

The principles of visual perception and their clinical application to denture esthetics

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When the term “esthetic” or “unesthetic” is used, the connotation is that something is seen which is pleasant or unpleasant. This complex process is not merely a rod and cone function. The visual stimuli pass to the center of vision in the brain where the physiologic stimuli can engender a pleasant or unpleasant psychologic response. Whether the viewer’s perception of a visual experience is pleasant or unpleasant may be conditioned to some extent by cultural factors, and what is considered “beautiful” in one culture may be “ugly” in another. For example, the practice of filing the teeth to sharp points as practiced in some primitive cultures is considered beautiful only in those specific cultures. Basically, however, the viewer’s response is a psychologic response resulting from the interpretation of physiologic processes. This stimulus and response constitutes the science of visual perception. Over the centuries, as artists have developed the management of these processes into principles of visual perception, they have been enabled to create scenes of intense vitality, beauty, depth, and realism, all on a two-dimensional canvas. Today, scientific investigations into the physiology and psychology of seeing confirm the validity of these earlier intuitive developments.

These investigations have resulted in the formulation and verification of a set of laws or “principles” of visual perception. It is the purpose of this article to discuss these principles and suggest their application to denture esthetics. The denture is subject to the same perceptual processes as anything else that is perceived. An understanding of perceptual principles can eliminate confusion in the realm of esthetics.

Many different types of denture teeth and systems for their placement are in use today. Some of these definitely produce a better esthetic result. The reasons why this is true lie in the realm of the visual perceptive principles.

The need for a simplified approach to esthetics is enormous. Half of the citizens of the United States over 55 have lost their natural teeth. An average of 20 per cent of inductees into military service require dentures.¹ Medical science is constantly increasing the human life span and there are more insurance plans with dental coverage. Dentists who understand the principles of perception can free themselves

from conflicting and confusing dental rules, and approach the construction of dentures with confidence that they will be esthetically pleasing.

The sins in the field of denture esthetics are of two types: (1) the sin against the principles of visual perception and (2) the sin against the principles of reality. The principles of visual perception should not be applied with such exuberance that a sin against reality results. These principles must be used with all the subtlety and wisdom required in the application of any natural law.

COMPOSITION

We "see" only because the eye differentiates. It can differentiate only if contrasts exist in the situation being viewed. As the amount of contrast increases, visibility increases. As the amount of contrast decreases, visibility decreases. Nature's protective coloration of some animals and birds demonstrates this phenomenon. We are enabled to "see" because of contrasts in color, line, and texture and, of course, enough light must be present to illuminate the contrasts. All of these factors are under the control of the dentist making dentures of beauty that will brighten a long darkened smile.

The study of the relationships existing between objects made visible by the contrasts in color, line, and texture is called composition.

Unity. The prime requisite of composition is unity. Unity means "one-ness." Unity is the ordering of the parts of a composition to give the individual total effect of the "whole." The whole is new entity—greater than the sum of its parts, just as a melody is a separate, greater, new entity than a collection of the notes of which it is composed. Unity exists in two types, static unity and dynamic unity. "Static unity is exhibited by such structures as regular geometric shapes. Natural inorganic forms such as snowflakes and crystals are examples of static unity. Plants and animals are dynamic unities. The former are passive and inert; the latter active, living, and growing. The static structures are fixed and without motion; the dynamic are a crescendo approaching a climax.

"Static designs are based on a regular repetitive pattern and on the uniform unchanging curve of the circle, whereas the dynamic are like the flowing continuity of the logarithmic spiral with its generating nucleus."²

Elements which tend to unify a composition are cohesive forces.³ Elements which lend disunity are segregative forces. Repetitions of shape, color, and line are cohesive forces. Arrangement of the elements of a composition in a definite pattern is a cohesive force. Arrangement of the elements according to a principle is a cohesive force. The presence of a border is a cohesive force. One glance at denture teeth on their card is enough to confirm the fact that most of these factors are present in the raw materials with which the dentist must create his denture. Unfortunately, the resulting unity is of the static type, so the resulting denture is a dull and uninteresting composition on its own merits. This impression is heightened by the placement of the anterior teeth on the unchanging curve of a circle—(the silver dollar denture). This type of composition has no place in a living or dynamic organism because the resulting appearance of the patient lacks unity because the denture does not give the entire patient the total undivided effect of a living being. This is the greatest sin against visual perception in denture esthetics—the placement of a static, dead denture in

