Topologization in Psychological Modeling: From Two-Dimensional Analysis to the Third Dimension in Psychometrics

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Abstract

This article contributes to the ongoing debate on topological explanations by developing the concept of topologization in psychological modeling. Referring to mathematical topology—particularly the notions of dimensionality and projection—it proposes a new interpretation of psychological constructs that goes beyond classical two-dimensional representations. The article addresses the issue of topologization in psychological modeling, indicating that many existing models—traditionally analyzed in two-dimensional spaces—may in fact possess a hidden three-dimensional structure. Based on conceptual, methodological, and psychometric analyses, the author shows that the transition to three-dimensional modeling allows for a more complete representation of the studied psychological constructs. The example of Antonina Gurycka's model of upbringing errors serves as an illustration of a situation in which the emergence of an additional dimension results from interpretative inconsistencies in the center of the circular model. The article discusses the limitations of classical statistical methods, such as factor analysis, and proposes alternative analytical approaches—including support vector machines with RBF kernel (from the field of artificial intelligence) and topological data analysis (TDA). These methods enable the detection of the depth and structural complexity of psychological models, thereby challenging existing assumptions in psychometrics and psychological diagnosis. The conclusion indicates how topologization may influence the future of psychological theory, measurement methods, and therapeutic interpretation.

Keywords: topologization, psychological modeling, three-dimensional structures, psychometrics, artificial intelligence.

Theory constitutes a set of abstract conceptual frameworks within which models are constructed to enable the operationalization of the phenomena under study. These models assume a specific structure, which allows for their empirical verification. A single theory can give rise to multiple models of various forms, including structural ones that present variables and the relationships between them, and circular ones used to represent typologies (Jonkisz, 1998; Szymańska, 2016, 2025).

Each model, regardless of its adopted form, requires an appropriate analytical space in which it can be examined. In this context, topologization plays a key role, enabling a formal description of the model's structure and the relationships between its components (Chazal & Michel, 2021; Wasserman, 2018). This process allows not only for a more accurate representation of the studied phenomena but also for the identification of hidden dimensions that may remain invisible in simpler models.

Topologization is directly related to the determination of the space in which models operate. In psychology, two-dimensional (2D) representations are often used, such as circular models or structural equation models (Szymańska, 2019; Szymańska & Torebko, 2015). However, there are also models with a more complex organization that require representation in three-dimensional (3D) space. These models may take the form of geometric solids, such as a sphere, or other shapes that enable precise mapping of the studied relationships (Geniesse, Sporns, Petri, & Saggar, 2019). The use of three-dimensional models opens new analytical possibilities, allowing for the capture of the dynamics of phenomena in a way that is more adequate to their actual structure (Saggar et al., 2018).

The fundamental question remains whether there are models in psychology that require a description in three-dimensional space, and if so, what analytical tools are necessary for their study (Szymańska, 2025). The use of 3D geometry in psychological modeling brings additional challenges, both conceptually and methodologically, which requires a revision of the approaches used so far and the development of new analysis strategies.

In this article, we will consider the existence of psychological models that can be described in three-dimensional (3D) space. We will focus on determining what characteristics such models would need to possess in order to be represented in this space. We will also consider whether such models already exist in psychology and what analytical tools would be necessary for their verification. In the following sections of the article, we will examine whether contemporary approaches allow for the empirical verification of such models.

Hidden Dimension Discovery in Psychological Models

For years, psychology has relied on two-dimensional models described within 2D space. The most popular among these have been circular and structural models. Circular models, used to represent typologies, illustrated different types in the form of a circle, thus depicting diverse traits (John & Srivastava, 1999). Structural models, on the other hand, presented variables and their mutual relationships, often taking the form of graphs verified through structural equation modeling (Borsboom, 2008a, 2008b).

Undoubtedly, these were strictly two-dimensional models functioning in 2D space, with no third dimension anticipated. In this context, our exploration leads to a fascinating question: is it possible that certain psychological models, previously considered two-dimensional, in fact conceal a third dimension?

If some psychological models, thus far regarded as two-dimensional, actually contain a third dimension, this discovery could significantly impact our diagnostics and analysis of psychological phenomena. The introduction of this new dimension could revolutionize the way we interpret complex relationships between variables and provide new analytical tools that more accurately reflect the complexity of the human psyche. This approach opens entirely new perspectives in the analysis of psychological data.

The dominance of two-dimensional models in psychology resulted from both conceptual assumptions and methodological limitations. It stemmed from an established research tradition in which statistical methods such as exploratory and confirmatory factor analysis operated within 2D space (Górniak, 1998). Data structures were interpreted in a coordinate system limited to two dimensions, which constituted the dominant approach in both psychometric modeling and personality theory.

The fundamental assumption that psychological variables can be analyzed in two-dimensional space is, however, a methodological issue rather than an actual property of the phenomena under study. Psychological reality does not necessarily adhere to the same limitations as its statistical representation. It is possible that some models, which have so far been constructed and interpreted in two dimensions, in fact possess a three-dimensional structure that has gone unnoticed due to adopted data analysis conventions (Olson, 2000; Szymańska, 2025).

