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ESSAY

The Revival of Structuralism: The Periodic Table of Mental Science

Orogee Dolsenhe

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HIGHLIGHTS

Hidden patterns in subjective experience might be the basis for a 'periodic table' of mental science. New thinking indeed suggests that fifteen different sensory or perceptual modalities can be mapped in a systematic and unified way.

ABSTRACT

Physical science solved an age-old problem in the 19th century: What makes elements similar or dissimilar? Mendeleev generally is given credit for the discovery of the underlying structure of chemical elements, known as the periodic table of elements. Like chemicals, qualia seem to share different relationships within a modality and between modalities. Wundt's structuralism represents an early effort to build the structure of mind through data obtained by introspection. Unfortunately, as with many other subjects, structuralism has been victimized by behaviorism's domination. And the cognitive revolution did not completely eliminate the unfavorable status of consciousness, thus hampering the revival of structuralism unlike many other topics in psychology. With the subject of consciousness having been just about fully sanctioned by science beginning in the early 1990s, the time has come to build the periodic table of mental science by uncovering the hidden patterns of qualia. This paper examines three different scales of intrinsic patterns: the principle of opposition, the double-cone system, and the square of opposition. In addition, an effort is made to accommodate 15 different modalities in a systematic and unified way: chromatic, emotive, hedonic, acoustic, tactile, olfactory, gustatory, exteroceptive orientative, exteroceptive locus, exteroceptive motion, proprioceptive orientative, proprioceptive locus, proprioceptive motion, magnitude, and predicative.

One of the greatest achievements in physical science is the periodic table, for which Dmitri Mendeleev, the Russian chemist, is mostly given credit. It explained the age-old problem of the underlying interrelationships of chemical elements, chiefly, what makes them alike or different. His system serves as a unifying factor not only in chemistry but also in physics. The periodic law (or periodic table) has two dimensions: Horizontal rows or periods are arranged in order of increasing atomic number, while the vertical files (groups) manifest a certain degree of similarity in chemical and physical properties. The periodic table has become one of science's most well-known icons. Not only did the periodic table unveil the underlying reason for family likenesses among elements—it also identified elements. For instance, it revealed that salt is not an element but a compound of two elements (sodium and chlorine), and it was able to predict the properties of undiscovered elements.

In like manner, there are many different types of mental qualities: redness, sweetness, warmth, sadness, and so on. These are called "qualia." And just as with the chemical elements, some qualia seem similar to each other while others seem dissimilar. Thus, mental science faces a situation in finding interrelationships between qualia that is similar to the problem of chemical elements. While the 19th century physical scientists attempted to find the

hidden structure of the objective world, psychologists are faced with solving the same for the subjective world: What are the mental elements? What makes them similar or dissimilar? Mental scientists must find a unified system analogous to the periodic table.

A BRIEF SUMMARY OF THE HISTORY OF MENTAL ELEMENTS

Buddhist philosophy perhaps was the first to offer a discussion of mental elements under the etymology "dharma" (in Sanskrit) or "dhamma" (in Pali), for the basic, irreducible, self-existing mental elements (Ronkin, 2005). The traditional Theravada lists 82 dhamma categories which are grouped into four categories: *citta* (consciousness), *cetasika* (mentality), *rupa* (materiality or physical phenomena), and *asankhata* (nirvana) (Ronkin, 2005).

C. S. Peirce introduced the term *quale* in 1866 and C. I. Lewis (1929) was the first to use the term "qualia" in its generally agreed upon modern sense. Lewis sees qualia as the simple, sensory, building blocks of conscious experience (Keeley, 2009). Woodworth (1906) suggests that thought contains elements that are wholly irreducible to sensory terms.

