity and Set Theory: Comparative Binary Relations

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ABSTRACT
In this article, some aspects of subjectivity are studied using the set theory, specifically those related to interpersonal contacts and the difficulties that arise in them. The material that is analysed comes from verbal expressions of the patients who come into consultation at the Psychopathology and Psychoanalysis Association of Seville (APPS), to which the corresponding set operations were applied.
As a result, it has been discovered that formalisation enables finding "binary relationships" and "graphs" in the comparisons that occur between different individuals. This allows us to see hidden connections, hardly inferable from the observed data.
What is found is not a simple mathematical pastime, but we have managed to: a) escape quantification which, although it may contribute to natural sciences, it does not to the study of subjectivity, b) bring into light underlying structures, this point being in connection with the structuralist postulates and c) provide a guide of inestimable value so that the clinician can address, through psychotherapy, the suffering these individuals go through.
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I.   Introduction

Up to now, the relationship between psychiatry (or psychology) and mathematics has been centred, almost exclusively, on the employment of procedures based on quantification. In this sense, scales and tests have been developed to measure features, abilities, or symptoms. Statistics have been in charge of presenting population distributions, both from symptomatic manifestations and disorders; in fact, the North American classification of these receive the name *Diagnostic and Statistical Manual of Mental Disorders* (1).

This dominant movement has left out taking into consideration what the person has to say and, therefore, the collection of those significant words that reveal the suffering that they go through and leads them to consult. By employing interviewing methods that are not as rigid as scales or psychological tests, in this research, we intend to apply some type of mathematics that allows us to objectify the psychological components of these individuals to understand them better. Mathematics is supposed to provide some type of knowledge to the problems that unfold in the clinic.

To attain these objectives, we depart from considering "subjectivity" the object of study of psychology and psychiatry, because, when we approach the subject to help, we analyse the perception he has of himself, how he values his relationships, and how these influence him. This particular way of grasping (the "interior" and "exterior") is part of subjectivity and involves appreciations, considerations, beliefs, assertions, opinions, feelings, and certainties, as well as an endless number of operations, even thoughit can not be said with certainty that all of them are conscious.

Before we focus on the task, we must mention a caveat: "subjectivity" is not the "brain" since this one is matter, while subjectivity is organised as a group of representations. It can be better understood with a simile: the difference is equivalent to the one that existed in informatics between the *hardware* (material part of the system where the different electronic components are included) and the *software* (local support of the system, that includes different programs). We have a physical support (the brain) and a program installed on it, made up of different representational groupings, forming a place that is not physical, but virtual, an issue that was already sensed by Freud when he spoke of a "psychic locality" (2).

Inside the vast quantity of elements that compose subjectivity, we start the research by discussing the "intersubjective relationships", in other words, how an individual experiences approaching his equals. Going a bit ahead we will say that, in these relationships, human contact is not always as peaceful as could be expected because, when interacting, failed relationships arise. These are the ones that will be discussed here since they have great clinical interest.

Methodologically, at least two problems are raised: a) the relevance of the employment of mathematics to address the issue that is proposed and b) the type of formalisation that will be used. Kurt Lewin (3) already pointed out that every scientific theory must compulsorily apply mathematical concepts, but the question is how to select the appropriate method, which is an aspect of extraordinary importance for the elaboration of a theory. While the material world is woven on space-time coordinates and the phenomena that compose it are reproducible, the subjective processes are irreproducible and, consequently, can not be measured (4). Therefore, the formal procedure to be used must necessarily be qualitative, it must identify structures and avoid using numbering.

