# #35
# SPATIAL SCHEMATA IN MUSEUM FLOORPLANS

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## ABSTRACT

The study introduces a method for a novel representational technique for spatial and visibility conditions that promotes the identification of categories of spatial experience, here for museum plans. This representation of spatial experience is built atop approaches from *schema theory*, which seeks to create models to represent mental categories that arise from continuous sensory-motor experience. Several schema are identified for the experience of museum space using clusters of syntax metrics as evaluated using Visibility Graph Analysis.

## KEYWORDS

Space syntax, cognition, museum, experience, schema

## 1. SCHEMA

Sets of architectural representations often include both images that capture the overall organization of space (through orthographic drawings and diagrams) and images that capture specific moments of situated experience (through perspective drawings, renderings, and photographs). These representation types are manifestly useful to central activities in architectural practice, such as evaluating design proposals, providing an informational basis for technical solutions, and communicating with clients, builders, and critics. However, common forms of architectural representation neglect what might be called the middle scale, which is neither as gross as the overall organization of building form nor as fine as the individual percept or detail. This paper is aimed at using Visibility Graph Analysis data to represent such a middle: namely, the dimensions of architectural form that exist but often go undescribed, that are real but open-ended, that are patternly but varied in form.

Rafael Moneo and Aldo Rossi both propound the idea of the obscure as a key dimension of architectural type. In Rossi's account, type is a pre-existing principle, but not a specific form. For Moneo, type has a generative potential that arises from the capacity of refinements and combinations of formal structures to produce great relational richness. In his 1978 essay on type, Moneo distinguished between Quatremère de Quincy's development of type, as restating primordial links to nature and history without providing models for form, and that of J.N.L. Durand, for whom type could be boiled down to a compendium of overt formal models meant to assist the newly professionalized architect in dealing with a proliferation of building functions. Moneo, acute to the Modernist rejection of type, recognized the modernist project of "form-space" (32) as calling attention to the conceptual dimension of space itself through the architectural qualities of buildings. Mies, at IIT, is his exemplar.

Moneo's description of form-space is interesting as an instance of a moment when the sensory experience of space is organized into something that can be recognized as a concept, category, or scheme. Schemata are useful for describing such emergent categories. Shema theory originates in Kantian philosophy on the productive imagination (1998/1781, 240) and is concerned with conceptual knowledge and how it is represented and used. From the point of view of learning and psychology, schema refers to cognitive building blocks that are vital to processing information and that represent generalizable chunks of knowledge individuals use to make sense of things. Schemata are, in short, formal structures for representing information. Music theorist Robert Gjerdingen has used schema theory as part of a program of formal analysis for things that unfold over time, like listening to a piece of music (1986); he used schema theory to identify the prevalence of specific and subtle middle-level conventions in music over time.

The specific approach from schema theory used in this study is of analogic matching, which maps approximate matches between the constituent elements of events occurring at distinct points in time (Becker, 1973). In analogic matching, for some sequence of events, one kind of occurrence has somehow become prominent, memorable, and mappable onto other similar occurrences occurring in other times or places (Rumelhart, 1980). The present investigation introduces a novel representational technique for Visibility Graph Analysis (VGA) data that draws on schema theory and recurrent patterns of combinations of syntactic variables from points along pseudo-algorithmically generated paths through museum floorplans.

## 2. MUSUEM SPACE

One of the fundamental functions of museums is as spaces of pedagogy (Hooper-Greenhill, 1994). The space syntax literature has described how spatial structure conditions encounters with artwork, stages social dimensions of museum space, and embeds the logic of its own visual structure. Cues from the artwork, whether of co-visible paintings (Lu & Peponis, 2014) or facing direction of sculpted figures and paintings (Stavroulaki & Peponis, 2003; Tzortzi, 2004), appear to have the capacity to condition physical engagement with the manifest work and cognitive engagement with its content.

Space itself, apart from the art exhibited, influences patterns of use and understanding in museums. Part of the cognitive content of museum space comes through a primarily social channel, for example, through implied codes of spatial use and knowledge acquisition (Peponis & Hedin, 1982), as well as through conditioning patterns of knowledge transmission through relationships of cross-visibility (Peponis, Conroy-Dalton, Wineman, & Dalton, 2004). In several studies, syntactic analysis has been used to illuminate non-discursive dimensions of curatorial intention (Psarra, 2009; Psarra, Wineman, Xu, & Kaynar, 2007; Zamani & Peponis, 2010). More concretely, syntactic measures of spatial integration and connectivity have tended to be good predictors of distributions of museum goers (Choi, 1997; Hillier & Tzortzi, 2006). Aside from this, the dynamics of visual structure of spatial paths themselves appear to differentially activate the intensity of imaginative engagement with the scene observed (Bafna, Losconczi, & Peponis, 2012).