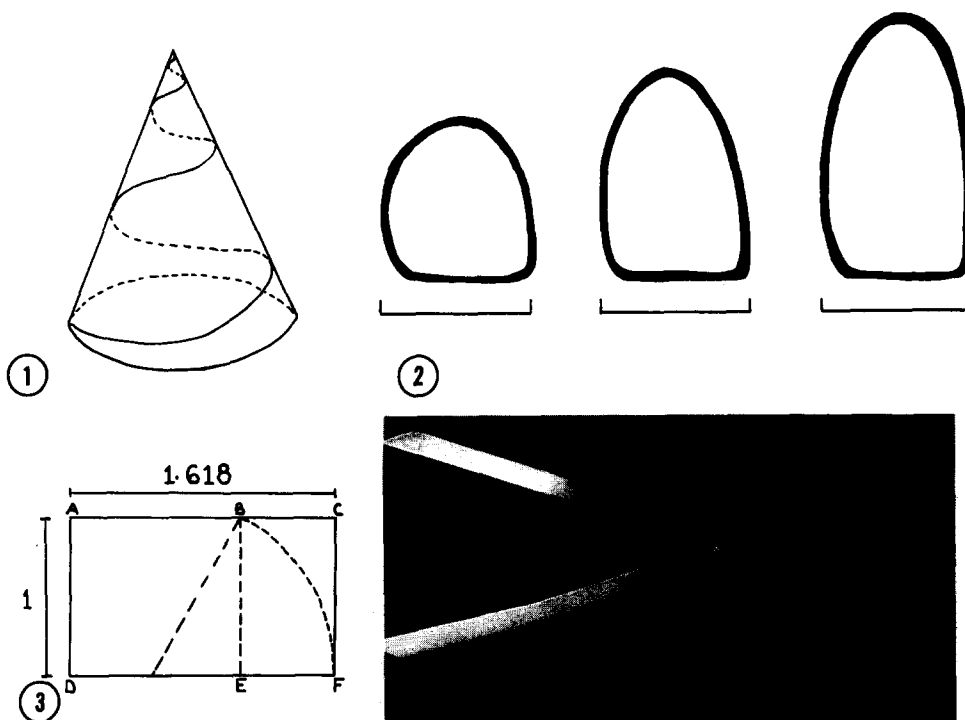


Fig. 1. Hogarth's line of beauty: A line inscribed around a cone. It is never the same at any two points, yet never deviates from the principle of the cone structure. Absolute unity with absolute variety is provided.

Fig. 2. Proportion: Teeth of equal widths but different lengths appear to have different widths.

Fig. 3. The golden mean rectangle: This geometrical construction provides the significant mathematical ratio or proportion mentioned above as follows:

$$\frac{AD}{AC} = \frac{AC}{AD \quad DF} = \frac{BC}{CF} = \frac{\text{Area BCEF}}{\text{Area ABDE}} = \frac{\text{Area ABDE}}{\text{Area ACDF}} = \frac{1}{1.618}$$

Fig. 4. Proportional divider: The openings at the ends provide a ratio of 89 to 55. This ratio is too strong for dental use.

the most mobile and active of all the facial features in a living, dynamic, human being. Bad as this is, it is usually only part of the macabre story. The teeth in such an abomination are usually set tight against the residual ridge so that, when they are in the mouth, they appear to be too high and too far back, in a position where they could not possibly be placed by nature. This is a sin against reality. The always-searching eye of the beholder notices this immediately as "something wrong."

The age, sex, and personality factors previously delineated for us⁴ are extremely important because they provide a type of subjective unity necessary to give the total undivided effect of a specific life, of a specific sex, at a specific place in time, and avoid another sin against reality. The objective of the dentist should be to provide dynamic unity, not static unity.

Unity with variety. Segregating forces must be introduced into the dental com-

position to produce dynamic unity. Segregating forces are the opposite of cohesive forces. Unity with variety is necessary to make a design effective because, although the elements must be bound together in an organic whole, they must be bound together in an interesting manner.

Hogarth's line of beauty has long been considered an outstanding example of unity with variety. It is commonly misunderstood to be an "S" curve. Actually it is a line inscribed around a cone. The line is never the same at any point along its course yet it never leaves the surface of the cone (Fig. 1). This is absolute unity with absolute variety. Adoption of a line resembling a segment of this line for tooth placement and base festooning adds greatly to the dynamism of a set-up and is strongly recommended as a substitute for the unchanging curve of the circle.