In this complex task, the "set theory" can be of great help. This is a part of mathematics or, better yet, a new approach to those whose invention we owe to George Cantor, a mathematician based at the German University of Halle, who suffered from a psychiatric disorder (5,6). This author raises the notion of "set" between 1895 and 1897, in the work titled: *Beiträge zur Begründung der transfiniten Mengenlehre.* Initially, these developments aroused notable critiques but, later on, were given due importance. Thus, an important part of mathematics and logic of the 20th century was based on cantorian elaborations. The success achieved was such that the Bourbaki collective (7) established the "set theory" as the source of all mathematics, reaffirming itself in an unifying attempt that maintained "setism" at all costs. Further on, the paradoxes were discovered and solutions began to be proposed (8,9), creating alternative systems (Zermelo, Fraenkel, von Neuman, Bernays, etc.).

The use of the "set theory" has a series of advantages when studying the problem that is of our concern: a) it is a method that does not employ measurement, which does not detract from the results since qualitative accuracy does not have an epistemological range lower than quantitative accuracy (10,11), b) it does not work with spatial dimensions (surfaces or volumes), c) it studies relationships (binary, order, equivalence, etc.), being able to be applied to subjectivity, which can be understood as a system of operations, d) the procedures that it uses are easy to apply, not involving complex calculations, e) the results are easily transmissible and f) there is a certain isomorphism between the problems that subjectivity poses and the set procedure, hence what is obtained is found familiar.

Thus, a relational and qualitative procedure is the only mode of analysis that psychic interiority can admit. The mistake would be to apply mathematical methods proper of physics to subjectivity, an attempt by some authors (Hertley, Herbart, Fechner, Wundt) who, nowadays, only have historical interest (4). Notwithstanding the methodological separation between physics and psychology (Windelband, Rickert or Dilthey) (12-14), we are currently witnessing the resurgence of quantification as a way of directing the "psi" disciplines towards the path of science. However, in this attempt the most important thing about the human subject has been lost, which is precisely, what we work on here: the "inner world" (4).

II.   Methods

For the proposed study about (inter) subjectivity, expressions obtained from patients who came into consultation at the Psychopathology and Psychoanalysis Association of Seville (APPS) have been used as material. More specifically, phrases that were obtained from eight consultants are used, although the rest of the studied individuals (in total: 20) show the same expressions. These patients are: **P-1**: 36-year-old male, married, **P-2**: 25-year-old woman, single, **P-3**: 22-year-old male, single, **P-4:** 32-year-old woman, single, **P-5**: 18-year-old woman, single, **P-6**: 36-year-old woman, divorced, **P-7**: 23-year-old woman, single and **P-8**: 25-year-old male, single.

To faithfully collect the verbal manifestations, the Subjectivity Approach Method (or MAS) (15,16) is employed, as we have used it in numerous psychological and psychopathological circumstances (e.g. grief, depression, schizophrenia, etc.) (17). It consists of carrying out non-directive interviews in a safe space where they can talk naturally about whatever they want.

Hereunder, the notions from the "set theory" (18-22) are applied, with which an attempt is made to formalise and carry out the corresponding operations on the material contained in the protocols of each one of the cases. From this theory, the following notions will be employed:

1. Set. Following Cantor, a set (*menge)* is a collection of determined and different objects gathered into a whole; Each of them is called an "element". It is possible to find out whether or not a given element belongs to a set, otherwise, it can not be considered as such (e.g. how many days will my cousin live).

2. Ordered pair. A "pair" is a set formed by two elements "x" and "y", written (x,y). It is said to be "ordered" if its elements are written in one of the possible orders, first "x" and then "y" or the other way around.In this way, (x,y) is different from (y,x):

$$(x,y) \neq (y,x)$$

3. Cartesian product. It is the set of all ordered pairs that can be formed with the elements of the two sets A and B, the first element from each pair of set A and the second from set B. It is written:

$$A \times B = \{ (x,y) \mid (x \in A) \wedge (y \in B) \}$$

A cartesian product can be graphically represented through coordinates, where each intersection point represents one of the ordered pairs.