In other scientific disciplines, the discovery of hidden dimensions has led to significant changes in the understanding of studied phenomena. In neuroscience, the assumption that brain activity occurs solely within three spatial dimensions and time is increasingly being challenged—recent studies suggest that neural processes may be embedded in spaces with a higher number of dimensions, which better reflect their complex functional and informational organization (Tozzi, 2019). In relativistic physics, the shift from classical mechanics to the concept of spacetime required the recognition of time as a fourth dimension, which enabled more precise modeling of the dynamics of moving objects. In theoretical physics—especially in string theories and modern cosmology—the adoption of additional spatial dimensions has become essential for describing complex phenomena that cannot be represented in classical three-dimensional space (Randall, 2012; Yau & Nadis, 2010). A similar paradigm shift in psychology may occur if it turns out that some models require interpretation in a three-dimensional system.

The fundamental question to be asked in this context is whether there are premises indicating the presence of a third dimension in psychological models. If the structure of relationships between variables suggests that their representation in 2D leads to oversimplifications or inaccuracies, then it is possible that the addition of a third dimension would allow for a more accurate reflection of psychological reality.

Considering this hypothesis requires an analysis of models that could naturally function in three-dimensional space. The key question is whether there are structures in psychology that can be considered 3D objects, and what analytical tools are necessary for their identification. In the following sections of the article, an analysis will be conducted of models that potentially possess a three-dimensional structure but have so far been interpreted in a manner limited to two dimensions.

Psychological Models with Hidden Three-Dimensionality

The prevailing approach to modeling psychological phenomena has been based on the assumption that their structure can be accurately represented within two-dimensional space. These models were constructed and analyzed within a 2D coordinate system, resulting from both accepted methodological conventions and the limitations of analytical tools. However, there are indications that, in certain cases, these models may possess an additional, third dimension that has thus far gone unnoticed.

The possibility of hidden three-dimensionality applies to various classes of psychological models, including circular, structural, interpersonal, and network models. In each of these cases, the adopted form of two-dimensional representation may have led to simplifications or misinterpretations of the relationships between variables. The recognition and analysis of these hidden structures may open new research opportunities and lead to a revision of existing methodological approaches in psychology.

In the classical approach to psychological modeling, analysis was based on an XY coordinate system, which allowed for representing the relationships between two variables in two-dimensional space. This form of visualization was intuitive and consistent with dominant methods of statistical analysis, which led to its adoption as a standard in psychometrics and model theory. However, in certain cases, there are indications that the actual structure of the phenomena under study may not fit within two dimensions, and its accurate representation requires the introduction of a third axis—the Z axis.

Adding a third dimension means that, in addition to the classic XY coordinates, it becomes necessary to include an additional variable that influences the organization and relationships among the data. The Z axis introduces a new plane of analysis, making it possible to capture relationships that remain invisible in 2D models. In this context, if certain psychological models do indeed possess a three-dimensional structure, it would mean that existing methods of interpretation may have omitted essential aspects of the studied phenomena.

Considering this possibility prompts reflection on the methodological consequences for psychology of incorporating a third axis of analysis. If certain models indeed operate in 3D space, their proper representation would require a new approach to defining coordinates and understanding what a given Z-axis value represents in context. Only by determining which variables might occupy this additional dimension will it be possible to identify models that truly extend beyond two-dimensional space and require a new mode of analysis.

In classical psychological models, especially those based on coordinate systems, we often operate in two-dimensional space (XY). In such a system, all variables and their mutual relationships must be presented on a flat surface. For example, when we model a structure in the form of a circle, it seems to describe something completely flat—regardless of how complex the relationships between variables we attempt to include. However, such a representation of reality does not imply that the phenomenon itself is truly two-dimensional—it may simply be projected onto 2D space because the methods of analysis used do not allow for the capture of an additional dimension.

To better understand this, let us consider the analogy of

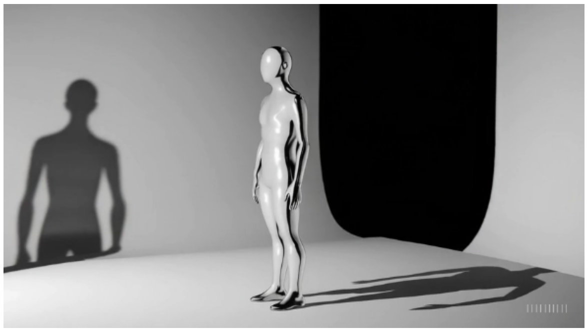

Figure 1: Projecting Reality: A Three-Dimensional Object and Its Two-Dimensional Projection. Author's own work, generated using the Sora Open AI model

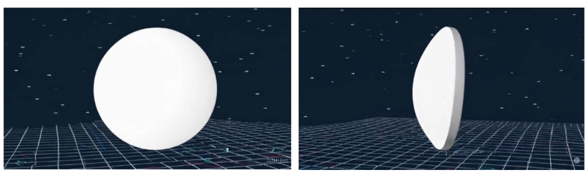

Figure 2: Perceptual Limitations: How Projection Alters Structural Interpretation. Author's own work, generated using the Sora Open AI model

a shadow cast on a wall. If a person stands opposite a light source, their shadow on the wall shows only a two-dimensional shape, which changes depending on position and lighting. But does that mean the person is actually flat? Of course not. The shadow is merely a projection of a three-dimensional object onto a flat surface—it reflects certain features of the person but cannot convey complete information about their volume, structure, and depth. This suggestion is illustrated in Figure 1.

