projection of a uniform circular motion, its primitive code will be

$$M_{a0fbt}(p). \quad (7)$$

But if the motion is perceived as uniform circular motion in a context in which all motions are uniform, circular, the primitive code will consist of only three parameters:

$$M_{a0f}(p). \quad (8)$$

For displays containing more than one moving light, the motions may be interpreted as being unrelated, with each light's trajectory being coded to the same stationary frame of reference; or the motions may be interpreted relative to each other in a hierarchical organization. An example of the latter is the case of a ball bouncing on the floor of a moving train. If the moving configuration is interpreted hierarchically, the train would be perceived as moving horizontally and the ball as bouncing on a vertical trajectory relative to the frame of the train, even though the motion of the ball relative to the stationary ground below the train follows a damped sinusoidal trajectory.

### 8.3. Structural Information Load

When dealing with primitive codes, the SIL is easy to calculate, because it is simply the number of primitive elements (parameters) in the code. Thus the SIL of the code in Eq. (3) is 7, and that of Eq. (7) is 5. We show later, however, that the SIL of endcodes is not equal to the number of primitive elements they contain.

### 8.4. Syntax

SIT proposes certain formal devices for reducing the length of codes, which in turn reduces their SIL. Consider the following reduction of a primitive code of a line drawing by use of the symmetry (SYM) operator:

$$n a n n a n n a n n = \text{SYM}[n a n n a n n], \quad (9)$$

which is further reduced as follows:

$$\text{SYM}[n a n n a n n] = \text{SYM}[\text{SYM}[n a n]], \quad (10)$$

where a and n are arbitrary primitive elements. Equation (9) reduces the SIL of the primitive code from 12 (12 primitive elements) to 7 (6 primitive elements + 1 operator), and Eq. (10) reduces it further to 5 (3 primitive elements + 2 operators). These examples show that each SYM operator adds (by definition) 1 to the SIL; for an explanation, see Buffart and Leuwenberg (1961). Another symmetry operator SYMM is used to condense patterns that are symmetric around a pivotal element or sequence (where n, a, p, q, and r, are arbitrary primitive elements):

$$n a p q r a n = \text{SYMM}[n a(p q r)]. \quad (11)$$

Further reductions are made possible by using the **distributive property**, indicated by the use of triangular brackets (\(\langle\)). For example:

$$a n a n n a n n a n n = \langle a \rangle \langle((n)(nn)(nn)(nn)(n))\rangle, \quad (12)$$

which reduces the SIL from 13 to 9. The iteration operation,

$$\langle a \rangle \langle(n)(nn)(nn)(nn)(n)\rangle = \langle a \rangle \langle((n)(nn)(nn)(nn)(n))\rangle, \quad (13)$$

further reduces the load from 9 to 6. (Note that the various types of parentheses and brackets, as well as the iteration symbol \(*\), do not add to the SIL.)
if the motions of two lights are interpreted as sharing a parameter (for instance, if they have the same frequency, or are in phase, or are both linear harmonic motions, and hence have the same tilt), reduplicated parameters are suppressed from the primitive code, yielding an end-code with only one token of each parameter. In other words, in this context the SIT reflects the number of different parameters in the primitive code of an interpretation.

8.5. Perceptual Decision

On the basis of the SIL of the several possible interpretations of a figure, SIT proposes a measure of the strength of the preference for the most common interpretation of a stimulus. If \( I(A) \) and \( I(B) \) are the SILs of interpretations \( A \) and \( B \) of a given stimulus, then the preference of interpretation \( A \) over \( B \), denoted as \( P(A > B) \), is a monotonic function of the ratio \( I(B)/I(A) \). Evidence in favor of this prediction can be found in Buffart, Leeuwemberg, and Restle (1981); Restle (1979); and Leeuwemberg (Note 2). None of these experiments has studied the functional relation between the ratio of SILs and the probability of an interpretation being perceived. Thus this part of SIT has remained merely ordinal to the same extent as Hochberg and McAlister's (1953) scheme.