As a functional type, museums provide enough points of contact between program and spatial conditions to support a study that seeks to represent recurrent categories of spatial event. In a previous study on imaginative engagement in the Seattle Public Library, we used contrived paths related to building function to organize a study of how variously-motivated users would experience the library in distinct ways (Zook & Bafna, 2012; Zook & Bafna, 2017). For points along each path, we evaluated several syntax measures from VGA conducted in Depthmap software (Turner, Doxa, O'Sullivan, & Penn, 2001). Using multiple parameters is expected to allow for identification of recurrent spatial schema that are more informative than visualizing single syntax metrics (e.g., integration) or the syntactic pair commonly used to describe intelligibility (i.e.., connectivity and integration).

The present study evaluates spatial schema by simultaneously visualizing mean depth, connectivity, maximum radials, and occlusivity for points along a path. Mean depth is used here to model how one cognizes the publicness of specific locations, with the idea that cognized publicness arises from one's apprehension of being in a spaces of social and informational centrality (Zook & Bafna, 2017). Measures of integration have been associated with higher distributions of users in a number of studies (e.g., Grajewski , 1993; Penn, Desyllas, & Vaughan, 1999). In addition, highly integrated parts of plan arrangements also appear to anchor the mental maps we use in wayfinding activity (e.g., Peponis, Zimring, & Choi, 1990). Connectivity, which is assessed in VGA analysis as isovist neighbourhood size, reflects, following Goffman (1959) the notion that with increased exposure comes modulation of behaviour that reflects a direct sense of being in public. To restate, mean depth is taken to represent publicness as cognized, while connectivity is taken to represent publicness as directly perceived. Both depth and connectivity have observed relationships to the social life and experience of museum space; for example, Choi (1997) found that museum goers tended to spend time where they were in visual co-presence with a high number of other museum goers, and this occurred in areas attached to highly connected and well-integrated portions of plans. While VGA connectivity indicates the area, and here the perceived publicness, of a space, combining it with maximum radial is aimed at providing some sense of the form this area takes, in terms of whether it provides deep or shallow views. Occlusivity reflects "perceptual uncertainty" (Benedikt, 1979, 53) or the capacity of a given view to admit dynamic information from portions of the edge of the view not lying along hard boundaries, such as walls.

The analysis of spatial schema was initiated with the expectation of identifying two schema that can be viewed as reciprocal to one another; the first has to do with well-connected and well-integrated spaces, whose significance has already been well-described in the syntax research on museums. The second is the opposite: the spaces that are peripheral. A third schema, having to do with spaces that diverge along the dimension of integration and connectivity was also tracked. Typically, positive correlations between integration and connectivity are taken as indicators of intelligibility, in the sense that in such configurations, the nearby environment will give meaningful cues about the spatial structure of the greater building (or street network) (Hillier, 1996; Bafna, 2003; Peponis & Wineman, 2010). However, this study is interested in the properties of spaces that bend away from such correlations, as they may reflect a particular spatial schema, rather than the mere failure to contribute to the intelligibility of the system.