4. Cartesian square. It consists of the product of a set by itself and it is written as: A x A = A^2 and it is defined as:

$$A^2 = \{ (x,y) \mid (x,y) \in A) \}$$

5. Graph. Every part G of the set A x B is called a graph on a Cartesian product A x B and it complies that the graph G is a subset of A x B, which is written: G ⊂ A x B.

6. Binary relation. It is the correspondence between a set and itself (e.g."being a sibling of" or "being subordinate to" are binary relations in the set of people). A series of ordered pairs (x,y) are formed and the set of them is the binary relation R.

The expression x R y ("x is related with y") means that the pair (x,y) verifies the relation R. Similarly, x -R y ("x is not related with y") means that the pair (x,y) does not verify the binary relation R.

It is compiled that the binary relation R in a set A is a subset of the Cartesian product A x A = A^2 and, therefore, the binary relation is a graph of A x A. Then, the ordered pairs belong to the relation R and this one is included in A^2: (x,y) $\in$ R ⊂ A^2.

The set of the pairs that do not comply with R makes up another graph, which is complementary to R, which is represented as R´ (see Figure 1).

Sets………………………………………..	A, B, C, …
Elements ……..…………………………..	a, b, c, ….
Indicator for sets…………………………. ..	{ }
Complement of set…………. .. ……….	A´, B´, C´…
Ordered pair………………………………..	(x,y)
Set membership……………………………	$\in$
Subset relation……………………………	⊂
Intersection of sets………………………..	∩
Union of sets………………………………	∪
Cartesian product………………………….	x
Universal quantifier……………………...……	∀
Particular quantifier…………..………………	∃
Empty set ……………………………………	∅
Binary relation……………………………..	R
Inverse binary relation……………………….	R^{-1}

FIGURE 1. Set Theory symbols

III.   Results

The comparison as a binary relation.

In intrapersonal relationships, any individual can compare himself with others, which is a quite common phenomenon in the contacts that are established (**P-1:** *"I am always comparing myself with my colleagues and I can't help it",***P-2:** *"I am too aware of my friends, if any of them stand out in something"*), this being like a game of the different selves of each one of the participants. In this comparison, from one's self, two possibilities can occur:

-He places himself below others, feeling "inferior", which is an assessment he makes of himself compared to others (**P-1:***"I think I am efficient in my company but when I see that somebody is more determined than me, my whole world falls apart";* **P-2:***"I feel below my friend M., who is very nice and everybody loves her"*). Let's talk about the "feeling of inferiority", as described by Alfred Adler (23,24), which is accompanied by low self-esteem, insecurity, and a demonstration of the "negative" aspects of oneself, along with the exaltation of the "positive" ones of others.

If we assign the letter "a" to the self of the first and "b" to the second one, a statement is established from subjectivity and it can be expressed like this: "a is compared with b and from the comparison, a is less than b". Hence, there is a relationship between "a" and "b" (a R b) that can be defined by the functor "less than" (<) and written as:

$$a \, R \, b = a < b \quad [1]$$

-The second possibility consists in "a" appearing above "b", forming what we call a "feeling of superiority" related to the rise of self-esteem, pride, and self-confidence (25) (**P-3:***"I think that I am better than my friends and now I realise that I have gone out with those who are much less than me, that way I can feel I am more than them"; ***P-4:***"I get together with friends who are ugly or stupid and I think I'm the coolest among*

them. That gives me a lot of security"). Here, we can see exactly the opposite that was previously described in [1]: an inverse relationship that is represented as R^{-1} and is written:

$$a \, R^{-1} \, b = a > b \quad [2]$$

Needless to say, what leads "a" to compare with "b" is not something objective, but rather belongs to its subjective world, since no subject is comparable or measurable to others, as each one is different. Two inequalities have been obtained, where the value of one of the members is lower (or higher) than the other, but is also about relationships between them, which definition is: $R \equiv$ "is less than" and $R^{-1} \equiv$ "is greater than".

Characteristics of the comparative binary relation.