A similar situation may occur in psychology. If a model presented in 2D space appears complete, this does not mean that there are no hidden relationships that could only be detected after taking a third dimension (Z axis) into account. In practice, this may mean that a structure we interpret as a circle in a 2D model is, in fact, concave or convex, which entirely changes the way the data is interpreted. This suggestion is presented in Figure 2. However, within two-dimensional space, we lack the tools to perceive this—we only see a projection, as in the case of a shadow on the wall.

No matter how we rotate the model in two-dimensional (2D) space or from which angle we view it, it remains a flat-

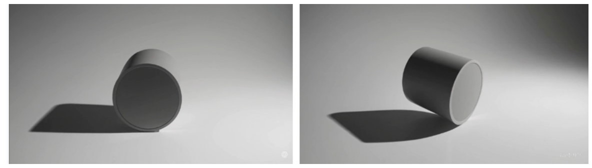

Figure 3: Shape Illusion: How Viewing Angle Alters Object Projection. Author's own work, generated using the Sora Open AI model

tened projection of reality. We can manipulate its position, change the viewing angle, but as long as we do not account for the third dimension (Z), our interpretation will be limited to a plane. This means that although we may observe changing patterns, the actual structure of the model remains beyond our reach. This phenomenon is perfectly illustrated by a cylinder casting a shadow onto a plane, shown in the third figure. Depending on how we position the light source and from which angle we look, the shadow may take different forms—at times it may appear as a circle, at other times as a rectangle. Even though both of these shapes seem valid within the context of two-dimensional analysis, neither accurately reflects the true form of the object. The cylinder, as a three-dimensional (3D) figure, has depth that cannot be captured in a flat representation (Figure 3).

Following this intuition, we can see how incomplete and potentially misleading it can be to limit analysis to two dimensions. What appears to be completely different shapes in 2D—e.g., a circle and a rectangle—may in fact be two projections of the same three-dimensional structure. Therefore, if psychology remains in two-dimensional space in its models, there is a risk that key relationships between variables will go unnoticed, and result interpretations will be burdened with significant simplifications.

The question that arises here is: do we also encounter such projections in psychology? Are the models we have treated as complete in 2D space actually just simplified projections of more complex structures? If so, it would mean that our current approach to modeling requires a fundamental revision, and analyses should include an additional dimension that may change the way we understand psychological mechanisms.

Circular models in psychology have most often been verified using factor analysis, the results of which are presented in coordinate systems (Górniak, 1998). In this system, factors are represented as vectors, and their length reflects the degree of development of a given trait (Bartholomew, Steele, Moustaki, & Galbraith, 2008). Therefore, model interpretation must remain consistent with the logic of coordinate space, in which values close to zero do not indicate the presence of a new trait, but rather its absence or underdevelopment.

In factor analysis, if a subject obtains high values on the X and Y axes, it means that the trait represented by these dimensions is highly developed in that individual. For example, if a person's result is (10, 10 – on a scale from 0 to 11), it means they have a high level of the trait, since their position in the coordinate system is far from zero. On the other hand, if the result is (1, 0.5 on a scale from 0 to 11), the person is very close to the center of the system, which indicates a low level of the trait or its absence.

This is particularly important in the context of psychological models that operate within coordinate space. If the center of the system does not merely represent zero values on the X and Y axes but suggests the existence of a distinct quality, this means that the assumed concept of two-dimensionality may be insufficient. In classical statistical approaches, values close to zero indicate the absence of a trait, not the emergence of a new category. However, if the center of the model is not empty but contains additional substantive content, it may indicate that the structure we regard as circular in 2D space is merely a projection of a more complex three-dimensional system.

Such a problem appears, for example, in Gurycka's model concerning the typology of parenting mistakes, which at first glance appears to be a classic circular model, but its interpretation indicates the need to include an additional dimension (Gurycka, 1990).

This model describes the structure of parenting mistakes identified by Antonina Gurycka, presented in the form of a circle. The model distinguishes eight fundamental parenting mistakes, placed around its circumference. Each of these mistakes refers to specific irregularities in the parent–child relationship, such as excessive strictness, aggression, restricting the child's activity, indifference, exaggeration of one's parental role, permissiveness, or doing things for the child instead of letting them act independently (Gurycka, 2008).