Wilhelm Wundt (1897), known as the father of experimental psychology. suggests: ". . . psychical elements, or the absolutely simple and irreducible components of psychical phenomena, cannot be found by analysis alone, but only with the aid of abstraction." Wundt (1912) recognizes the importance of mental elements and boldly states: "The whole task of psychology can therefore be summed up in these two problems: (1) What are the elements of consciousness? (2) What combinations do these elements undergo and what laws govern these combinations?"

THE PRINCIPLE OF OPPOSITION

An interrelationship among qualia was noted by Aristotle, who suggested that all sensible objects contain the principle of opposition. In ancient Chinese metaphysics as far back as 4,000 years ago, the *I Ching* (known as the Book of Changes) describes three fundamental characteristics of human thinking: 1) bipolar organization of the dimensions of cognition, 2) attribution of positive to the yang pole and negative to the yin, 3) parallelism in the orientation of the dimensions in terms of underlying positiveness/negativeness (Osgood & Richards, 1973).

Consider the apparent interrelationship among qualia that can be seen in color. Yellow, for instance, seems more distant from red than does orange. Green seems even more distant from red, to the point that they are opposites. As far back as the 17th century, such obvious interrelationships have prompted color specialists to propose a geometrical model of the color system. Thus, the structural model of qualia actually began long before the periodic table of chemistry.

The modern approach of combining empirical data in the attempt to build the structure of mind began with Wundt. He was able to identify three bipolar dimensions of feelings: excitement–calm, pleasure–displeasure, and strain–relaxation (see Titchener, 1908). Titchener (1908) proposed that all sensations have four attributes: quality, intensity, clearness, and duration. He attempted to classify the structure of mind like the periodic table of chemical elements.

INTERRELATION AMONG MODALITIES

Interrelationships among qualia are also evident between different modalities. Sensory correspondence between modalities often is revealed in everyday language. For example, we say certain colors are loud, soft, warm, or cold. We describe certain cheeses as sharp and certain wines as smooth. And we label high-pitched sounds as bright and low-pitched sounds as dark.

One of the earliest attempts to investigate intermodality correspondence was made by Sapir (1929). He found that a particular vowel /i/ represents a smaller size than /a/ in native speakers of Chinese and of English. Newman (1933) not only confirmed the findings but also discovered that brightness and pitch also are associated with vowels: /i/ is brighter and has a higher pitch than /a/. Hornbostel (1931) argues that cross-modal brightness is more than an analogy; it is, he says, an "identical side" of different sensory systems. Hartshorne (1934) proposes sensory correspondence of all sensory modalities by introducing three bipolar dimensions corresponding with color: activity–passivity (red–green), joy–sorrow (yellow–violet), intensity–faintness (white–black). Hartshorne's model is remarkably similar to Wundt's (1912/1973) tridimensional theory of feeling.

Perhaps the most comprehensive empirical study of semantic structure was carried out by Osgood et al. (1957). They attempted to map words into various dimensions of meaning: "semantic differentiation." In their study, subjects would rate words with respect to 50 bipolar dimensions. The obtained data were then analyzed and condensed into three major factors: evaluation, potency, and activity. Interestingly, the three factors are quite similar to the three bipolar dimensions of Hartshorne (1934) and the tridimensional theory of feeling of Wundt (1912/1973). Marks (1978) made perhaps the most comprehensive

review of the studies of sensory correspondence and summed up by saying that different senses assist one another and share common phenomenological attributes.

Using 1096 schoolchildren as subjects, Simpson et al. (1956) found that violet and blue were associated with low frequencies, orange and red with intermediate frequencies, and green and yellow with high frequencies. Wicker (1968) based the two-dimensional map of color–sound correspondence upon similarity ratings between color and color, sound and sound, and color and sound.

