term “levels of analysis” refers to identifiable entities (such as teams, software modules, computer networks, factory machining centers, or even individual managers) that (1) can be objectively identified and enumerated as entities, (2) have the potential to be hierarchically nested within larger entities that meet the conditions in item 1, and (3) have the potential to be decomposed (i.e., analyzed) into smaller piece parts, components, or separate entities in and of themselves. In contrast, the use of the term "hierarchical levels", as in organizational charts, while a valuable construct in its own right, would not lend itself to the specific use referred to here. A hierarchical organizational level may contain some or many entities of research interest, but it is not, in and of itself, what is meant by the term “level” in this context. By using a more technically based definition of level, we retain the ability to equally test the relationship of variables and entities, which is the central insight that is explicated in the classic 1984 text, *Theory Testing in Organizations: The Varient Approach* (Dansereau et al., 1984). (This is also the source of the term “varient”, i.e. variables + entities.) The fusion of these two concepts is not without precedent in other fields, and has been carried forward by the later work of Edward Tufte (Tufte, 1997). In summary, the juxtaposition of the concern with variables and entities allows for testing advanced research questions as explained below.

The First Inferential Component: SLA – Single Level Analysis

Let us now turn our attention to the issue of how to visualize the results of a WABA analysis. Traditionally, the DETECT program starts with what is termed Single Level Analysis, or SLA, before moving to MLA (Multiple Level Analysis), MVA (Multiple Variable Analysis), and MRA (Multiple Relationship Analysis).

In explaining the visuals for the SLA inference, the general scientific issue can be viewed as that of texture identification. In much the same way that deep space astronomers are concerned with detecting the inherent structure and texture of matter, be it visible or invisible and large (such as supernova) or small (such as specific molecular components), so also is the organizational scientist, using the rubric of groups and multilevel studies, concerned with similar issues of texture and structure.

The essence of SLA is the empirical identification of appropriate entities and variables. This analysis assumes that: (1) there is an explicit grouping entity, (2) there are at least two continuous variables that are attributes of the component entities, (3) that these component entities are embedded or nested within the original grouping entity. For example, in a study of merit raises and performance appraisal scores (Markham, 1988), the following research question was posed, "Is there a supervisory group effect such that whole groups can be characterized by their average scores on each variable, and the groups high on one are also high on the other?" To the novice in this area, the above research question carries a large learning curve with much complexity. Let us decompose and analyze its parts.

(1) A grouping variable has been explicitly identified*:* *supervisory workgroups*.

(2) Lower level entities (i.e., components) are also evident: the *individual managers* for whom the two continuous variables are attributes. In other words, each manager has a continuous score for merit raise and performance appraisal, along with an indicator variable showing membership in a larger workgroup. Thus, the use of an ANOVA design makes intuitive sense because it asks if there are significant differences between these supervisory groups based on the individual members who are embedded within them.

(3) These two continuous variables can be thought of as either independent or dependent variables: *merit raise percentage* and *performance appraisal scores.* The use of OLS (Ordinary Least Squares, either in the form of correlations or regression analysis) makes intuitive sense in asking the extent to which are the two variables associated.

But this is where the need for the inferential procedures in WABA comes in; for it is not clear *a priori* if the correlation is best calculated based on (1) all individual managers, or (2) all supervisory groups, or (3) managers after adjusting their individual scores for membership in their workgroups. More importantly, each mutually exclusive option above is associated with a very different visual image as will be shown later.

The overall point of the SLA research question is to discover if the application of the various statistical tests that are used for WABA I and WABA II tests will jointly point towards an inference that the grouping entity is important for modeling the data. Thus, at the highest inference level, SLA determines which of the four mutually exclusive conditions shown in Figure 1 is more plausible.