Dominance. Just as unity is the prime requisite of a good composition, dominance is the prime requisite to provide unity. One shape, color, or line must dominate, and all others must be subservient. A grouping of similar visual weights in a composition produces incoherence unless they are arranged in a definite pattern, which then produces a static composition. This leaves only one possibility for the dentist to achieve dominance in the denture. One tooth must dominate the anterior tooth arrangement by virtue of its size. The central incisor is the logical choice (reality). The central incisor selected should be enough larger than the lateral incisor to dominate the composition and bring order and coherence to it. The cuspid size is not a factor because only its mesial aspect is seen.

The mouth is the dominant feature of the face. It dominates by virtue of its size, its mobility, and the psychic associations with which it is involved. The amount of dominance to be given to the mouth by the denture set-up depends upon the evaluation of the patient's personality and the strength of the background facial features with which the mouth must compete to attain dominance, and thereby bring harmony to the total facial composition.

The dominance of the dental composition may be increased by making it more visible. Increasing mold size, using lighter teeth, placing the teeth farther anteriorly, and increasing the exposed gingivoincisor length, are all methods of increasing visibility. By decreasing these factors, less visibility is achieved, and therefore less dominance. Mold and shade selections depend upon this dominance requirement. For a patient of soft personality, of "mousy" coloration, with average facial features, and with an average amount of tooth area exposed, mouth dominance may be achieved by minimizing the above factors. For a patient of strong personality, striking features, and brilliant coloration, all or part of the above procedures may be resorted to in order to bring the mouth to its dominant role in the facial composition.

PROPORTION IN DENTURE ESTHETICS

The entire human figure can be described in terms of proportionate sizes of the various parts.⁵ In discussing the size of the teeth, it is always necessary to consider the element of proportion. The relationship of width to length of a tooth is important because, if two teeth are of the same width and different lengths, the longer tooth will appear to be narrower (Fig. 2). The true value of proportion in denture esthetics, however, is in its usefulness as the key tool in providing the unity-with-variety quotient to the dental composition. "From the standpoint of design, the best possible

division of any surface is one that creates those two basic requisites of all fine design, unity and variety."⁶ The most satisfactory surface division, therefore, is one in which interest and unity are produced by dividing the plane into parts that, although contrasting in shape or size, are related to each other and to the original surface.

The repeated ratio. This is accomplished by the use of a continued proportion or repeated ratio. For example, the so-called "golden mean," 1.618, was known to the Greeks and appears in their architecture. It is the approximate constant factor in the summation series 1, 2, 3, 5, 8, 13, 21, 55, 89. It is best expressed as a mathematical proportion: 89/55. The width of the golden mean rectangle is one side of a square; its length is one half the square plus the diagonal of half the square. This results in a rectangle in which the length/width ratio is 1.618/1 (Fig. 3).

Greek buildings, built without algebra, were constructed by using "rope stretchers." The sizes of various parts of the building were kept in proportion by the use of ropes. The Parthenon, long considered among the most beautiful architectural creations in history, has all of its parts laid out on the proportion of 1.618 to 1. This ratio is found in nature, in shells and plants. In a sunflower head 5.6 inches in diameter, the intersecting curves will show a series of 55 long curves crossing 89 shorter ones.⁷ In smaller or larger heads the numbers change but the ratio remains constant. This ratio has been explored in relation to tooth size and as a repeated ratio for the horizontal division of the area of the mouth, but it has proved to be too strong for dental use (Fig. 4).

Further studies are indicated to determine the presence or absence of a specific width of tooth ratio that is pleasing. For now, all that can be done is to use the ratio established between the width of central and lateral incisor and continue this ratio in the placement of the remaining teeth and spaces.

If the same ratio between the width of the central incisor and lateral incisor is repeated between the lateral incisor and the amount of cuspid shown, and between the cuspid and bicuspid, etc., each tooth size will be different (variety) but related (unity) because of the repetition of the same ratio. This is bringing order by organizing the elements according to a principle.

The repeated proportion provides a guide to some questions raised under the discussion of unity. How large should the central incisor be in relationship to the lateral? It is true that the central incisor should be large enough to dominate the composition, but how much larger than the lateral incisor should it be? How wide should the cuspid be when viewed from the front? If a space is to be left between teeth, how wide should it be? By selecting a proportion and placing the teeth accordingly, a composition exhibiting unity with variety can be produced.