8.6. Critique of Structural Information Theory

The most innovative parts of SIT are the rules that allow the shortening of a primitive code into a parsimonious end-code. These have not yet been submitted directly to empirical test; indeed, such tests would probably be quite indirect in that they would be based on comparing the loads of alternative interpretations against people's preferred organizations of the stimuli. Any discrepancy between these two could indicate a problem with the rules employed or, more ominously, an error in the underlying assumption that human perception strives for economical descriptions of stimuli. Moreover, assuming that the general approach of using rules is correct, it is not clear in the absence of alternative sets of rules whether the rules just described are optimal or whether all the rewrite rules used in applications of SIT to line drawings are in fact necessary.

In Figure 36.43, adapted from Buffart, Leeuwemberg, and Restle (1981, Figure 19, display 1), a stimulus pattern is shown at (e), along with illustrations of the two most common interpretations of the stimulus. The top pair, (a) and (b), show the features required to present Buffart et al.'s code; the bottom pair indicates an alternative coding scheme devised by the present authors and explained later.

The codes obtained by Buffart and his colleagues use two new context-dependent operators. Both are continuation operators, and they have the form \( @(x) \) where \( x \) can either be any string of symbols or an &amp;, which represents an infinitesimal element and is called the grain. The first operator \( @(x) \) means, "repeat \( x \) until a part of the figure already specified in the code is encountered." If the \( x \) is a string of primitive elements, the meaning of \( @(x) \) is made clear by the following reduction of the code of a square of side 1, where \( a \) stands for a right angle:

\[
\overline{1} a \overline{1} a \overline{1} a = \overline{1} @; (a \overline{1}).
\]  

(14)

The resulting end-code has a lower SIL than

\[
\overline{1} 3 *(a \overline{1})
\]  

(15)

because the continuation operator is considered not to add to the SIL. The second operator \( @; : & \) means, "draw a straight line until a part of the figure already specified in the code is encountered." This device makes it possible to code a square

\[
\overline{1} a \overline{1} a \overline{1} a = \overline{1} a \overline{1} a \overline{1} a @; ; : & = 3 *(\overline{1} a) @; ; : &.
\]  

(16)

We propose to show that these two continuation operators sometimes produce codes that are obscure because they are not

![Figure 36.43](image_url)

**Figure 36.43.** An alternative coding scheme to SIT. (e) The pattern to be coded. This pattern can be interpreted either as a mosaic in which one square is abutted with another square whose upper-left quadrant has been removed, (a) and (c), or as two squares, one of which occludes the other, (b) and (d). Parts (a) and (b) are labeled for the Buffart, Leeuwemberg, and Restle (1981) coding; (c) and (d) are labeled for the present authors' alternative coding. It is argued that the latter coding is more faithful to observers' perceptual organizations of the original pattern. (Parts (a) and (b) are adapted from Buffart, Leeuwemberg, and Restle, 1981.)
readily translatable into verbal descriptions that people might produce. In addition, the SIL of other codes, based on different primitives and operators, can be just as effective in predicting the verbal descriptions of human observers. From this we conclude that SIT in its current state lacks an adequate criterion for selecting recoding operators.

The two interpretations of the stimulus pattern at the top of Figure 36.43 are, first, a mosaic composed of one complete square and another square missing its upper left quadrant; and second, one complete square overlapping another complete square. Letting \( -a \) stand for a clockwise angle of magnitude \( a \), Buffart, Leeuwenberg, and Restle’s (1981) code for the interpretation shown in Figure 36.43a is

\[
\begin{align*}
\text{n a n a n a n a n a n a n a n a n a n} &= @; (n a n) - a @; (n a n) a @; ( & ) - a @; ( & ) \quad (17) \\
\text{=} &= \langle a @; (n a n) \rangle \langle (a @; ( & ) - a @; ( & ) \rangle \quad (18)
\end{align*}
\]

Similarly, Buffart et al.’s code for the interpretation in Figure 36.43b is

\[
\begin{align*}
\text{n a n a n a n a n a n a n a n a n a n} &= @; (n a n) @; (n a) @; (n a n) @; ( & ) \quad (19) \\
\text{=} &= \langle (a @; (n a n)) \rangle \langle (a @; (x)) @; ( & ) \rangle \quad (20)
\end{align*}
\]

where \( a = a n \).