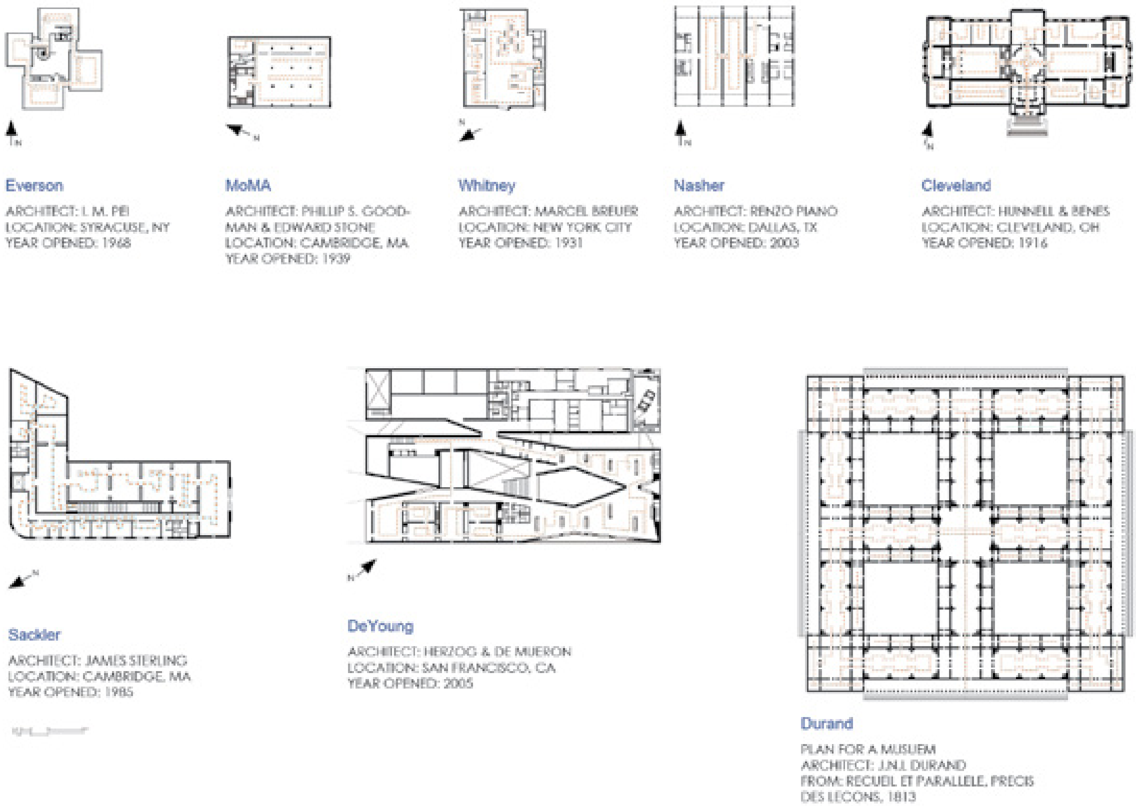


Figure 1 - Eight museum plans with paths

## 3. MUSEUM SPATIAL SCHEMATA

Identifying spatial schemata depends on having representations that promote the recognition of patterns. For example, in Gjerdingen's work on conventions in classical music, musical notation supports the visual identification of schema. To get to such a representation for museum VGA data, fourth main steps were taken. First, a pseudo-code was created to guide the generation of paths through all eight museums. The purpose of the pseudo-code was to create comparable paths through floorplans that varied in size and form, and main instructions in the pseudo-code governed turning decisions, distances from architectural elements, path termination, the completion of major rings, and the avoidance of backtracking. Second, after paths were established, points were plotted at 5-foot intervals and spatial analysis data was captured for each point using UCL Depthmap (Turner, Doxa, O'Sullivan, & Penn, 2001). (See Figure 1.) Third, each of these measures was normalized relative to the highest value (i.e., as a percent of the maximum value). Fourth, line charts were created from the normalized values of the spatial variables for each path point. In the line charts, each tick on the horizontal axis corresponds to 20 sequential points along the museum path (or 100 feet of path length). The y-axis represents the percent of the maximum value.

For the purposes of the present study, the output of the line charts are examined visually. In future work along this line, it may be valuable to develop methods that use data mining or other statistics-based identification strategies.

Eight museum floorplans are represented. J.N.L. Durand's published plan for a museum (1813), the original building of the Cleveland Museum of Art by Hunnell and Benes (opened 1916), the Whitney by Marcel Breuer (opened 1931), the Museum of Modern Art by Phillip Goodman and Edward Stone (opened 1939), I.M. Pei's Emerson Museum (opened 1968), James Stirling's Sackler Gallery (opened 1985), the Nasher Sculpture Center by Renzo Piano (opened 2003), and Herzog and de Meuron's De Young Fine Arts Museum (opened 2005). The Durand museum was selected as a reference case, an "overt model" of conventional museum space. The remaining museums were selected as representing a variety of museum sizes and layout properties in the United States.

### 3.1 AN OVERT MODEL FOR MUSEUM SPACE – DURAND, BIG CENTRALITY, AND MARGINALITY

Figure 2 shows the line chart representation of path points for Durand's plan for a museum. One recurrent pattern appears on the top row, where connectivity (dark blue) peaks over a relatively stable occlusive perimeter (light blue), with mean depth forming a valley (light orange), and maximum radial forming a small peak within a valley (dark orange). This spatial condition can be described in more everyday terms as one of markedly large views, spatial and perceptual centrality, and a potentially dynamic view; in a setting that is in use, it is likely that animation by other museum goers would be both directly perceived, in people entering and exiting a loosely bounded view and sensed at a more cognitive level, as one anticipates the presence of others in spatially central locations. The points along the path displaying this arrangement of values are located in the central crossing of the plan. It recurs whenever that path passes back through the central crossing, and it appears not to occur elsewhere in the plan. Let's call this particular pattern of values "big centrality".