One of the most well-known cross-modal translations is the association between color and emotion. For instance, blue is typically associated with sadness and yellow with joy. A stronger form of cross-modal translations is manifested in synesthesia. In synesthetes, one type of sensory experience provokes perception in another sensory modality. For instance, hearing the musical tone C induces seeing the color red. Interestingly, although there are some variations among synesthetes, the association between color and sound is often regular, systematic, and consistent from one person to another (Marks, 1978). In reviewing about 40 past studies on the correlation of colors and vowels, Marks (1975) concluded: ". . . a capacity for true synesthetic perception lies latent and dormant within most if not all people, ready to come forth when properly catalyzed. The potential to experience synesthesia is probably universal."

OSWALD'S DOUBLE-CONE SYSTEM OF CHROMATIC MODALITY

In the 17th century, several types of color systems had been put forward: a two-dimensional color chart, a two-dimensional color triangle, a color sphere, a color hemisphere, a color cube, a double tetrahedron, and an octahedron (see Oswald, 1931).

Perhaps the most advanced and certainly the most commonly used model of color was developed by Oswald (1931). Oswald (1931) developed the double-cone structural model (or the spindle shape) of color, which can systematically accommodate the three psychological dimensions of hue, saturation, and purity. The corresponding physical basis of hue is the wavelength of light. Brightness is the amplitude of light waves. The physical basis of purity is the amount of white light added to monochromatic light. The double-cone structural model not only can accommodate all colors in a simple, comprehensive, and systematic way, it also can show complementary hues and predict additive mixtures (Figure 1).

The Emotive Modality

Due to its dominance in human consciousness and behavior, emotion has been extensively studied by psychologists. Perhaps that's why the building of a structural model of emotion is far more advanced than that of other perceptions, with the exception of color. And the cross-comparison between colors and emotions is well ahead of those for other modalities.

McDougall (1921) was one of the first to indicate a correspondence between colors and emotion. Hartshorne (1934) also emphasized three bipolar dimensions by comparing emotions with colors: activity–passivity (red–green), joy–sorrow (yellow–violet), and intensity–faintness (white–black). Schlosberg (1952) demonstrated the correspondence experimentally by describing facial

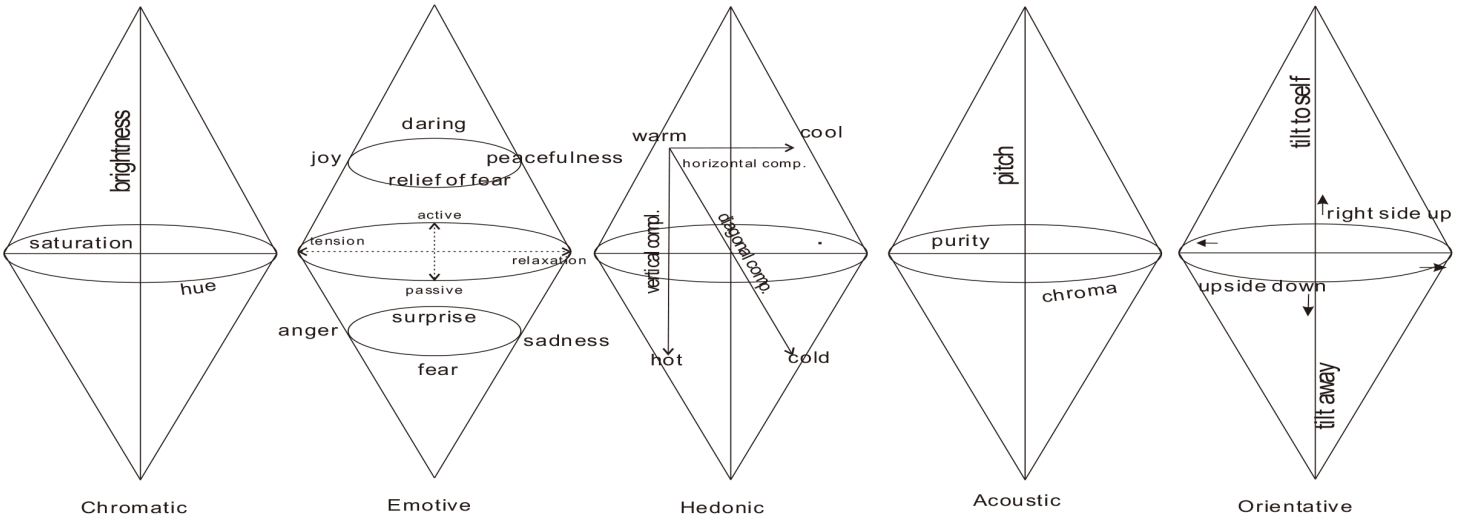

Figure 1. The unification of modalities.