In the extremely wide mouth, the bicuspid may be the tooth that "turns the corner." In following the ratio, care must be taken to avoid placing the cuspid or bicuspid so far lingually that interference occurs with the tongue's activity during speech.⁸

The first bicuspid is one of the most common sinners against both perception and reality, and is often placed without adequate consideration to its explosive effect on an otherwise attractive set-up. It is usually the key tooth in maintaining the repeated ratio and is the key tooth in a natural transition from "front to back." The

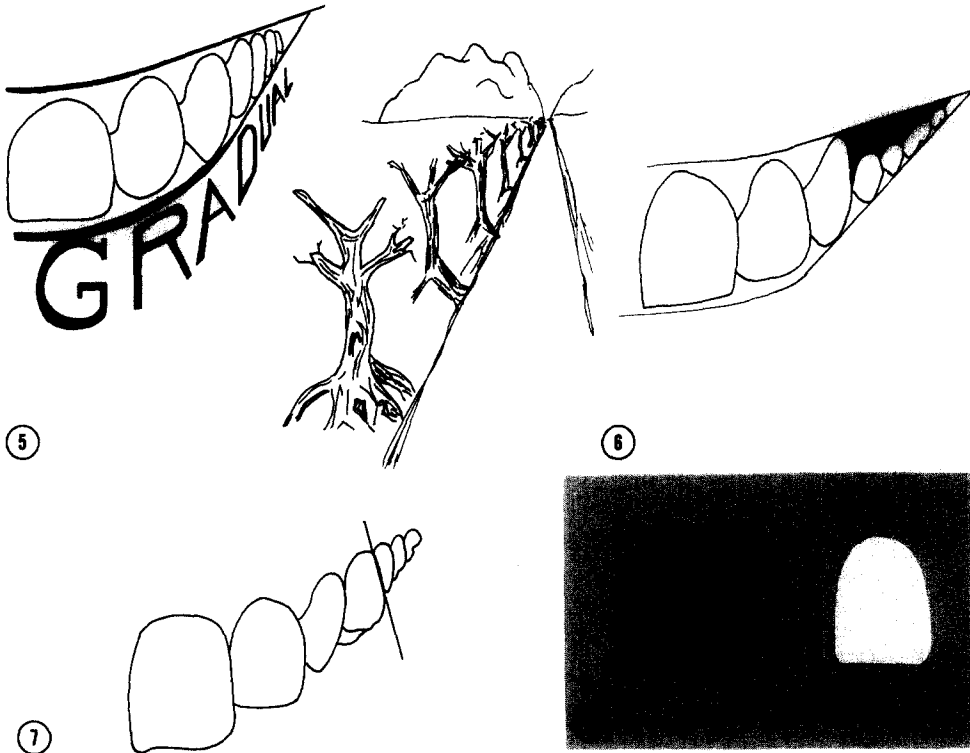


Fig. 5. Gradation: The diminution in size and detail must occur gradually.

Fig. 6. Short bicuspid: This destroys the illusion of depth and realism.

Fig. 7. Buccally placed bicuspid: This also destroys the illusion of depth and looks unreal.

Fig. 8. Principle of illumination: In two objects of the same size, the lighter will appear larger.

first bicuspid must meet all the requirements of an anterior tooth. Therefore, from the esthetic standpoint it is an anterior tooth and should be considered as one of the *eight anterior teeth*.

Illusion. The front-to-back progression is a critical factor because the illusion of arch shape and depth must be provided in the composition. The principle of gradation must be observed. If two like structures are placed at different distances on a line from the viewer, the closest one to the viewer will appear larger. If other like structures are interposed between these two, the size reduction will appear to be a gradual one from the size of that of the closest one to that of the farthest (Fig. 5). The use of a short bicuspid violates this principle (Fig. 6). The bicuspid placed too far buccally is also in violation (Fig. 7).

The buccal corridor helps achieve these requirements by altering the light. If two objects are the same size, the lighter one appears larger; this is the principle of illumination (Fig. 8). As the teeth pass posteriorly, the light is reduced and this gives a gradually darker shade and therefore a smaller appearance. It also blurs the detailed features, which increases the illusion of distance and therefore depth.