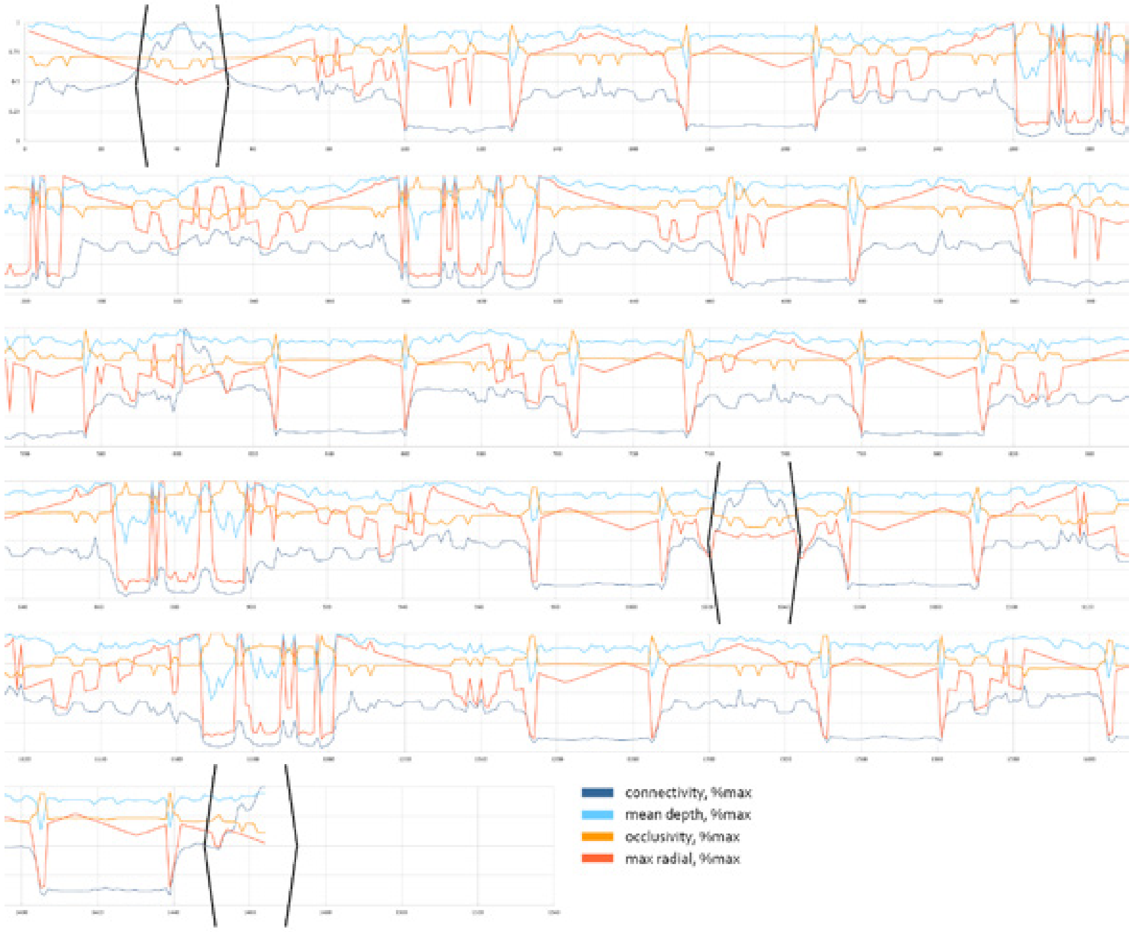


Figure 2 - Representation of path point VGA data, Durand museum scheme, big centrality in brackets

A different, but similarly distinctive pattern is bracketed in Figure 3. In it, mean depth peaks, and occlusivity, connectivity, and maximum radials dip, especially connectivity. Views are short and small in area and can be expected to be relatively less prone to be animated by in-movers; the spatial position relative to the rest of the floor is peripheral. We will call this pattern of values "marginality". Unlike big centrality, marginality is not tied to a unique location in Durand's scheme, but recurs where the path enters the boxcar-like rooms that line the museum courtyards.