expressions compared with colors and built a circumplex model of emotion (see Petri [1986] for an overview of the circumplex models of emotion). Just as color can be put into two dimensions (blue–yellow, red–green), he suggested two axes of emotion: pleasantness–unpleasantness and attention–rejection. Russell (1980) used 28 affective words in a multidimensional scaling method and also found two bipolar dimensions: pleasantness and arousal. And this two-dimensional arrangement of affective terms was pancultural (Russell, 1983). Plutchik (1962, 1980, 1983) departed from other models by proposing a three-dimensional version of emotion using eight primary emotions: anger, joy, acceptance, surprise, fear, sorrow, disgust, and anticipation. The third dimension he added is the intensity factor: The narrow bottom represents lower intensity while the top implies maximum strength. However, the dimension of intensity can be represented by the distance from the center of a circle as suggested by Schlosberg (1952). It seems that Plutchik (1962, 1980, 1983) added a third dimension without fully making use of the first two dimensions. The same problem also exists in the conical model of Daly et al. (1983).

A common problem in the study of cross-modal comparison is relying exclusively on primary colors. For instance, although there are nearly infinite shades of blue, we are culturally and linguistically biased toward the primary colors. The preconception of associating a type of emotion with a primary color may hinder the discovery of intrinsic relations between them. Therefore, the use of color patches that can show intermediate shades rather than relying on a few primary colors would be better for experimental studies. Thus, I propose the structure of the emotive modality is equivalent to the double-cone of the chromatic modality (Figure 1).

The Hedonistic Modality and the Notion of Square of Opposition

Despite the dominance of hedonic feelings in our lives, the hedonic structure lags behind the studies of emotion. Troland (1932) classified hedonic states into three categories: beneception, nociception, and neutroception. Beneception is pleasant feeling, and nociception is unpleasant feeling. Neutroception is neither pleasant nor unpleasant. Interestingly, Beebe-Center (1932) made associations between hedonism and color by attaching bright pressure to pleasant feelings and dull pressure to unpleasant feelings. Both Troland (1932) and Beebe-Center (1932) emphasized a hedonic continuum with a neutral state in the middle of two opposing extremes of pleasant and unpleasant feelings.

One of the most common hedonistic feelings is thermal sensations which have four different hedonic states: warm, cool, hot, and cold. Also, each thermal sensation has three complementary relationships with the others: the horizontal complementary, the vertical complementary, and the diagonal complementary. Warm–cool and hot–cold are horizontal complementaries as shown in Figure 1. The three complementaries are equivalent to the notion of the square of opposition, originated with Aristotle.

The sensations of warm and hot are associated with high temperatures while cool and cold are associated with low temperatures. The vertical complementary represents the opposition of positive (the upper parts) versus negative (the lower parts): Warm is pleasant, while hot is unpleasant; cool is pleasurable, while cold is displeasing.

The diagonal complementary relationship is apparent in our common experience. Suppose the thermostat of your house is set at 22° C throughout the year. During the hot summer, when outside temperatures rise above 32° C, you feel cool air when you walk into your house. The unpleasant feeling of hotness in the sun and the pleasurable sensation when you walk in the house represent the diagonal complementary. Consider also the freezing pain in winter weather and the warm sensation when you walk into the house. The hedonic state of the initial stimulus and that which follows represents exact opposites in quality (or the diagonal complementary). Both the uncomfortable feelings and the pleasurable feelings give us the double insurance of our well-being.