The relationship between two elements of a set is called "binary relations" but, to demonstrate that they are present in the material studied here we must determine: 1°) that "a" and "b" belong to the same set, 2°) operations are done between several elements of that set, 3°) ordered pairs are formed, which are those related to the relationship and 4°) the binary relation is a subset of the cartesian product of the set itself, consequently, the binary relation is a graph. If we manage to prove these four conditions, we will have that both R and R^{-1} are "binary relations".

1°. Regarding the first of them, it is easy to verify that both "a" and "b" are two selves that are connected, therefore, it can be determined that there is a set to which both belong: the set of the selves, which we will call hereinafter Y.

It may be thought that this set is infinite, given the number of selves that exist in the world, however, for practical purposes (and it is demonstrated by clinical experience), it is not since any individual relates (from his subjectivity) only with a finite number of people. For the intended purpose, we are going to assume that there are only four elements in this set: a, b, c, and d, which can be defined by extension and by understanding as:

$$Y = \{a, b, c, d\} \quad [3]$$
$$Y = \{x | x \text{ a compares to a self}\}$$

2°. Concerning the second point, we must say that it is fairly frequent, as we have observed in the sessions, for individual A to compare themselves to others (b,c,d), systematically placing themselves above or below. This comparison shows two characteristics:

I) It is established from one to another, forming different relationships, always from a's subjectivity (a < b, a < c, ...) (**P-4:** *"When I'm in a new group, I look at how I am in relation to each one of the girls: she has this and I don't, this other has something else that I don't have…"*) and

II) It occurs with all of the elements of the set Y, which allows us to write:

$$
\begin{array}{ll}
a < b & a > b \\
a < c & a > c \\
a < d & a > d \\
\hline
\forall x \, (a < x) & \forall x \, (a > x) \quad [4]
\end{array}
$$

As it is shown, an inevitable consequence of these contacts is a generalisation, because he feels inferior (or superior) to any other (b,c,d), hence the employment of the universal quantifier "$\forall$" ("for everything"). What is stated can be easily illustrated in the cases that were studied (**P-5:** *"When I am in a reunion I don't open my mouth because I see myself below others, everyone has something I don't, a specific quality"*; **P-2:** *"I look at everyone from below", "I am always below and that keeps me from relaxing during reunions and makes me aware of everything that comes from others".* **P-4:** *"I went out thinking I was better than anyone else").*

Thus, if we consider that individual (a) compares himself to another that we call "b", or to any other that we could call "c" or "d", we are establishing binary operations in the set of selves that connect with each other (Y).

3°. Ordered pairs are formed, in a way that if "a" feels inferior to "b", we have an ordered pair (a,b) which is not the same as (b, a), in other words: (a,b) ≠ (b, a). Saying that "a feels inferior to b", is not the same as saying that "b feels inferior to a". Precisely, due to the order that is established between the elements, we can properly speak of "ordered pairs". Given four subjects, these can be formulated as:

Comparison	Ordered pairs
a < b	(a,b)
a < c	(a,c)
a < d	(a,d)

$$\forall x \, (a < x) \quad \text{(generalisation)} \quad (a,x) \qquad [5]$$

4°. The following condition that we have imposed is that each of the ordered pairs that have been formed must belong to the relation R which is, in turn, a graph of the Cartesian product Y x Y = Y^2 :

$$(a,b) \, R \subset Y \text{ x } Y \qquad [6]$$

First of all, we are going to form the Cartesian product Y x Y:

$$Y = \{a, b, c, d\}$$

Y x Y = {(a, a), (a,b), (a,c), (a,d), (b, a), (b,b), (b,c), (b,d), (c, a), (c,b), (c,c), (c,d), (d, a), (d,b), (d,c), (d,d)} [7]