Additionally, Gurycka placed parenting attitudes that are

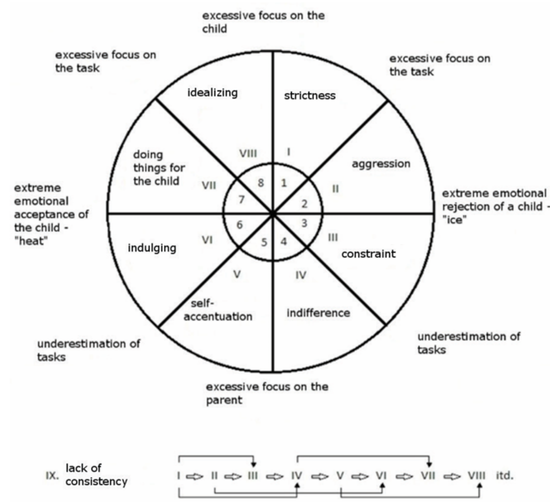

Figure 4: Circular model of parenting mistakes according to Gurycka (1990). Author's own work, after: Szymańska (2019), based on Gurycka (1990).

opposite to the mistakes in the center of the circle, which serve as their alternatives—marked in the Figure with numbers inside the circle. For example, the counterbalance to the mistake of inhibiting a child's activity is guidance, and the opposite of indifference is engagement and openness to the child's needs. In this way, the model is not limited to describing mistakes but also points to correct parenting patterns that can replace them (Gurycka, 1990). The graphic representation of the model is shown in Figure 4.

An essential element in Gurycka's model is that the center of the circle contains indications of attitudes that are opposite to the parenting mistakes, which would suggest that these are distinct traits. However, according to the logic of factor analysis, the center of the coordinate system cannot contain a new value, but only indicate the absence of a given trait (Bartholomew et al., 2008). This means that in the classical statistical approach, the center of the circle can only represent the absence of the mistake of inhibiting a child's activity, but not the presence of a different attitude, such as guiding the child's activity.

However, if we assume that the variables placed at the center of the model truly represent qualitatively distinct parenting attitudes, it would mean that the classical coordinate space is insufficient for their proper representation. It would therefore be necessary to expand this space with a third dimension, in which the center of the coordinate system would not represent merely the absence of a trait, but could represent another category of parenting attitudes, as assumed in Gurycka's model. If the center of Gurycka's circular model does not represent merely the disappearance of a trait but a distinct variability, this means that we are not dealing with a classic two-dimensional (2D) model, but with a projection of a more complex structure onto a plane.

In psychology, there are many models that truly function in two-dimensional space, because no additional trait is found at their central point. Examples of such models include Schaeffer's model or Schwartz's value model, which describe relationships between variables in a circular layout but do not suggest the existence of a new quality in the center (Schaeffer, 1959; Schwartz & Sagie, 2000).

However, in the case of Gurycka's model, the situation is different. The presence of a different trait in the center of the circle suggests that its structure is not flatly embedded in two dimensions, but may be the result of projecting a three-dimensional system onto a 2D plane. This would mean that the current interpretation of this model was limited by the way it was presented, and the actual organization of the variables may be more complex.

Projection of a Three-Dimensional Structure onto Two-Dimensional Space: A New Perspective on Gurycka's Model

If Gurycka's model is not actually a flat two-dimensional structure, but rather a projection of a three-dimensional figure onto a plane, then the question arises: what form could this actual spatial structure take?

To better understand this, let us imagine projecting a three-dimensional object onto a flat surface. When we shine a flashlight on a three-dimensional object, its shadow on the wall is a two-dimensional representation that does not reflect the actual depth of the object. A similar mechanism may occur in Gurycka's model: what we see as a circle may be the shadow of a more complex geometric figure.

If we consider the organization of variables in this model, it is crucial that the extreme traits (parenting mistakes) are located on the circumference of the circle, while the positive traits are closer to its center. This suggests that these variables may be arranged along a third dimension that has not been included in the classical interpretation of the model.

If we attempted to reconstruct the spatial structure of this system, the most intuitive solution would be a cylinder or a truncated cone, in which the top base—representing attitudes opposite to the mistakes—would be smaller than the bottom base. We can imagine that:

• The outer edge of the circle, that is, the circumference, corresponds to one base of the cylinder—it is the place where parenting mistakes are strongest, and their distance from the center is greatest.

• The center of the circle, which in the classical approach would only indicate the absence of a trait, may in reality correspond to the second base of the cylinder, located further in space—this is where the positive attitudes, i.e., the opposites of the parenting mistakes, would be situated.

• The transition between these points, that is, the intermediate values, would not merely mean a gradual disappearance of the mistake but a transformation of the parenting attitude into its opposite along the third dimension.

Consequently, instead of perceiving this model as a circle where the center is a neutral point, we should begin to think of it as a spatial structure in which extreme and central values do not lie on the same plane but on two different levels of this figure.

If we were to actually shine light on such a system, what is closer to the light source would be projected as larger and more distinct on the circumference of the circle, while what is farther away—i.e., the positive attitudes—would take on a smaller shape, located in the center of the circle. This suggestion is presented in Figure 5.

In this way, Gurycka's model, which until now has been interpreted as a two-dimensional system, could in fact be a projection of a three-dimensional space onto a plane, and its true structure might require a new approach to analysis and visualization.

Figure 5 illustrates the mechanism of projecting a three-dimensional structure onto a flat surface, showing how different elements can be represented on a two-dimensional plane in a way that does not reflect their actual spatial organization.