Thermal sensations invoke hedonic feelings that clearly have pleasant and unpleasant states as in emotion. While both emotion and hedonism are motivating factors in anyone's behavior, the former occurs generally in cognitive and sociological situations whereas the latter is geared toward physiological needs. Hedonistic feelings like hunger, thirst, pain, itchiness, etc., are directly connected to the needs and well-being of the body. It is as if the body rewards the organism with pleasurable sensations when it does something beneficial to itself but punishes it when it doesn't.

Besides thermal sensations, there are four other kinds of the hedonism: gastronomic, hydro, protective, and energetic. Gastronomic hedonism is involved with food intake and discharge (hunger, satiation, the urge to defecate, and relief from defecation). The hydro hedonism is the positive and negative feelings associated with drinking water and releasing it (thirst, quenching, the urge to urinate, and relief from urination). The protective hedonism is those hedonic qualia involved in protecting the body from injury or irritants: injurious pain, relief from pain, itching, and relief from itching. Energetic hedonism is the one responsible for motivating an organism to be active and to rest: boredom, stimulation, tiredness, and

the pleasure of rest. Energetic hedonism is a revised form of the square of opposition discussed earlier (Dolsenhe, 2005).

The Acoustic Modality

Hearing is the second most important sense and is the primary means of communication and music appreciation. Despite its importance, attempts to build the acoustic structural model began only recently. One of the earliest attempts to investigate the acoustic structure through speech perception was conducted by Miller and Nicely (1955) by employing confusions in noise among 16 English consonants. In their experiment, the subjects were forced to guess sounds which were spoken over a voice communication system with frequency distortion and with random masking noise. Shepard (1972) built a two-dimensional structure using the data of Miller and Nicely (1955). Wicker (1968) used intramodality comparison and intermodality comparison of patches of color and pure tones. In his study, subjects were to make similarity judgments between patches of color, pure tones, and patches of color and pure tones. Then, all the stimuli of both colors and pure tones were plotted in two-dimensional space. Simpson et al. (1956) earlier found that children associated violet and blue with low frequencies, orange and red with intermediate frequencies, and green and yellow with high frequencies.

I propose that all sounds can be plotted in the double-cone system, each with its corresponding item in the chromatic modality and the emotive modality (Figure 1). The acoustic modality should consist of three dimensions: The vertical axis represents pitch, the circle corresponds to tone chroma, and the horizontal distance from the center stands for saturation or purity. I would suggest that the voiceless sounds (*p*, *t*, *k*), which are closer to white noise, may be more toward the center of the equator section while voiced sounds (*d*, *z*, *b*) may be more distant from the center. The brighter sounds (*m*, *n*) are likely to be higher on the vertical axis.

The Tactile Modality

Though our skin is the largest sensory organ of the human body, adjectives describing the sense of touch are far fewer than for most other senses. Perhaps for this reason, a structural model of touch has not yet been proposed. Despite its linguistic limitation, some words describing touch have apparent opposite relationships: something can be as smooth as silk or as rough as tree bark, hard as rock or as soft as sponge, and slippery as the surface of ice or as sticky as chewing gum. I would propose our tactile sensation comes from the tactile modality that consists of three dimensions. The first dimension is sharp–round on the equator section of the double-cone. The sharp–round dimension is based on contacting an object's shape. Something can have sharp corners like a brick or can be round like a baseball. The second dimension on the equator of the double-cone is the high grating–low grating dimension. A lower frequency of grating means a larger size of grooves, and a higher frequency means a smaller size. Difference in frequency of grating can be understood with textural distinction. For instance, a burlap bag has a lower frequency of grating per unit area than does silk. Lederman & Taylor (1972) found that subjects could discriminate between spatial frequencies differing by as little as 3 percent. Gwosdow et al. (1986) reported that people tend to find high-grating material like silk more pleasurable than low-grating material like burlap. The third dimension is the vertical axis of the cone which is based on the degree of resistance when our body makes contact with the object. The upper cone section represents the degree of cushion or firmness. For instance, a pillow feels soft because it gives up resistance when the body pushes against it. Manufacturers of bedroom furnishings assign different degrees of firmness to mattresses. However, a concrete floor does not give, and this translates to the feeling of hardness. Although we might think that hardness may be the opposing quale to softness, stickiness may be more opposite to softness than hardness. I would suggest that the sensation of hardness is located in the equator section of the double-cone on the vertical axis. The lower section of the cone represents a sticky sensation, such as is experienced when we step on chewing gum.