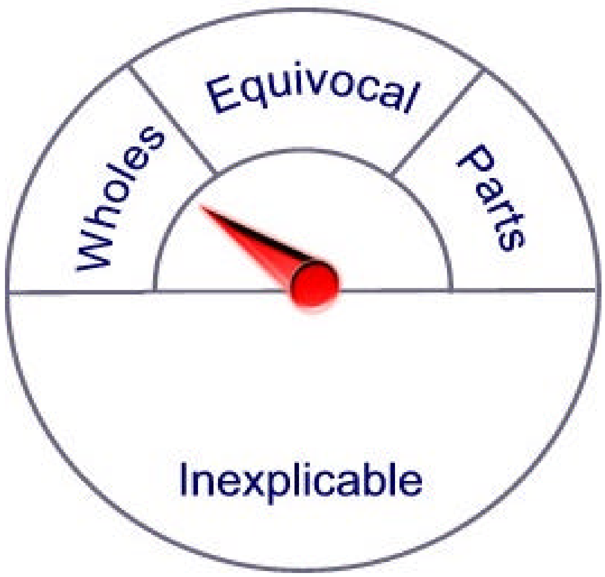

Figure 1: The Basic SLA Inferential Indicator

In the merit raise study referred to earlier (Markham, 1988), it happened that a whole group effect, based on sub-inferences about entities and variables, was hypothesized in line with the research question noted above. From a practitioner perspective, the critical question can be rephrased as, "Should I care about the impact of groups on my organizational systems?" This question can be applied to many types of settings.

Whether the research issue applies to merit raises (a variable) and workgroups (an entity), quality DPM (defects per million) criterion and factory machining centers, or call volumes for help desks, there is an additional burden placed on any information system if it is required to track in its databases the lower levels of detail along with all of the various entity membership identifiers. Similarly, there is an additional analytical burden placed on managers who must track multiple levels of detailed data. Thus, it can be highly advantageous to focus precious organizational resources (hardware, software, and analysts) on fewer, but more potent views of the same data. The following images help convey the differences between the inferential options previously shown in Figure 1.

Let us start the process of explaining SLA by examining Figure 2, which shows a whole group effect much like that postulated by the merit raise study noted above.