The cylinder shown in the figure hovers above the surface, and its shadow is projected onto the ground. A key element of this visualization is the difference in the intensity of the shadow:

• The lighter shadow, with a larger surface area, represents

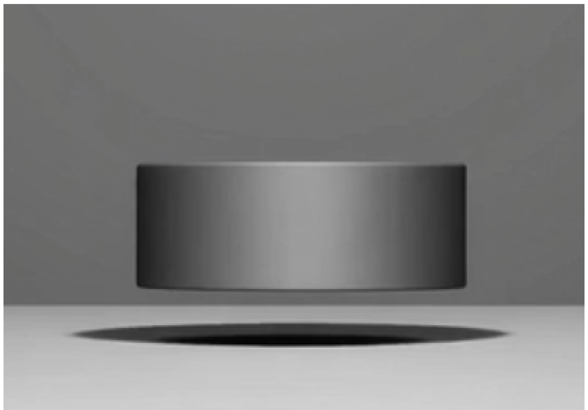

Figure 5: Projecting a Value System onto a Plane: A Spatial Interpretation of Gurycka's Model. Own elaboration, generated using the Sara Open AI model

the closer base of the cylinder, which is nearer to the light and casts a more distinct outline.

• The darker shadow, located closer to the center, comes from the second, more distant base of the cylinder.

This effect reveals a key intuition: what we see on the projected plane does not necessarily correspond to the real organization of the object in three-dimensional space. Analogously, if a psychological model is projected from three dimensions onto a 2D coordinate system, its elements may be represented in a way that falsely suggests their flat organization.

A similar mechanism may apply to Gurycka's model, where the outer values of the parenting mistake model correspond to one base of the cylinder (the lighter, closer one), while the values located in the center of the circle may represent the second base of the cylinder (the darker, more distant one). This suggests that the model may be a spatial structure whose actual shape has been simplified by a two-dimensional representation.

In conclusion, all previous considerations lead to one conclusion—the Gurycka model cannot be two-dimensional. If we look more closely at the principles of factor analysis, which—in both exploratory and confirmatory forms—describes variables in a coordinate system space, it becomes evident that within its framework, it is impossible to place a different trait in the center of the circle, only a zero point indicating the absence of the variable. As Górniak explains, each factor should have "some loadings close to 0 and some high ones, close to 1 or -1" (1998, p. 94), which clearly indicates that a zero value in factor analysis means a lack of intensity of the trait, not the presence of an opposite trait. This interpretation is also confirmed by classic visualizations of factor space by Bartholomew and co-authors (2008), where the center of the coordinate system represents variables not associated with any factor—that is, lacking distinct intensity within the given structure.

This means that for years we have looked at this model in a limited, flattened form, not realizing that it is actually a projection of a three-dimensional structure onto a 2D space. The fact that we are only now beginning to see this relationship shows how strongly the methodological framework of analysis could have influenced the way psychological models are interpreted. Gurycka's model is not an exception but an example of a broader problem—psychology has for years relied on two-dimensional interpretations that may have, in fact, distorted the reality of the studied phenomena.

Limits of the Classical Statistical Approach: Implications for Model Verification

For years, the discovery and verification of psychological models based on factor analysis have taken place within a two-dimensional statistical space, where the assumption was that values located at the center of the coordinate system indicate the absence of a given trait, not its different form (Schaeffer, 1959; Szymańska & Torebko, 2015; Tracey, 2000). In the context of Gurycka's model of parenting mistakes, which was presented in the form of a circle, this meant that researchers analyzed only values related to the mistakes, treating their opposites as the absence of occurrence rather than as a separate psychological category.

From this perspective, factor analysis did not commit a fundamental methodological error, because it always operated on a single plane—projecting a specific dimension. Studies on parenting mistakes focused solely on analyzing the relationships between different forms of mistakes, and central values—close to zero—were interpreted as the fading of a trait, not as the existence of another psychological dimension (Szymańska & Torebko, 2015). As a result, even if Gurycka's model indeed represents a three-dimensional structure, previous analyses were correct within the context of classical model verification methods.

Factor analysis, as a statistical method, is based on a two-dimensional space in which traits are represented as vectors in a coordinate system. The length of the vector indicates the strength of a given trait, and values close to zero are interpreted as its absence (Bartholomew et al., 2008). In the case of Gurycka's model, this meant that the vectors describing parenting mistakes were arranged around a circle, while the center of the system—according to the accepted logic—should correspond to the absence of a given trait, not the existence of a new variable.

For this reason, factor analysis correctly verified the covariance structure between parenting mistakes, because the extracted factors were interpreted in line with the assumptions of this method. The problem only arises when we assume that the center of the circle represents a separate trait, rather than simply the absence of an extreme trait. Factor analysis could not capture this, because it operates by identifying the greatest differences between variables and does not account for spatial relations beyond the XY plane (Bartholomew et al., 2008).

In practice, this means that if the actual structure of parenting mistakes was three-dimensional, factor analysis always provided us with a correct solution within a single plane—that part of the model which could be operationalized along the coordinate axis. Even if the model in fact contained an additional dimension, classical factor analysis did not distort it but merely omitted it.

This means that all previous analyses of Gurycka's model, conducted in 2D space, appear to remain valid within the adopted methodology. However, they are not sufficient to fully capture its structure if the model truly functions in a three-dimensional space.