The Olfactory Modality

Compared to color or sound, describing smell to someone is quite difficult. Our shortcomings of olfactory expression may arise from the fact that the human's sense of smell is comparatively less developed than that of other animals like insects or rodents.

One of the challenges for the attempt to develop a clasification system of odor is that there is no "obvious" or "direct" mode of objective description of the degree of similarity of odorants as seen in color and sound (Dubois, 2000). Two molecules of similar size and shape can be judged to be greatly different (Schiffman, 1974; Wright, 1982). The findings have all but ruled out Amoore's (1970) stereochemical model (which proposed that the shape of molecules determined the kind of odor we smell). To make the situation worse, the physiology of the olfactory receptors is still largely unknown (Sicard et al., 1997).

The discussion of smell classification goes back as

far as Aristotle. The most well-known model of olfactory qualities is Henning's (1916) smell prism. On the basis of similarities between more than 400 odors, he concluded that there were six primaries: fragrant, ethereal, putrid, spicy, resinous, and burned. In addition, he suggested that the prism is hollow and all intermediate smell should be located at the surface, not inside the prism. Utilizing a multidimensional scaling method based on reports of odor similarity, Wright & Michels (1964) and Schiffman (1974) were able to plot olfactory stimuli in a two-dimensional arrangement. I would propose that all odors can be plotted on the double-cone, and the method of intermodality comparison, particularly with colors, may be useful in finding the intrinsic structure.

The Gustatory Modality

We express whether food tastes good or bad. However, "taste" technically refers only to the perceptions that result from the contact of substances with the taste receptors of tongue, such as sweet, sour, salty, and bitter (Bartoshuk, 1971), whereas, the word "flavor" includes smell, touch, pressure, pain, and so on, in addition to taste (McBurney, 1978). Mozel et al. (1969) found that the ability to identify food substances is severely disrupted when odor perception is eliminated. Subjects were unable to identify coffee, garlic, and chocolate without smell.

Perhaps because of the substantial reliance of other modalities (i.e., smell, touch, etc.) in the intake of food, taste has the fewest number of stimuli among all senses. It is widely believed that there are just four primary tastes (Henning, 1927). Schiffman & Dackis (1975), however, proposed that there are other qualities not contained in the four primary components. They suggested three additional tastes: alkaline, sulfurous, and fatty. And these are not the product of olfaction because even anosmic individuals (those who cannot smell) are able to taste them. O'Mahony and Ishii (1986) also added another called "umami." The taste of umami should be familiar to people who have eaten foods like beef jerky or soup that contains monosodium glutamate. Because of the small number of gustatory qualia available, building the gustatory model is greatly hampered. Nonetheless, intermodality comparison may help to find the intrinsic structure of the gustatory modality.

The Exteroceptive Orientative Modality

Hebb (1949) proposed that lines constitute "primitive unities." His proposal was substantiated when David Hubel and Torsten Wiesel (1959) made one of the most important breakthroughs in neuroscience when they painstakingly began recording with microelectrodes from single cells in the visual cortex. They discovered that, unlike cells in the retina, cortical cells are selectively sensitive to specific patterns. By inserting an electrode into a neuron, they could measure the response of that neuron to various light patterns on the retina. One of the most dominant patterns that the neurons in the striate cortex respond to was orientation to lines and edges. Each cortical cell will respond vigorously to only a particular orientation. And if a line tilt is away from the optimum orientation, the cell's response drops off. The cortical cells in monkeys can distinguish the orientation to within 5–10°.