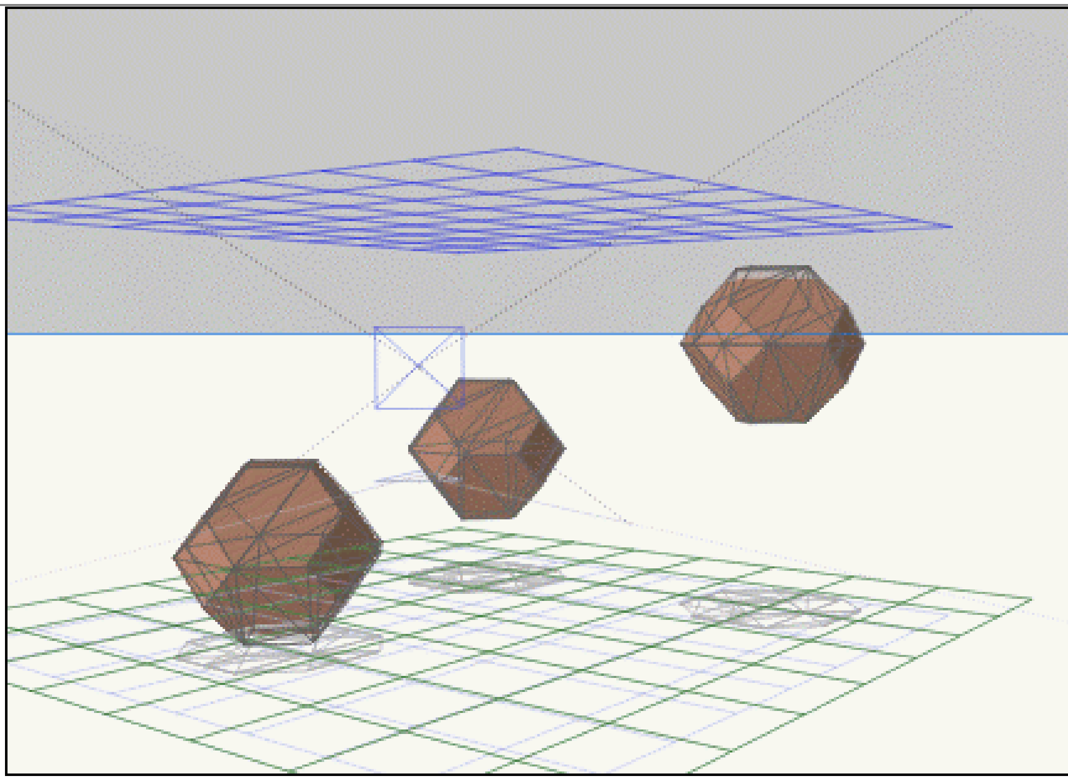

Figure 2: The Wholes Inference from a Texturing Perspective

By way of explanation of the visual cues, the organizational research space that is displayed is bounded by the upper and lower grids on the floor and ceiling planes. This denotes that there are finite dimensions for what is under consideration. In other words, limited x-, y-, and z-axes denote a similarly constrained organizational setting. The wire frame icosahedrons indicate that there is a something visible and real about each group, and that each group has, in fact, a virtual membrane (a surface) that can be detected. The solid rendering indicates that the entities inside of each icosahedron are not visible; that is, in this case, individual spheres representing individual managers are not visible at the core of the icosahedron[2]. (In later figures, the use of the transparent, plain wire frame will be important later for display a group-parts inference.) The y-axis in this same figure represents a measurement tool to indicate real differences in magnitude, as one would expect in a wholes condition, and that is visually confirmed by the shadows cast on the floor plane. Similarly, there are open spaces, representing wide differences, between the groups, and, if the icosahedrons' walls were totally transparent, you could also see (1) how closely individual entities were clustered, and (2) how little additional space existed between that cluster and the inner surfaces of the icosahedron's walls. By way of contrast with Figure 2, note that Figure 3 shows an alternative way in which group membership can be detected.

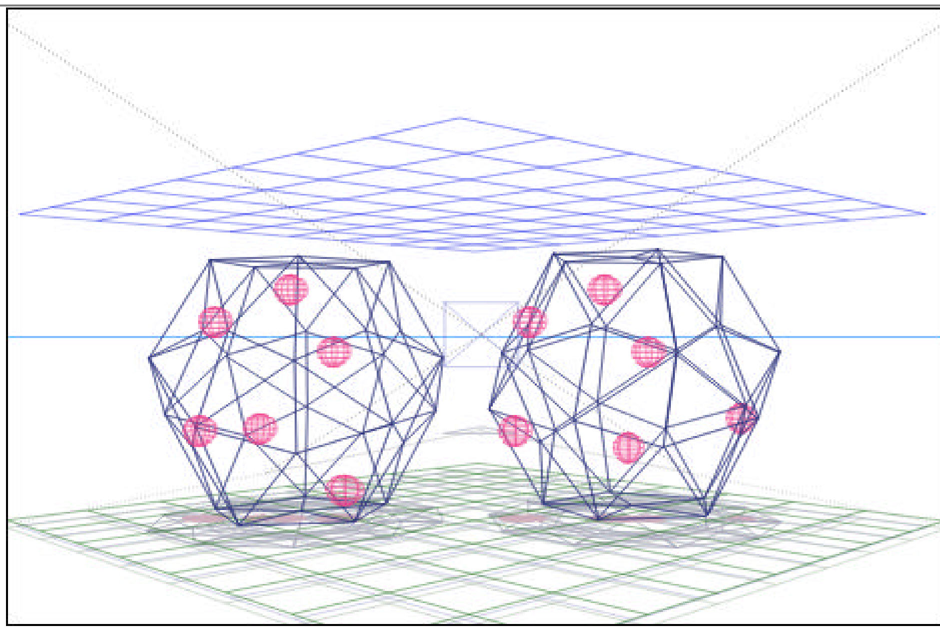

Figure 3: The Parts Inference from a Texturing Perspective

---

[2] For display purposes, the icosahedron is used generically to denote any grouping entity. It is possible, within a specific organizational context, to create a vocabulary of geometric primitives that can be individually assigned to show teams, departments, larger or smaller collectivities.