This product represents the logical space in which all the relationships that can be established between the four elements that conform set Y have place. It can be graphically represented through Cartesian coordinates (Figure 2).
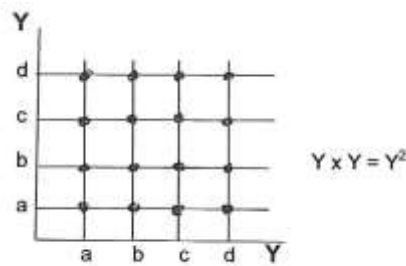

FIGURE 2

The relations specified above, where "a" is placed first in the pair, form a graph G that is included in Y x Y, as it can be easily proven.

$$G = \{ (a, a), (a,b), (a,c), (a,d)\} \subset Y^2 \quad [8]$$

With what has been mentioned, it is proven that the relation R is a subset of the Cartesian square Y^2 and that it is a graph. It follows that the comparative relationships, which are frequently observed in sessions with patients, meet the necessary characteristics to be considered "binary relationships".

Analysis of the comparative binary relation as a graph.

Since the individual establishing the comparison is "a", we can see that the relationships of his interest (from his subjectivity) are those established by himself and are all those formed by the pairs where "a" appears in the first place, in the form (a,x). The first pair (a, a) is included in this assessment, although this last circumstance can not be explained yet and it will be covered elsewhere. The obtained graph will be called hereafter "N" and it is composed of:

$$N = \{(a, a), (a,b), (a,c), (a,d)\} \quad [9]$$

It could also be written as:

$$N = \{(a,x) \mid a,x \in Y\} \qquad [10]$$

It is met that N is a subset of the set Y, which represents the logical space of the possible relations with all other subjects, that is to say that: N $\subset$ Y x Y = Y^2. It can be graphically represented in the following way (Figure 3):
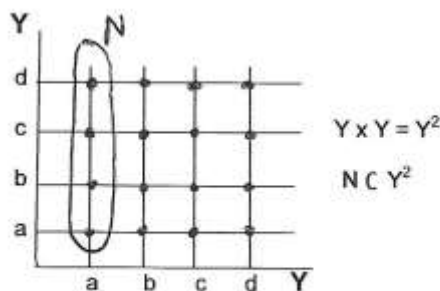

FIGURE 3

We have chosen the letter "N" to name the graph in which the first term of the pair is "a" because it is the initial of "narcissism" and its use has to do with the type of connections that the individual establishes in these circumstances, where he places himself ahead of any other (a,x). These formal appreciations fully match what the patients say, demonstrating the great self-importance that the person who organises things in this way gives himself, regardless of whether they place themselves below (a < x) or above (a > x) (**P-1:** *"My work life is beautiful if I feel privileged in relation to my colleagues"*; **P-4:** *"I don't let anyone getting in my way, I'm always the first"*).

The relation of disdain as the complementary of N.

The subject from the comparison (a) is only interested in relationships with others if he is in the first term (a,x), valuing the contact from himself (from his self); this is what is shown by graph N, as seen in [9] and [10]. At the same time, there is clear selflessness towards the relationships others have between them, which is a form of disdain directed towards their peers; He is not interested in how they are or what kind of feelings they express. We could say that there is no real concern for them, but they are only there based on the place occupied by the acting subject (**P-1:***"When my colleagues tell me about their problems, I'm absent, I simply don't care"*; **P-2:** *"I lose interest in what my friends say, I don't care"*).