I would propose that the sense of orientation is also a separate modality. Therefore, it can be accommodated to the double-cone model. The equator section determines the angle of orientation: from 0° to 360°. Arrows would point to the left on 0°, to the top on 90°, to the right on 180°, to the bottom on 270°. Thus, the top half of the circle is right side up and the bottom half is upside down. The vertical dimension represents the tilting of a line either toward me (the top portion of axis) or away from me (the bottom portion of axis). Just as with any colors, any degree of orientation in the three dimensions can be plotted on the double-cone (Figure 1).

The discovery of neuronal selectivity on orientation by Hubel & Wiesel (1959) was essentially only on half of the equator section from 0° to 180°. That means there should be cells selectively responding to upside down orientation. In addition, there should be cells responding to a tilting toward me or a tilting away from me.

The Exteroceptive Locus Modality

All of us have a sort of cognitive map of the world we live in. We can tell where an object, a person, or a place is located relative to another. Spatial perception and its organization allow us to have a three-dimensional internal representation of the outside world. Kant (1781) suggested that space is an a priori form of perception; the property of spatiality precedes the content of sensory experience. His statement regarding space more than two centuries ago is remarkable because we do not normally ask whether space perception is a fundamental visual dimension. I would endorse Kant's proposal and say that, just as with color, sound, smell, taste, and orientation, the sense of location is an elementary modality which cannot be further reduced.

Following the seminal work by Hubel and Wiesel, there has been a flurry of investigations of neuronal selectivity. Among them, neuronal selectivity of locus was reported by Knudsen & Konishi (1978), who found that, in an owl, the unit (receptive fields) responded to sound only when the sound originated from a specific area of space. Interestingly, the nature and intensity of the sound caused

no changes in neuronal activity. Furthermore, the receptive fields of space in the owl are bimodal, responding to both auditory and visual stimuli (Knudsen, 1982).

Locus modality can be plotted on the double-cone system. On the equator section, the central point represents the center. The first dimension is left–right and the second is up–down. The third dimension (vertical) is distance from an observer, with far distance represented on the lower portion of the double-cone and close distance on the upper portion of it. Locus modality allows a sense of location of an object in a visual map and a relative sense between objects. In addition, locus modality enables us to perceive the 3-D shape of an object. For instance, when we see a cubical object like a pair of dice, the sense of 3-D is possible because we perceive some portions of the object is farther from us than others.

The Exteroceptive Motion Modality

An essential question about motion is whether it is a fundamental property or just the displacement of a visual image over time. Nakayama (1985) has discussed the often neglected yet very crucial issue of motion. He persuasively argues that mounting evidence leaves no doubt that motion is a fundamental visual dimension, meaning it is a primary sensory dimension and is not capable of further reduction. He invokes phi movement which is a phenomenon that stationary objects are seen as moving: When two light flashes appear about 100 milliseconds apart, observers see movement despite the inability to perceive an actual object moving across a gap. Gregory (1966) posits that senses of motion and position are separable dimensions. Furthermore, movement can be perceived not only by sight but also by sound and touch (Hornbostel, 1925).

I would support the idea that the sense of motion is an independent modality like the other modalities. Therefore, motion modality also can be expressed with the double-cone system. The first dimension is the motion of left–right. The second dimension is top–down. The third dimension is the sense of the motion coming toward an observer (the upper axis) or moving away (the lower axis) from an observer. And the farther away from the center of the double-cone, the higher speed of motion an object would appear to have.