Given the above issues related to factor analysis and the method of data representation in coordinate space, it is worth examining Gurycka's scale as a specific case of a model that likely included three-dimensionality from the very beginning. What is key in this context is that this scale not only described parenting mistakes within the classical 2D space but also its response format may have suggested the existence of an additional dimension.

In classical factor analyses, we operate on numerical values assigned to individual responses in a scale, assuming that higher values indicate a stronger presence of a trait, and lower values – its absence (Anastasi & Urbina, 1999). In the case of most psychometric scales, such as Likert scales, we respond to questions in a linear way – from complete agreement to complete disagreement (Anastasi & Urbina, 1999). Meanwhile, in Gurycka's scale, we are dealing with a different response format, in which the values at the ends of the scale are not simply gradations of the same trait, but refer to qualitatively different categories of parental behaviors (Gurycka, 1990; Szymańska, 2019).

For example, while in a typical Likert scale, responses form a continuum from "strongly agree" to "strongly disagree," in Gurycka's scale, values 1 and 7 may refer to entirely different behavioral dimensions. Value 1 may signify, for example, "praise" of the child, while value 7 – "criticism." This means that movement along the scale axis does not represent a simple intensification of the same trait (as in a typical psychometric scale) but a transition between different behavioral dimensions.

From the perspective of factor analysis, however, regardless of the content of the questions, the scale values are treated as one numerical dimension – and this is key to the interpretation. Factor analysis does not "see" that extreme values may represent qualitatively different behaviors. It sees that high and low values are correlated with a certain response pattern, which leads to statistically correct but conceptually simplified conclusions. Therefore, even though factor analysis correctly identified factors related to parenting mistakes, the way the responses were coded in the scale may have concealed an additional dimension that was beyond the reach of classical methods of analysis.

To sum up, Gurycka's scale already at the level of question construction contained elements pointing to its three-dimensional character. This means that even if classical factor analyses did not commit a methodological error, psychologically, this model may have been interpreted in an overly simplified manner.

Could factor analysis have accurately captured the structure of the model despite the hidden three-dimensionality? Looking at the way responses were coded in Gurycka's scale, we are dealing with a middle value (4), which serves as a neutral point. This means that values 1, 2, 3 shifted in one direction, and 5, 6, 7 in the opposite, representing two qualitatively different poles. In the classical model of factor analysis, where we treated this layout as two-dimensional, values 1–7 were interpreted as a continuum of one trait, even though they actually describe two different processes – guiding the child's activity and inhibiting it.

If, however, we look at this structure in three-dimensional space, we may notice that values 1, 2, and 3 should shift toward the Z axis (the third dimension), instead of merely being extreme values along the X axis. The X axis, meanwhile, would still correspond to the intensity of the parenting error within the framework of inhibiting the child's activity, whereas the two-dimensional space could not capture the actual curvature of this dimension.

Did the classical statistical approach introduce a significant error? At first glance, it may seem that if the scale has a hidden three-dimensionality, then factor analysis should have rejected or misinterpreted it. However, the key question is whether the results of this analysis were nonetheless correct and still useful.

Factor analysis operates on correlations between variables, and the mere fact that the model was projected onto two-dimensional space does not automatically mean that the conclusions drawn were incorrect. Even if the actual model was three-dimensional, the fact that values 1–3 and 5–7 were strongly correlated allowed factor analysis to correctly extract the main dimension. This means that, in the context of studying parenting errors and their mutual relations, factor analysis could effectively differentiate the intensity of errors, even if it did not account for the full topology of the model.

Moreover, because the scale was dichotomous, factor analysis was still able to correctly determine that values 1–3 represented a low level of error and 5–7 a high level, allowing for accurate classification of respondents with respect to the main dimension.

The results obtained by the classical factor analysis method do not require correction, because projecting the model onto two-dimensional space still reflected the relationships between variables. Even though the actual model may have been three-dimensional, the interpretation of correlations between errors was still correct, as the proportions of trait intensities in the statistical analysis were preserved.

However, what we do need to change is the way we interpret the middle values in the scale. If the neutral point (4) was in fact the intersection point of two dimensions, this means that previous interpretations may have overlooked subtle differences between the absence of an error and another type of behavior (e.g., actual guidance of activity instead of inhibition).

To sum up, although factor analysis projected the model onto two-dimensional space, this did not result in a statistical error, only a possible interpretive simplification. There is therefore no need to correct previous studies, because factor analysis still correctly differentiated the intensity of parenting errors. However, the new perspective allows for a better understanding of the full structure of the model and highlights that middle values in the scale may represent not only the absence of an error but also a transition to a qualitatively different category of parental attitudes.

Continuing this reflection, the question arises whether the process of topologization—that is, incorporating additional dimensions into psychological modeling—should become a standard procedure in the analysis of psychometric structures. The existing statistical approach, operating mainly in two-dimensional space, has proven effective in capturing relationships between variables, but has also led to simplifications in the interpretation of certain traits, especially in the case of models containing potentially three-dimensional organizational structures.