This phenomenon can also be expressed mathematically: the ordered pairs of Y^2 that do not belong to N, will be part of the complementary of N, which is N′; It is a set of ordered pairs in which "a" does not appear in the first term:

$$N′ = \{(b, a), (b,b), (b,c), (b,d), (c, a), (c,b), (c,c), (c,d),$$
$$(d, a), (d,b), (d,c), (d,d)\} \quad [11]$$
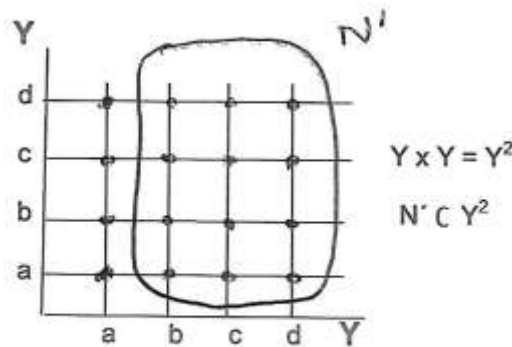
We can also represent it graphically (Figure 4)

FIGURE 4

The set N′represents those relations in which "a" is not interested. Psychologically, it is justified in the fact that the person becomes the centre of his universe, not caring about what others think, feel, or desire and, if he takes with them, it is only concerning his status; Clearly, they are relationships that we can describe as "narcissistic". Cases **P-6** and **P-7** are very demonstrative:

P-6 C*onstantly compares herself with her friends in terms of being successful with the opposite gender, always feeling inferior; When she goes out with them she is unable to listen to them, despite repeating many times that they are her "friends." At the same time, she finds herself caught in her overthinking ("This one receives more attention than me", "this other is nicer than me", etc.). She does not care about how they are or the relationship they establish between them, but only that they are better than her in this or that aspect.*

P-7. *She claims to spend plenty of time out of home and, in the contacts, she feels inferior and is always wondering: How will they see me? Will they like me? Am I nice? Will they judge me? etc. She feels very anxious since she has to constantly modify her pose to be accepted. At the same time, she admits to not listening when they talk to her because she has to pay attention to her behaviour.*

N and N′ do not have any element in common, that is to say: N ∩ N′ = ∅. This indicates that the person does not consider others, which is experienced, from the subjectivity of "a", as something exclusive. But, if "a" compares himself, it means that he does not take them into account, he only considers himself and the position he occupies concerning others.

Additionally, it is also given that: N ∪ N′ = Y^2. It indicates that the union of N and its complementary (N′) form the total space of intersubjective relations, Y x Y. We can take this space, in the development we are

following, as a "universe set" because it contains all possible contacts between individuals, many of which are not important for the patient (those corresponding to N´).

The underlying (formal) structure of the comparative relationship.

When Alfred Adler (23,24) described the feelings of inferiority and their corresponding offsets, he forgot to mention the narcissistic aspect underlying them. Employing the "set theory" has served to prove those components of the clinical reality that easily go unnoticed and we could say, without any doubt, that it reveals the hidden elements of subjectivity.

This is a very important proposal for clinicians because, to perform psychotherapy with these individuals, it is essential to know what the hidden details are. This desire boosted and launched the structuralist movement (26), led by authors of such standing as Lévi-Strauss, Lacan, Althusser, or Barthes, and that, coincidentally, extended to mathematics with the Bourbaki group (7).

In our case, the manifest reality of the feelings of superiority/inferiority, as described in texts, is simple, while the carried-out analysis gives way to the underlying structure evidenced with the help of mathematics. It is revealed that these feelings are comparisons of narcissistic nature, where the subject places himself in a privileged relationship. The clinical observation of the patients continues to provide clues and sustain the formal findings, since they often present an important self-referential component, which means that, in their relationship with others, everything revolves around themselves. This component, even if it does not get to be delusional, can be disruptive because they believe all eyes out there are going to be on him/her. Frequently, a person's inferiority/superiority is combined with the fact that they will become the centre of attention for others, an aspect that the "N graph" captures remarkably.

IV. Discussion and conclusions

The research proposal that was followed here has aimed to work on subjectivity through mathematics. However, not any type of formalisation can be used because subjectivity is not a physical object involved in the space-time coordinates (4). This has been the great mistake of those trends (in psychology and psychiatry) that apply quantification to the capture of the human subject.