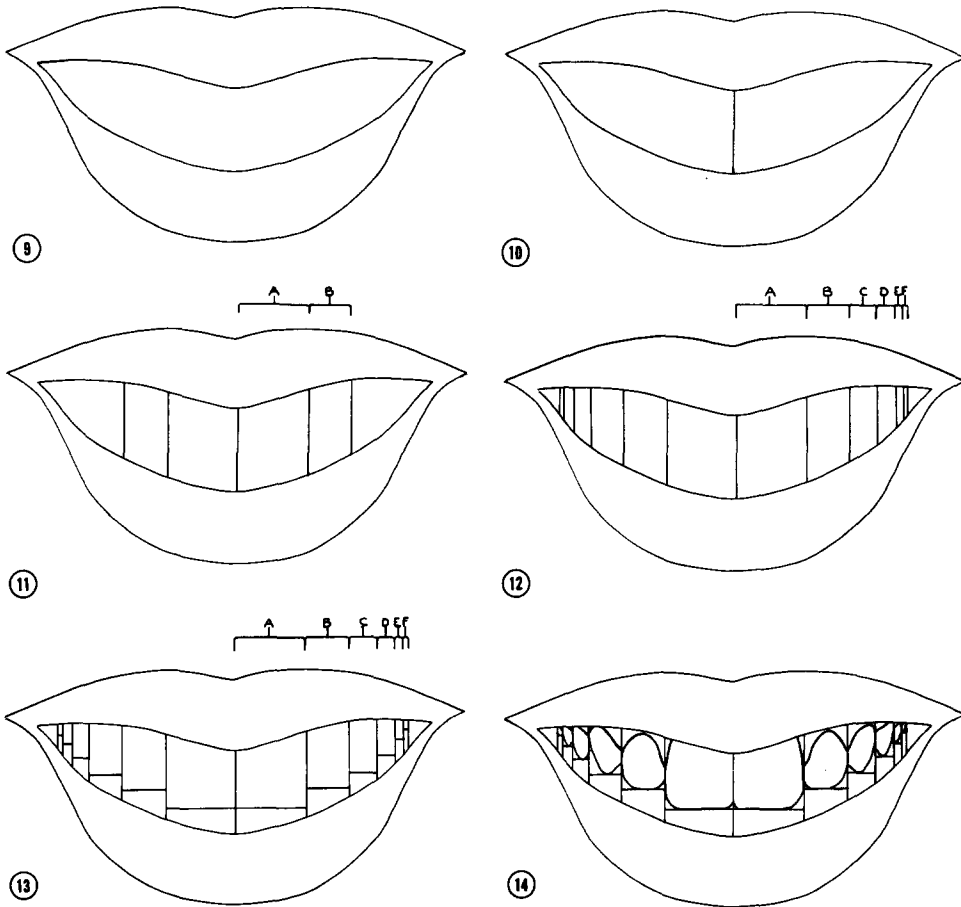


Fig. 9. Preplanned esthetics: The edentulous space is visualized as the surface to be utilized for a dental composition.

Fig. 10. The midline is established.

Fig. 11. Horizontal space allocation begins: Central incisor and lateral incisor spaces *A* and *B* have a ratio to each other.

Fig. 12. The repeated ratio: Horizontal space allocation for remaining teeth is continued by repeating the ratio. $A/B = B/C = C/D = D/E = E/F = K$, a constant.

Fig. 13. Vertical space allocation: Incisal length is established.

Fig. 14. Actual tooth shapes assigned: The tooth shapes are placed in the areas in the spaces allocated.

ESTHETICS

Preplanned esthetics. The preceding discussion provides enough information for preplanning the esthetic design, or tooth space allocation of the proposed denture. Such planning is one of the most important steps in the procedure and the one most commonly omitted. Bearing in mind the evaluation of the patient as a being, an analysis should be made of the shape of the mouth. Important features to be considered are width and height, and the location of commissures when the mouth is

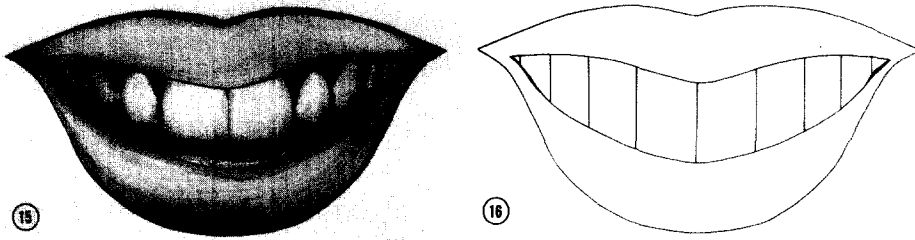


Fig. 15. The preplanned prosthesis: Mold characteristics, matrix, shade, and the modeling effects of light create the completed prosthesis.

Fig. 16. Unplanned esthetics: Horizontal space allocation provides a monotonous division of space.