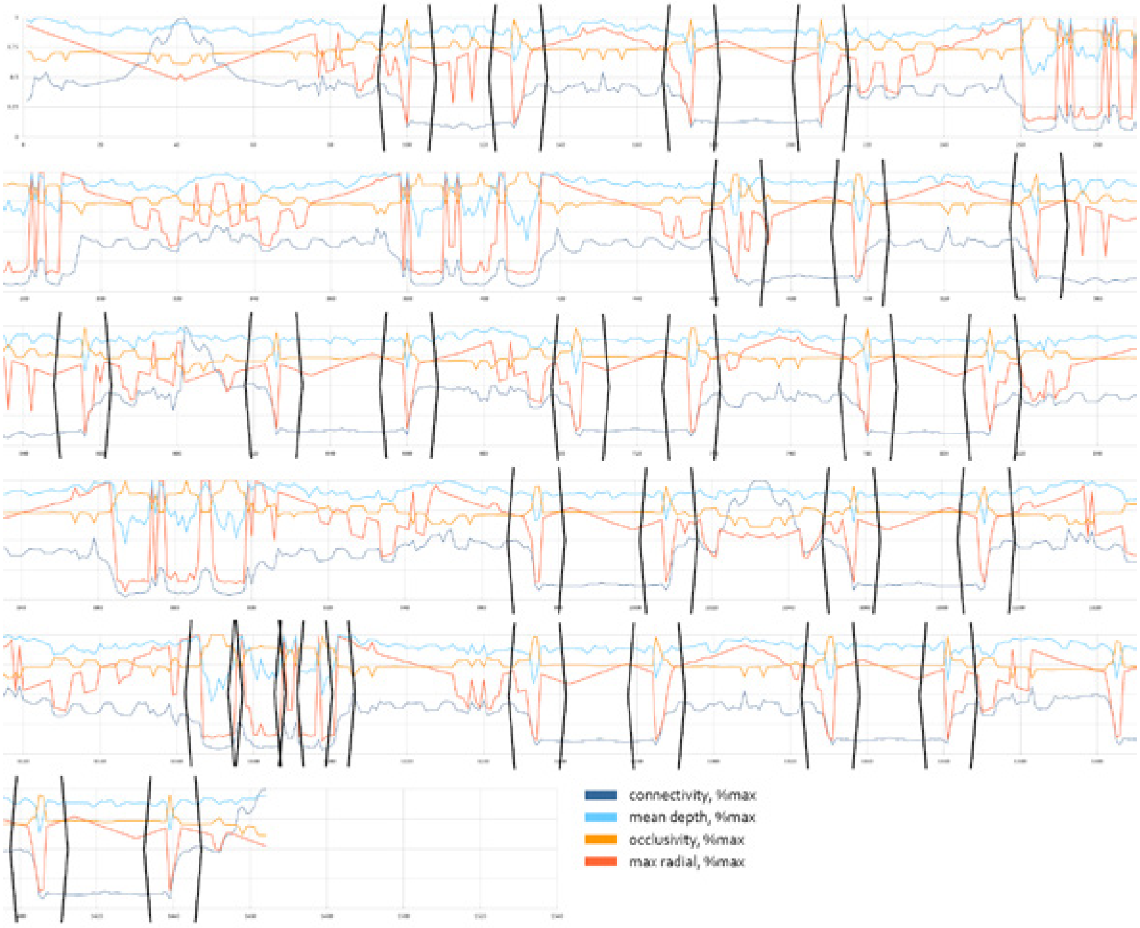


Figure 3 - Representation of path point VGA data, Durand museum scheme, marginality in brackets

A number of additional patterns could be observed from Durand's scheme. This is, however, enough to begin a discussion of the set of plans. Before doing so, however, a third attribute of the Durand line chart merits mention, and that is its overall patternliness and geometric order. Figure 4 shows the path values for all museum paths compressed to the same width. The values for the Durand scheme are visibly repetitive and orderly, with the schema often showing symmetrical distributions of syntactic values.