The Proprioceptive Modalities

In the last three sections, we discussed the three types of modalities all dealing with the perception of an object: orientation, locus, and motion. We can also have those types of senses regarding our own bodies and limbs. The former three modalities are exteroceptions and the latter three are proprioceptions. The terms "kinesthetic sense" and "vestibular sense" are used to designate proprioceptive sensations. Kinesthesia means "perception of movement" in Greek, but it usually includes the sensation of static limb position (Clark & Horch, 1986). The vestibular sense is defined as the system that provides information about orientation, movement, and acceleration (Matlin, 1988). Kinesthesia and vestibular sense often overlap and can be somewhat confusing because the distinction is based on physiology rather than on any intrinsic modality differences. The vestibular sense comes from the central cavity of the bony labyrinth of the ear. The nonauditory labyrinthine organs are known as the vestibular system (Howard, 1986). Kinesthetic sense, on the other hand, arises from activity in sensory receptors that provide information about the angle of the joints, the lengths of the muscles and tensions they produce, and the rates at which these values change (Clark & Horch, 1986).

I would suggest that both kinesthesia and vestibular sense include three types of proprioceptive modalities: proprioceptive motion, proprioceptive orientation, and proprioceptive locus. And the proprioceptive modalities are identical to the exteroceptive modalities in their representation in the double-cone system. The proprioceptive orientative modality gives us a sense of uprightness, which is crucial in keeping oneself standing. We also can have a sense of our limbs using the proprioceptive orientative modality. The proprioceptive motion modality gives our body or limbs the sense of what direction we are moving in and how fast are we moving. The proprioceptive locus modality gives us the sense of where we are.

The Magnitude Modality

Kant (1781) proposed that our way of "sizing up" the world or estimating "how much" is an a priori concept. Korzybski (1958) also suggested that size and numbers represent a higher order of abstraction. Certainly, sizing up is one of our preoccupations: A house is big or small, a person is short or tall, a person is rich or poor, etc. A question we could ask is: Is magnitude inherent within an object or a person? Let's say your friend has $5,000 in his bank account. Is he rich? For an average person, $5,000 would be fairly large amount of money. But it's not considered such an exceptional amount by a millionaire. Thus, just as in thermal sensation, magnitude is not inherent within the objective world but is actually a product of subjective appraisal.

I would propose that the magnitude modality consists of three dimensions. First is the length–width dimension, and second is the number–volume dimension. The vertical axis represents larger magnitude on the upper cone and smaller magnitude on the lower.

The Predicative Modality

As discussed earlier, Aristotle was the first to discuss the notion of the square of opposition. It is a two-dimensional way of showing the interrelationship between the four types of predicates. Like thermal sensations, they show the three complementaries. Aristotle's square of opposition is, I believe, a section of the predicative modality. The predicative modality consists of three dimensions in the double cone. The first is the dimension of certainty. The words like *must*, *probably*, *perhaps*, *could*, *may*, and *possibly* characterize the confidence of sureness. The second is the dimension of proportion such as in the concepts of *all*, *virtually all*, *almost all*, *some*, *few*, *very few*, *virtually none*, and *absolutely none*. The third is the dimension of positive (the upper axis) or negative (the lower axis).

CONCLUSIONS

This paper focuses on the identifying and listing of mental elements and their relationships. It attempts to present a unified system of qualia consisting of 15 modalities: chromatic, emotive, hedonistic, acoustic, tactile, olfactory, gustatory, exteroceptive motion, exteroceptive orientative, exteroceptive locus, proprioceptive motion, proprioceptive orientative, proprioceptive locus, magnitude, and predicative, as shown in Figure 1. The proposed model posits that all modality characteristics have corresponding parts in other modalities. For instance, there are red-like emotions, red-like sounds, red-like hedonism, etc. The attempt to unify qualia is, I believe, equivalent to the effort to produce the periodic table in chemistry in the 19th century. It is a long overdue task in mental science.

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