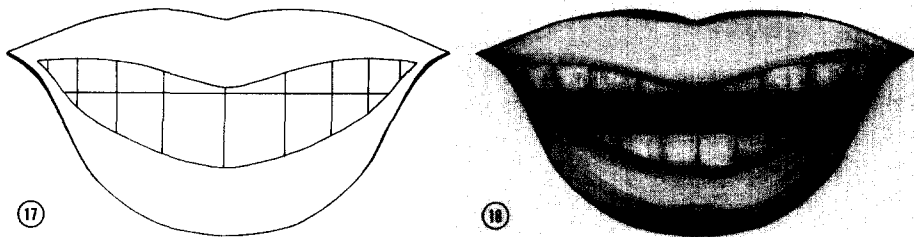


Fig. 17. Vertical allocation of space: The placement of the teeth against the residual ridge results in an unreal position of teeth.

Fig. 18. Completed unplanned prosthesis: The resultant prosthesis provides the typical static denture that results in so-called "denture mouth."

in a smiling position. Because the immediate frame of the area to be occupied by the dental composition is provided by the lips, the edentulous mouth may be regarded as a blank space of irregular outline in which the dental composition will be made. Because the most space is shown in the wide smile position, it is this space that should be considered.

All decisions made in regard to tooth selection and placement should be made on the basis of the features of this space and the evaluation of the patient as a being. This fact eliminates the laboratory technician from this phase, and means that these decisions must be made by the dentist because he is the one who "sees" the patient. In the event that the laboratory technician is to be asked to make the set-up, after the mold and shade have been selected, he must be provided with complete and detailed instructions, including sketches to indicate desired tooth positions.⁹

There are very few dentitions that cannot be made more attractive by minor alterations. When an immediate denture is to be made, the existing dentition should be subjected to analysis to find the minor modifications that can be made to bring the resulting denture into closer agreement with the esthetic factors involved.

The preplanning of the esthetics is illustrated (Figs. 9 to 15). Unplanned esthetics will result in a multitude of sins (Figs. 16 to 18).

Requirements of an esthetic upper denture. An esthetic upper denture requires

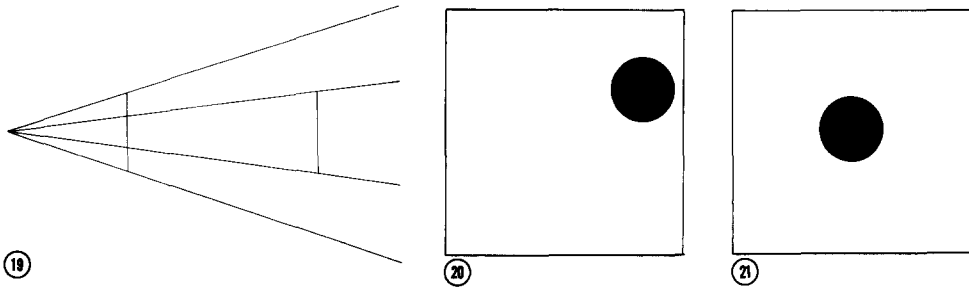


Fig. 19. Illusion: The vertical lines are the same length.

Fig. 20. Lack of balance: The disk on the square would look better in another position. It is unstable.

Fig. 21. Balance: The disk seems more stable in this position.

that its dental composition exhibit all the above-mentioned qualities. Not all anterior teeth must be of similar widths. Dominance must be exhibited by using a central incisor of sufficient size to dominate the composition. Teeth must not be set on the static curve of a circle, but on a dynamic line similar to Hogarth's line, and teeth must be set with regard to a repeated ratio to provide unity with variety. The teeth must be modified to harmonize with the patient's age, sex, and personality to provide subjective unity. Variety of shading must be provided. The lines provided by the matrix must not be straight. The composition must be placed in a natural position. Hierarchy and gradation principles must be observed. The composition must be balanced. With a prosthesis meeting these requirements, a patient will have all of his "parts" giving the undivided total effect of life—his particular life. The denture will exhibit unity with the entire patient.

All other esthetic factors must be analyzed after the teeth are set-up and viewed in the mouth. Because the background directly affects the appearance, it is necessary that all of the teeth be set-up for try-in. The practice of evaluating six anteriors in a bite-block is therefore valueless. The dentist should set-up the teeth while the patient is present for these reasons and because of the wonderful educational opportunity presented by this procedure.¹⁰

BALANCE IN DENTURE ESTHETICS

One of the most important factors to be considered at try-in is that of balance. The dictionary definition of balance states that the word denotes the stability resulting from the equalization or exact adjustment of opposing forces. Balance suggests a steadiness that results when all parts are properly adjusted to each other, when no one part or constituting force is out of proportion to another. A synonym for the word balance is equilibrium, if esthetics is the subject to which it is applied.