In Figure 3, which represents a group parts inference, there is essentially very little difference between the height and size of the groups represented by the wire frame icosahedrons. This also can be symbolized by the similarity of the center points of both figures with respect to the y-axis. Thus, any comparison of differences in performance as measured by the y-axis would be both fruitless and misleading. This is why each icosahedron stretches almost from the floor to the ceiling plane. As a corollary, the most interesting and meaningful space in this diagram is not what is visible outside of the icosahedron, but that space which is located within each one. Within each icosahedron there are spheres representing individuals (in this case, these are the lower level, component entities). These spheres, in comparison to the previous figure, are both (1) visible and (2) attached to either a wall or to one of the vertices of the icosahedron. This is symbolic of the fact that it is the relative position within the group that is of importance in understanding the relationship of the component entity to the grouping entity. In fact, any attribute of the sphere can only be interpreted by knowing its location on the icosahedron. This is the visual image for a within-unit score in WABA terminology, and it requires that both the raw score and the unit score be known so as to calculate a signed deviation score. In review, there are two distinct visual images for what the group effect can look like: a whole group effect illustrated in Figure 2 or group parts effect shown in Figure 3.

Recall that the inferential dial in Figure 1 also showed two other possible inferences for the SLA step. The third of the four inferential conditions, the equivocal condition, is depicted in Figure 4, and it uses the same visual syntax as the previous figures. In other words, the same x-, y-, and z- axes form the same research space for the organization that is being scrutinized, and the individual spheres represent the smallest, non-decomposable entity under consideration: individual managers. There are a number of ways in which an equivocal condition can be inferred, and the reader is referred to the *Theory Testing* text for a full explanation.