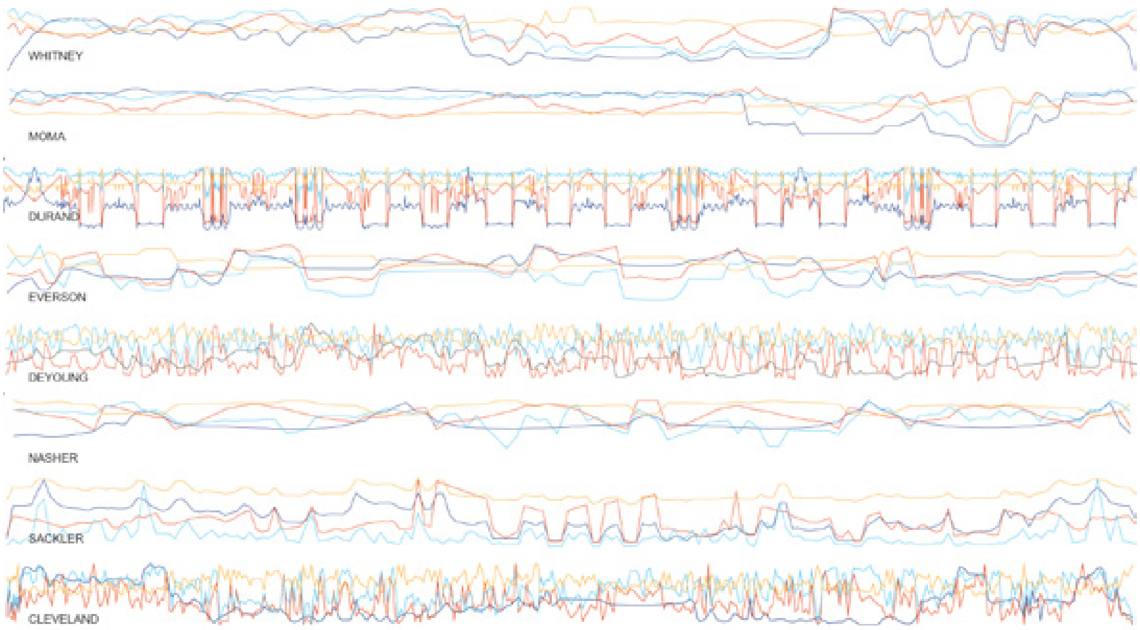


Figure 4 - Representation of path point VGA data for eight museums

The Nasher Sculpture Center (Figure 5) evidences the big centrality schema. The moments of big centrality are, in this case, toward the geometric centre of the plan, where the four open galleries are crossed by the horizontal corridor. Again, the distinctive spatial condition is tied to a specific location, but in the Nasher the location is not defined by as perceptible and easily-conceivable space, as it was in Durand, as the Nasher's big centrality spreads horizontally and is not associated with a recognizable geometric figure, as in Durand. In further distinction from Durand, there are not locations in the Nasher plan that are clearly marginal.

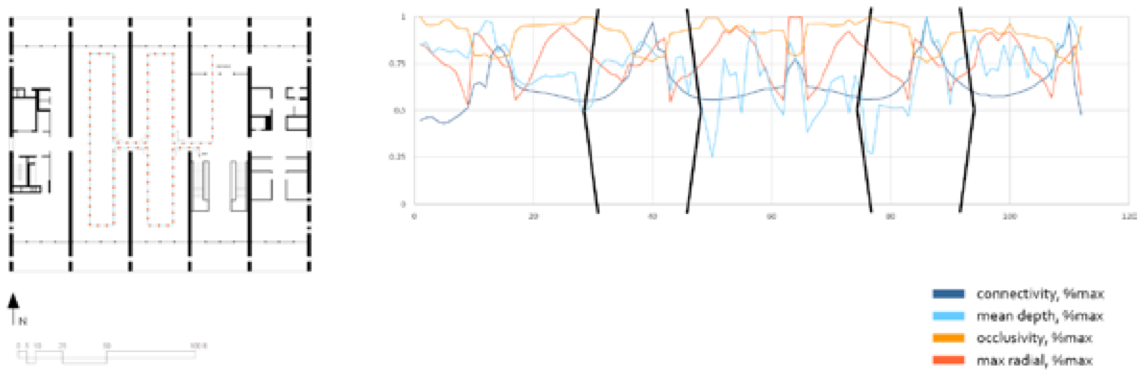


Figure 5 - Big centrality at the Nasher

### 3.2 REMOVAL

The Everson (Figure 6) shows the same marginality schema at the beginning and end of the path, in the short, fat corridor that leads from the spiral stair the ring of exhibition space. The space of the Everson also offers a pattern of space in its gallery spaces that is characterized by a peak in mean depth and a valley-shaped connectivity line, which nonetheless represents a relatively high visible area and ranks second, after mean depth, among the spatial metrics. Maximum radials dip and isovist occlusivity hits rock bottom. Such a schema may rightly be thought of as a space apart; there is some sense of self-importance in the isolated nature of the space, which screens out distractions within the context of isolated, static, and generously-sized views. This schema, which I am terming “Removal”, should be regarded as having a flavour that is distinct from that of marginality. The removal schema instances occur in the large gallery rooms of the Everson, perhaps supporting the art-viewing dimension of the function of museums. Removal can also be observed in the path representation at the Sackler Gallery, in the several largest galleries of the plan (Figure 6).