Every act of seeing is a judgment. One can see nothing without also seeing the immediate surroundings at the same time. Isolation is visually impossible. The mind is constantly interpreting the relationships of objects to each other. The item viewed is catalogued instantly as "in front of," or "larger than," or a "different color from" the other objects in the visual stimulus. Such cataloguing occurs effortlessly and without conscious thought. Even illusions are accepted until some other event proves

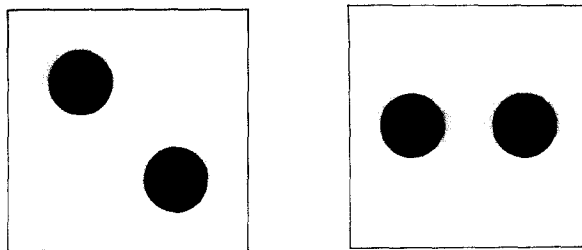


Fig. 22. Balance of pairs: When a pair of disks are placed on the square, it is the location of the center of the pair which lends balance and stability to their placement.

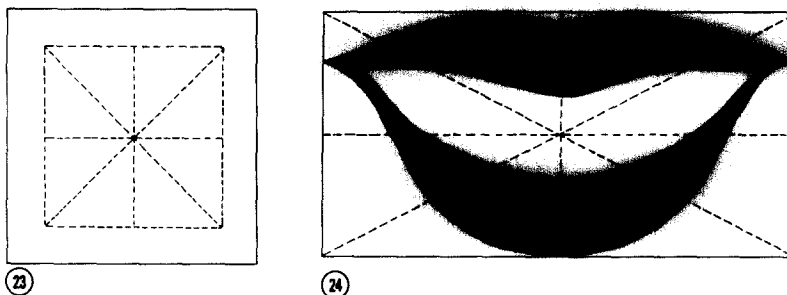


Fig. 23. Structural map: The directions in which the disk seems forced to move on the square are illustrated by the dotted lines. These indicate the structural axes of the square along which the disk gains the most stability. The most stable position is the center, which is the intersection of the structural axes.

Fig. 24. A proposed structural map of the tooth area: The most stable point is at the intersection of the axes and indicates the critical role of the midline.

them wrong. In fact, it may require a measurement to prove that two lines in an illusion are actually the same length (Fig. 19). The eye perceives them as having different lengths, because the additional information provided by the surrounding lines can be interpreted no other way. Certain visual relationships exist in which the perceived object and its background exhibit an uncomfortable tension.

Induced forces. The disk on the square exhibits the phenomenon of induced forces (Fig. 20). There is a desire on the part of the beholder to see the disk move toward a more stable position—probably toward the center (Fig. 21). If another disk is added, the tension is relieved when the center of the “pair” of disks coincides with the center of the square (Fig. 22). (Experimenting with the disk and square is a good exercise to demonstrate this to oneself. It may be carried one step further and carried out on the complex mouth shape.) “This tension is not a supplementary contribution of intellect or fancy. It is as much a part and parcel of the percept itself as size, location, or blackness.”¹¹ Since the tension has a magnitude and a direction, it may be described as induced force because nothing is actually pushing or pulling on the disk. The force field of the disk is affected by the structural features of the surface upon which the disk is moved.

Structural map. The most stable position of the disk is in the center. It seems to be repelled by the borders. It seems more stable along the diagonals of the square

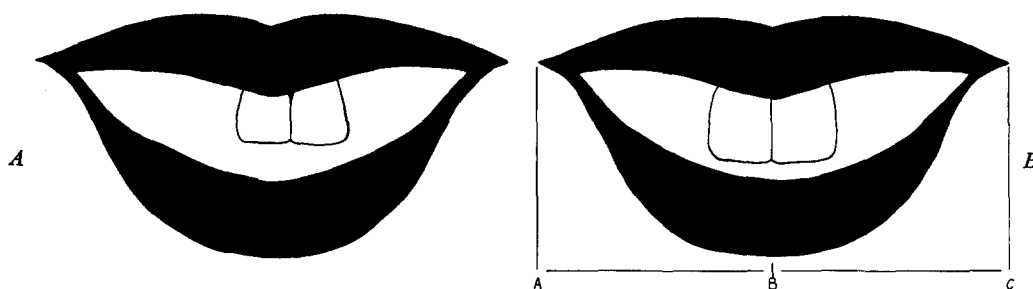


Fig. 25. (A) Improper midline: The teeth seem induced to move more toward the center. (B) A measured midline.