The example of factor analysis shows that despite the use of a two-dimensional coordinate system, reasoning about trait intensity was correct, because statistical analysis effectively differentiated the intensity of the studied dimensions. However, the problem arises at the level of interpretation, where the omission of the third dimension may have led to incorrect assumptions about the nature of the analyzed constructs. In the context of Gurycka's scale, this did not affect the statistical validity of the model, but revealed an additional structure that had previously gone unnoticed.

Introducing topologization could prevent such simplifications and allow for a better understanding of the hierarchy and organization of variables in the research space. In particular, it could apply to all models that contain elements of hidden hierarchical structure, such as interpersonal models or circular models. Analysis in three dimensions could provide more precise tools for assessing relationships between variables, enabling, among other things, better separation of correlated traits and the inclusion of dynamic processes in the structure of the analyzed model.

From the perspective of psychometrics and the methodology of psychological research, topologization does not need to replace classical methods of analysis but may serve as a complement in cases where there is reason to suspect that a model has more than two interpretive dimensions. This would enable more precise diagnosis of relationships between variables and prevent errors resulting from limiting the analytical space.

Ultimately, incorporating topologization into standard procedures for analyzing psychological models could increase their validity and interpretability, especially in studies of complex constructs that have thus far been approached in a simplified way. It therefore seems that future approaches to modeling should take into account not only classical statistical analysis methods but also an assessment of the structural organization of models in multidimensional space.

New Methods for Verifying Three-Dimensional Models

Previous approaches to analyzing psychological models were based on methods operating in two-dimensional space, which stemmed from the limitations of statistical tools used in psychometrics. Factor analysis, classical regression models, or network analyses were constructed within the framework of two-dimensional representation, which meant that variables and their relationships were modeled on the plane of the X and Y coordinate system (Bartholomew et al., 2008). However, as demonstrated in previous considerations, there are psychological models in which an interpretation limited to two dimensions leads to simplifications and may distort the actual structure of the studied constructs.

In this context, it becomes necessary to consider new methods of data analysis that would be capable of capturing a three-dimensional structure. The introduction of a third dimension would require a redefinition of statistical approaches and the adaptation of analysis tools to operate in XYZ space, instead of only XY. This means that methods previously used in psychometrics, such as classical factor analysis, should be extended with spatial components, which would allow for more precise mapping of model structures that—as the example of Gurycka's model shows—may in fact be three-dimensional.

The main weakness of traditional methods is their inability to detect additional dimensions if they are hidden in the data structure. Exploratory methods operating in a two-dimensional system may suggest that variables are correlated in 2D space, whereas in reality their mutual relationships may be better described in 3D space. An example could be factor analysis, where factors are presented as vectors in the XY system, but if the Z dimension were introduced, it might turn out that variables that are close to each other in 2D space are actually separated in the third dimension.

Therefore, verifying three-dimensional models requires the application of new analytical tools that allow the assessment and visualization of relationships in 3D space. Particularly promising are modern machine learning techniques that allow for the identification of hidden dimensions through clustering and nonlinear dimensionality reduction in multidimensional spaces. In this context, Szymańska proposed the use of Support Vector Machines (SVM) with a Radial Basis Function (RBF) kernel as a tool enabling the projection of data into higher-dimensional space (Szymańska, 2025). This method differs from classical statistical approaches because it uses artificial intelligence algorithms capable of detecting nonlinear relationships and structures even when traditional techniques prove insufficient. The RBF kernel plays a key role here, allowing data to be projected into a multidimensional space in which class separation or analysis of relationships between variables becomes more effective (Hearst, Dumais, Osuna, Platt, & Scholkopf, 1998).

The advantage of this approach is the lack of necessity to assume prior hypotheses about the data structure, which makes it a useful tool in analyzing psychological models previously treated as two-dimensional but potentially three-dimensional in reality. A Support Vector Machine with an RBF kernel can thus serve as a tool for testing the hypothesis of model multidimensionality by analyzing their separability in spaces with more dimensions (Szymańska, 2025). This represents a significant complement to classical methods such as factor analysis or Multidimensional Scaling (MDS), as well as more modern, geometrically oriented approaches.

TDA allows for the identification of global properties of the data space, such as loops, holes, or branches, which may be particularly useful in analyzing psychological models with hidden, irregular structures (bibliography). In contrast to methods based on classical statistical assumptions, topological analysis makes it possible to capture the shape of data in a way that is independent of metrics or distribution, offering new perspectives for research on the complexity of psychological constructs (bibliography).

The second approach worth noting is Topological Data Analysis (TDA), which enables the detection of complex geometric structures in datasets (Chazal & Michel, 2021; Wasserman, 2018; Zieliński, Lipiński, Juda, Zeppelzauer, & Dłotko, 2021). TDA allows for the identification of global properties of the data space, such as loops, holes, or branches, which may be particularly useful in analyzing psychological models with hidden, irregular structures (Geniesse et al., 2019; Lum et al., 2013; Sizemore, 2016). In contrast to methods based on classical statistical assumptions, topological analysis makes it possible to capture the shape of data in a way that is independent of metrics or distribution, offering new perspectives for research on the complexity of psychological constructs (Dryden, Koloydenko, & Zhou, 2009; Saggar et al., 2018; Stolz, Emerson, Nahkuri, Porter, & Harrington, 2021).