We have worked on interpersonal relationships from the subjective world and how they are experienced. These contacts are not usually calm, since the comparison is a handicap to living harmoniously; This is because, by acting this way, there is no longer enjoyment of the union with others and the only thing that is attended is the reason for comparison.

The "set theory", developed by Cantor and the concepts that result from it (ordered pair, Cartesian product, graph, etc.) have been proven relevant for the analysis carried out, especially because it is a qualitative and relational procedure, two characteristics that (isomorphically) match subjectivity. Throughout the research, it can be seen how we have not gone far from what the patients share in the private context of consultation, a place where a special environment is created, that allows them to express their concerns, which are usually silenced outside of this place.

As a result, the comparisons, inevitable and made from the self, with its two forms (inferiority/superiority), are presented as "binary relations" in the set Y. Furthermore, ordered pairs are organised in which the interviewee occupies the first place, taking the form (a,x). This entails, additionally, a generalisation, given that the comparison involves any self, which can be clinically seen in how the acting subject shows, in the presence of any other, emotional reactions (restlessness, uneasiness, lack of naturalness, vegetative manifestations, etc.).

The ordered pairs corresponding to the "binary relationship" make up "graph N", composed of all those pairs where the patient is the first element. This can be read in the following way: the subject is only interested in the relationships in which he is placed in the foreground. On the contrary, those other contacts between those around him and his particular circumstances have no interest for him, since he does not appear in the first term when having to give away the place to another; The complementary of N (noted as N´), has this sense. The incompatibility between N and N´ reflects how the subjectivity of these individuals is limited to the relationships in which they represent a role (inferior/superior) and not where they can be irrelevant. This is experienced in an exclusive way, which leads us to think about the mental inflexibility they show.

The application of mathematics has allowed us to reveal the underlying structure that goes unnoticed by those who only go as far as the observable data. According to structuralist approaches, the researcher must build models that correspond to the foundations of reality, to overcome the sensible appearance (26), something we already did in relation to clinical structures (27,28). In this sense, the simple description of feelings of inferiority (or superiority), as it happens with Adler (23,24), falls very short since he missed the importance that these patients give themselves, so much as to disregard others (graph N´). This happens even in those cases in which they feel "inferior", something that may seem paradoxical but it can be seen clearly that they contemplate

in others only the specific traits in which they differ and to which they compare themselves (beauty, intelligence, attractiveness, etc.). Then, narcissism is the hidden component that lies beneath these presentations.

We are aware that what is shown here goes against contemporary psychiatry (and psychology) in the sense that it is purely based on observational data, discarding the organisation underlying clinical reality, as it appears in international classifications (1,29) and it rates the symptoms, rejecting the subjective material of the person who consults. However, to be able to modify the symptoms (in this case, comparisons, feelings of inferiority, pride, uneasiness, etc.) the underlying elements of the problem must be addressed.

To conclude, we will say that the formulas that we have been presenting throughout the text enclose condensed information so that the translation into a common language has a multivocal character. For example, the formula $\biguplus x(a < x)$ can be translated as: "the person feels inferior to anyone", "they are not calm in front of others because they have to compare themselves with everyone", "they never find themselves on the same level as others", etc. As a result, formulas do not restrict the psychological material, not losing the kaleidoscopic aspect that human behaviour shows. The fact that each expression has many readings has to do, additionally, with the fact that these expressions do not use numbering; Thus, the expression "2+3=5" refers only to "two units plus another three equals five" and nothing else.

Far from Plato's explanations, who considered mathematics as existing entities for themselves ("ideals"), the actual perception is that it is a human product and that, through it, we can understand some parts of the mind. Certainly, it is a journey back to the mental apparatus that created them. This suggests that man uses certain types of mathematics (qualitative, relational, combinatory, etc.), being unaware of it when thinking, feeling, or acting. Placing mental life in formulas does not mean taking away its spontaneity or freshness, it works the same as music, the fact that we provide a formal structure to it does not make it less beautiful.

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