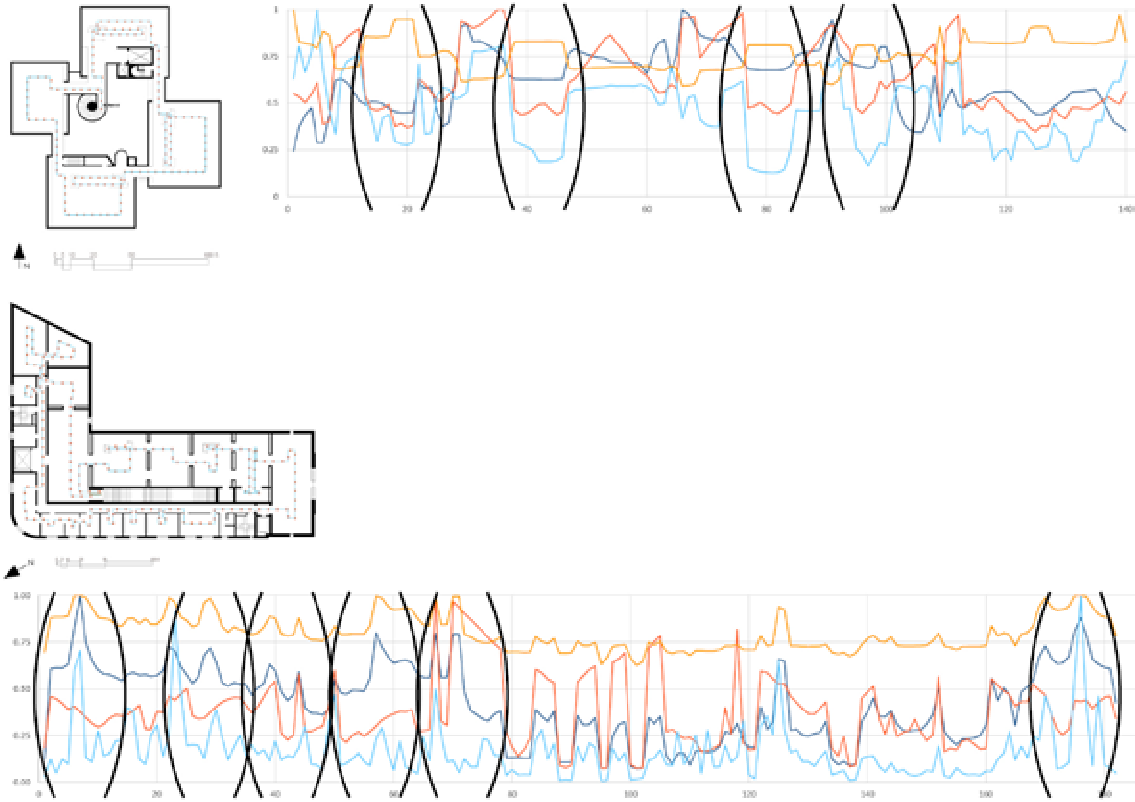

Figure 6 - Removal at the Everson (above) and the Sackler (below)

### 3.3 OTHER KINDS OF PHENOMENA

Apart from the identification of schema, the representation of syntactic variables in a simultaneous format allow for observation of other kinds of phenomena. For example, taken as wholes, one can see that MoMA and the Whitney line charts show a bifurcation in the distribution of values across the course of the path (Figure 7). In both cases, all of the syntactic values are constrained to a narrow, middle band through the first portion of the trajectory, then, in the second half, all of the values swing into new highs and lows. For both building plans, the change marks the transition from an open floorplan (punctuated by freestanding partitions in the Whitney and by columns at MoMA) to one or more cellular rooms. In both MoMA and the Whitney, the rooms can be characterized by the marginal schema of the peripheral rooms in the Durand plan (Figure 9). The first half of the trajectory through MoMA is remarkably stable, with most variable values nearly flat, raising the possibility that this may be what is meant when Modernist architecture is described as “boring” (e.g., Venturi’s dismissal that in Modernist architecture, “less is a bore”).

However, for its apparent attempts to be, if nothing else, stimulating (Jencks, 1977), post-modernist architecture also has static spatial attributes. In the Sackler, almost without exception, mean depth is not only high, but the highest value of the four spatial parameters. Almost without exception, isovist occlusivity is the lowest value, with some flip-flopping between maximum radial and connectivity as the middle values, with all values tending to rise and fall together. The Sackler is a museum of rooms, of somewhat isolated rooms (Figure 6).