Summary and Discussion

The discovery of three-dimensional structures in psychological models may lead to a completely new way of interpreting the results of psychometric research. The previous practice of analyzing models in two-dimensional space was based on statistical methods such as factor analysis, both exploratory and confirmatory, which assumed that the X and Y coordinate system fully described the variables and their mutual relationships (Bartholomew et al., 2008). However, our considerations show that some models, including Gurycka's model, may in fact have a three-dimensional structure, which has gone unnoticed due to methodological and conceptual limitations.

The consequences of this shift are twofold. First, it opens new perspectives for psychological theories that have so far been interpreted in a manner limited by classical statistical models (it is possible that many circular models should be reanalyzed with the hidden third axis in mind, which would allow for a more adequate mapping of relationships between variables). Second, it challenges the existing statistical methods used in psychometrics, which may be insufficient for more complex structures of psychological models.

The key conclusions from this analysis indicate the need to verify psychological models for potential three-dimensionality. Topologizing models may become a standard element of psychometric analysis, as it allows for a better capture of the data structure and avoids simplifications resulting from projecting models onto two-dimensional space. In particular, the introduction of new analysis methods—both within statistics and artificial intelligence—may help more precisely determine which models indeed require three-dimensional interpretation and which can continue to be analyzed using classical two-dimensional approaches.

The emerging new analytical possibilities also come with significant theoretical and methodological challenges. In this part of the article, we will look at several key issues that arise from our considerations and at the same time remain open and require further research.

One of the most important questions to ask is in which cases psychological models should be treated as three-dimensional, and when two-dimensional representation remains sufficient. Not every circular model must possess a hidden three-dimensional structure—it may concern only specific cases, such as Gurycka's model, in which an additional feature is located in the center of the circle. Models such as Gurycka's and probably also Olson's show a three-dimensional structure due to the presence of an additional dimension in their internal organization (Gurycka, 1990; Olson, 2000). It remains an open question which other models may have similar properties, which requires further research and analysis. Accordingly, the issue of identifying those models that require verification in three-dimensional space remains an open question.

Another important problem concerns methodological implications for psychometrics. If we assume that some psychological models indeed function in three-dimensional space, we need to consider to what extent traditional psychometric tests based on factor analysis and other exploratory techniques remain adequate. The key question is: should current methods of factor extraction be supplemented with approaches that take the third dimension into account? Possible alternatives may include machine learning techniques and topological data analysis, which may better reflect the true structure of psychological data.

In addition to methodological issues, there are also interpretative challenges. Even if we assume that a given model has a third dimension, it is necessary to determine how it should be interpreted (Szymańska, 2025). Does it constitute an actual psychological trait, or merely a mathematical artifact resulting from the limitations of existing analytical methods? Without clearly defined criteria, there is a risk of overinterpreting results and inappropriately attributing meaning to new dimensions. Therefore, future research should develop principles that allow us to distinguish between real psychological structures and artifacts arising from the applied statistical methods.

Another area where the implications of discovering a three-dimensional structure may be important is psychological diagnosis and therapy. If we assume that psychological models have a real three-dimensional structure, it may imply the need to adapt existing diagnostic tools. If previous models were based on simplified two-dimensional representations, there is a likelihood that they did not account for certain significant aspects of psychological functioning. Including the third dimension in analysis could improve both diagnostic accuracy and the effectiveness of therapeutic interventions by more accurately reflecting the phenomena under study. In this context, for example, in interpreting the results obtained using Gurycka's parenting error scale, taking the third dimension into account could mean extending the interpretation not only to parenting errors but also to the presence of positive parenting patterns, which may have gone unnoticed in the previous two-dimensional perspective.

One of the key challenges also remains the issue of further falsification and testing of the hypothesis of three-dimensional structures in psychological models. There is a need to develop new empirical methods that will allow us to determine unambiguously whether a given model should be interpreted in three dimensions. Classical statistical techniques such as factor analysis and multivariate analysis may be insufficient for this purpose. It may be necessary to develop new conceptual approaches and analytical tools that allow for more precise modeling of psychological phenomena.

The discussion presented in this article shows that the discovery of three-dimensional structure in psychological models opens new perspectives, but at the same time is associated with a number of challenges that require further research and reflection. This does not mean an immediate need to revise all of psychology but suggests the need for a gradual evolution of analysis methods and a rethinking of some theoretical assumptions.

The development of new statistical methods and the use of artificial intelligence tools may contribute to a better understanding of the structure of psychological variables and improved diagnostic accuracy. Future research should focus on further testing the hypothesis of three-dimensionality in psychological models and developing new standards for psychometric data analysis that take into account the possibility of hidden dimensions in the studied phenomena.

Ultimately, the main goal of this article was to emphasize that psychological models should not always be treated as two-dimensional and that classical data analysis methods may not be sufficient for their full understanding. Introducing a third dimension into analysis may be a significant step toward more precise modeling of mental processes and may allow for a better reflection of the complexity of the phenomena under investigation.

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