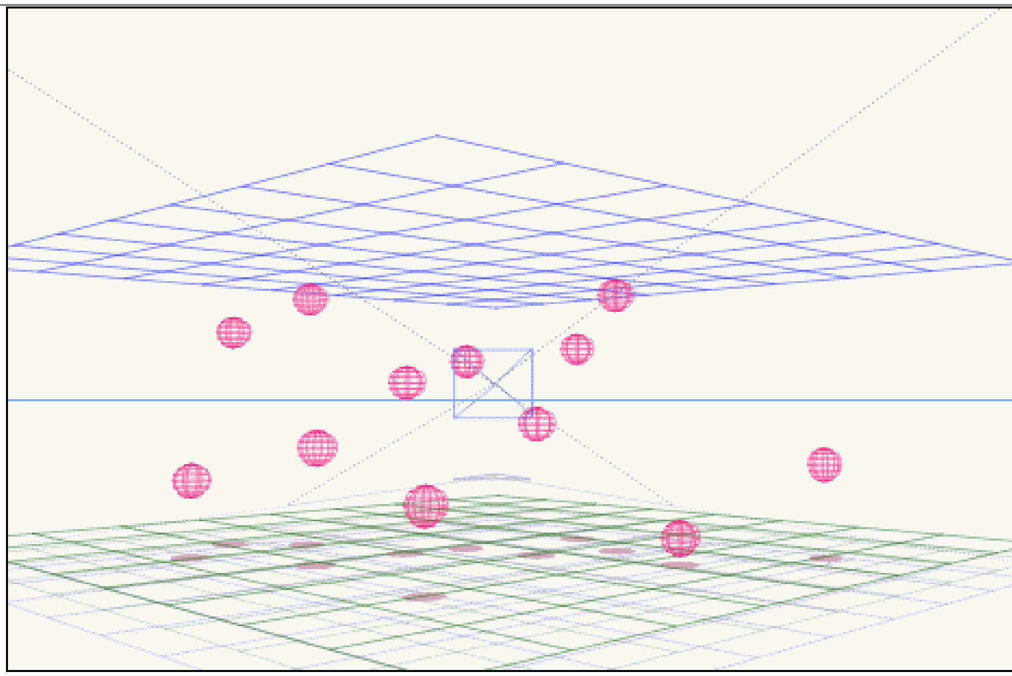

Figure 4: An Equivocal Inference from a Texturing Perspective

In the above situation, group membership is not relevant. How is this shown? -- by the absence of icosahedrons. Thus, neither a whole group effect, using a solid icosahedron, nor a groups part effect, using a transparent icosahedron with embedded spheres, are visible. However, there are still interpretable relations amongst the variables; and the relationship still exists, but only for the lower-level entities, which is why only spheres are shown. Note also that there are substantial differences between these individual entities as shown by the wide dispersion across the x-, y-, and z-axes.

The final possible inference within the SLA procedure is termed inexplicable, and it is equivalent to the traditional null condition. This means that no group effects have been detected for entities, and no variables are significantly related. To visualize this condition, imagine Figure 4 without spheres and or icosahedrons, just a blank, gray zone with grids for the floor and ceiling planes.

In summary, the indicator in Figure 1 can be enhanced by utilizing the above discussion as shown in Figure 5. A glyph that symbolizes these different inferences has been entered into each of the four description zones above the dial.

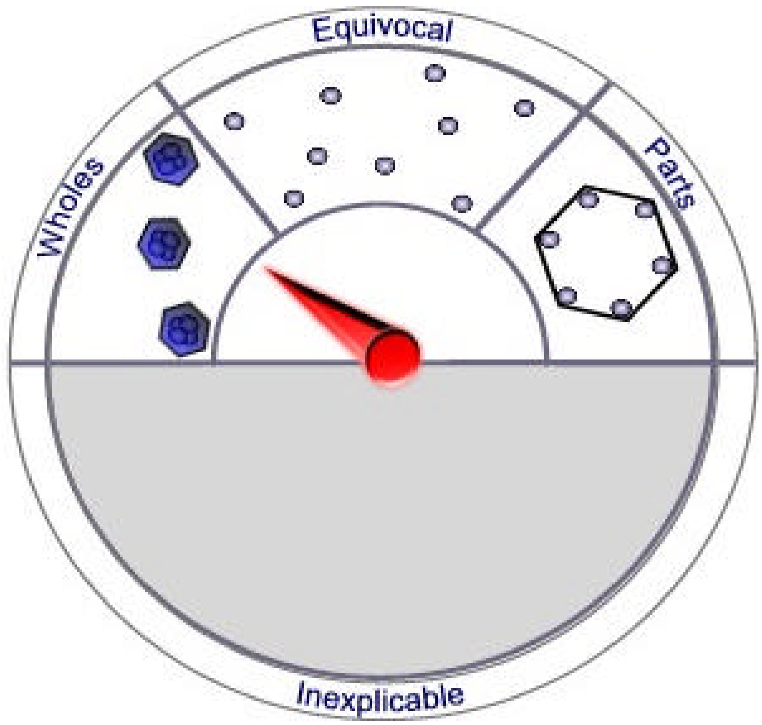

Figure 5: Visual Glyphs for each SLA Inference

In the above "wholes" condition, the image shows a 2-D view of the icosahedron that has just enough transparency to show that tightly clustered spheres at its core. The glyph for the equivalent condition shows individual spheres relatively evenly scattered. The parts condition shows a 2-D view of the wire frame icosahedron with the spheres clearly attached to the vertices. Finally, the inexplicable condition is shown simply as a non-textured gray zone.

The Second Inferential Component: MLA - Multiple Level Analysis

The SLA inference is without a doubt the best starting point for understanding the overall logic of WABA, but it is by no means the ending point. While a fair amount of space has been devoted to visualizing the SLA inference, it is indeed a necessary foundation for the remaining inferential components.