If we forgo the context-dependent continuation operator and we code each part of an interpretation (such as the complete and incomplete squares in the mosaic interpretation) separately as a chunk, while taking care to use the same primitive elements as did Buffart et al., the mosaic interpretation shown in Figure 36.43c is coded in a far more transparent fashion:

\[
\begin{align*}
\text{n a n a n a n a n a n a n a n a n} &= (n a n a n a n a n a n a n a n a n - a n) \quad (21) \\
\text{=} &= [4*(n a n)] \langle 3*(x) \rangle \langle a - a \rangle \langle n \rangle \quad (22)
\end{align*}
\]

where \( x = n a n \). The code of the two overlapping squares interpretation in Figure 36.43d is

\[
4*(n a n) + y,
\]

where \( y = 4*(n a n) \).

According to Buffart et al., the SIL of the interpretation in Figure 36.43a, Eq. (19), is 6, and the SIL of Figure 36.43b, Eq. (22), is 4. By contrast, our coding scheme yields an SIL of 9 for Figure 36.43c, Eq. (21), and an SIL of 5 for Figure 36.43d, Eq. (22). According to the data reported by Buffart et al. from three experiments, almost all subjects selected the interpretation shown in Figure 36.43b and d. Even though the end-codes proposed by Buffart et al. are quite different from the alternatives we have presented, as are their respective SILs, the ordering of the SILs is the same. Thus the data are consistent with both sets of end-codes. It is possible, however, to choose between the two pairs of end-codes on the grounds that those we have developed here attempt to mimic more closely the verbal descriptions subjects might produce for the original stimulus. For instance, in Eq. (24), \( 3*(x) = 3*(n a n) \) represents the intact part of the square (that is, its three quadrants), and \( (a - a) \langle n \rangle \) represents the missing quadrant.

Our purpose here is not to propose an improved version of SIT. Indeed, we are not certain that our proposal is entirely consistent with the spirit of SIT. Nevertheless, we consider it imperative for SIT to formulate explicit criteria for assessing the adequacy of primitive codes and end-codes.

8.7. The Influence of Context

As Garner (1974) has noted, the verbal description of a stimulus given by an observer will depend upon what other stimuli are present, have been present recently, or are suggested by the original stimulus. A stimulus that when presented alone might be called simply “a circle” is likely to be called “a single circle” if it follows presentation of a pair of concentric circles, or “a black circle” if it follows presentation of other stimuli varying in color. Although SIT does not address the issue of the relation between verbal descriptions of forms and end-codes, we have suggested that the cause of uniqueness of end-codes would be served well by using verbal descriptions as empirical data to which end-codes must conform in some fashion. If this suggestion is correct, the end-code of a figure will depend on other figures that comprise its context. Restle (1979) recognized this need explicitly in his discussion of the number of parameters required for the description of circular motion. It is difficult to see how SIT can accommodate this sort of context dependence without introducing further assumptions about the nature of contexts and their effects on verbal descriptions.

8.8. Prägnanz versus Likelihood

SIT was conceived in the spirit of the simplicity or prägnanz principle. Its authors state this explicitly, and they designed SIT specifically to produce end-codes that maximally exploit the symmetries and other regularities in the stimulus. Their measure of complexity of a pattern in its SIL, and their approach has been to search for coding rules such that organizations that are preferred by observers have smaller SILs than nonpreferred organizations. In this search coding rules that fail to produce minimal SILs for preferred organizations are rejected.

By way of assessment, we support SIT’s approach of viewing perceptions as structural descriptions, and we applaud its goal of formalizing the codification of these descriptions. At the same time, this approach might benefit if its links with the prägnanz principle were weakened for the reasons cited, and if means could be found by which codes for likely elements would require fewer parameters than for unlikely elements, as the earlier quotation from Attnavee (1981) suggests. With these modifications, SIT also would become capable of handling the many cases where the likelihood principle prevails over prägnanz. Finally, if the coding of patterns were tied more directly to the actual organizations of stimuli that are perceived by human observers, the result would be a theory of perceptual organization that is formal, testable, and congruent with phenomenology.

REFERENCE NOTES


REFERENCES

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THEORETICAL APPROACHES TO PERCEPTUAL ORGANIZATION


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