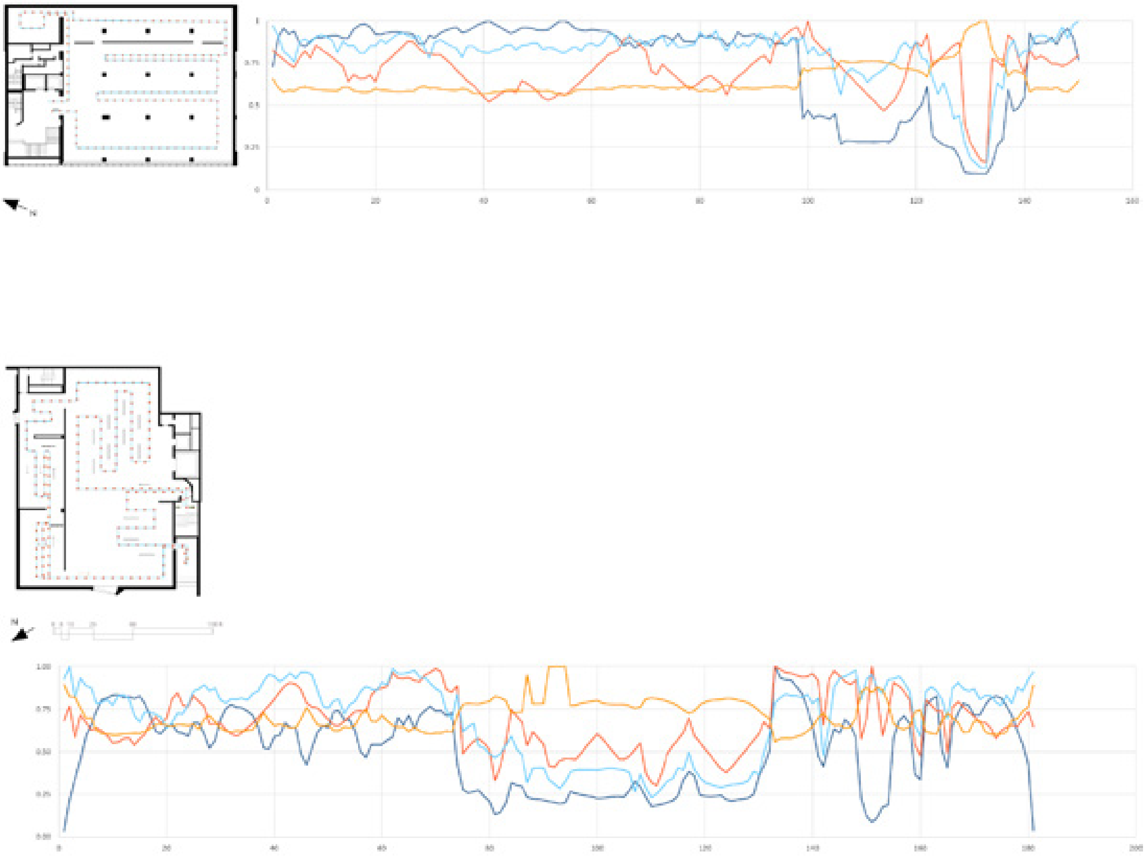

Figure 7 - MoMA (above) and the Whitney (below)

The linecharts for the conventionally planned Cleveland museum and the DeYoung, a museum with a difficult-to-conceptualize plan, appear similar. The central crossing at Cleveland shows big centrality. Otherwise, both museums are "noisy" insofar as the visual identification of schema (Figure 4). Both show a range for all variables, without readily apparent repetitive patterns. The connectivity value for the Cleveland sometimes flatlines for long stretches, indicating a notable duration in a fairly enclosed room. However, the differences between the two plans are not as pronounced as one might expect. Although, a close look indicates that within the spatial variety of the two plans, something approaching the marginality schema is frequently apparent, though fleeting. In general, the style of plan geometry seems to matter less than spatial order to the identification of syntactic schemata.

## 4. CONCLUSION

Inspired by work in music theory, this study set out to test a novel method for representing spatial data, specifically values for VGA-derived space syntax measures. Several spatial schemata were readily identifiable from inspection of line charts that allowed for simultaneous visualization of multiple syntactic variables.

Spatial schemata may provide a useful approach to multidimensional or quantitative investigation of how type or category arises from continuous spatial experience. Recurrent patterns of clusters of spatial variables related to well-studied ideas of centrality and peripherality appeared as expected, with the present approach enabling a nuanced look at the patterns of distributions of these conditions. The schemata-based approach also supported the identification of certain clusters of variables—namely one including high connectivity but low integration—as having a particular experiential quality—as features rather than bugs, to borrow an expression from software development. The present study is exploratory in nature. In addition to there being room to develop further theory on spatial schema, there is also scope to validate the idea of schemata-dependent experience using empirical research. Future research with more advanced quantitative methods could also make a more rigorous, less eyeball-dependent study of repetition, rate, and apparent precedent-antecedent spatial schema, among other things.

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