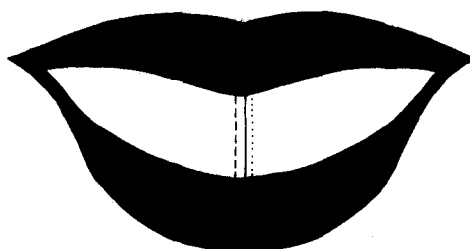


Fig. 26. Visually determined midline: The eye is a competent evaluator. Dotted lines indicate lines drawn in an effort to place the midline by freehand drawing. The line on the left was placed first and found to be wrong. The line on the right was placed second and was also wrong. The heavy line was then placed and judged to be correct. This line exactly overlies the line of the measured midline in Fig. 25, B.

and along the cross formed by the central vertical and horizontal axes. The "center" is established by the crossing of these four main structural lines. A structural map of the force field of the square may be drawn (Fig. 23). It illustrates the directions in which the disk seems to be induced to move toward the more stable positions, which are at the important structural elements of the square. A proposed structural map of the force fields of the tooth area of the mouth is illustrated (Fig. 24). The proper midline location is necessary for stability. It may be conjectured that the attractive qualities of the "smiling line" may derive from the stability gained by this line's approximation to the diagonals of the structural map.

The induced forces principle answers the question of whether the midline should be placed in the middle of the head or the middle of the mouth. It should be placed at the point where it seems to remain stable and does not seem to move left or right (Fig. 25). The midline need not be measured. A long contemplative look at the midline will reveal if this stability exists (Fig. 26).

Because of induced forces, unbalanced things look transitory, restless, unfinished, accidental, temporary, aggravating, and tense. Balanced things, in contrast, look permanent, stable, completed, planned, peaceful, and in repose, because the visual tensions are eliminated.

Generally speaking, left and right balance may be considered in terms of the visual weights in the composition over a centrally located fulcrum. Things farther out from the center exert more leverage than those closer to it. Balance does not

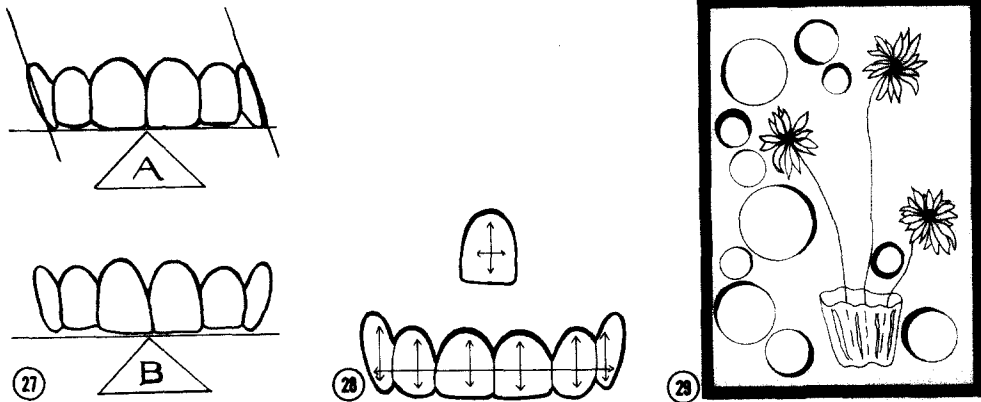


Fig. 27. (A) Balanced of direction: Directions must be balanced as well as weights, or the resulting arrangement looks transitory and unplanned. (B) Direction of the midline: Imbalance results from altered direction of the midline.

Fig. 28. The primacy of the whole: The dimensions of an individual in a series become secondary to the dimension of the new whole created by the entire series.

Fig. 29. The presence of a border: The border unifies the elements within it. The elements of the painting have no relationship to the shape of the wall upon which it is placed.

require symmetry, although formal balance means that things are the same on both sides. Informal balance means that the weights of the elements on either side of the fulcrum are equal but not symmetrical. Two small children on one end of the teeter-totter may balance one large child on the other end. The weights on either end are equal, but not symmetrical.

Balanced weight and also balanced direction must be achieved in a successful composition. Any visual weight added on one side of the fulcrum requires a balancing compensation on the other side of the midline. The principle of illumination must also be considered when speaking of balance. This merely says that when two objects are the same size, the lighter one will appear larger. The larger object has more visual weight. In denture esthetics the balancing problem is complicated by the fact that the patient sees the prosthesis in the mouth only by looking in a mirror, and therefore sees only a mirror image in which left and right are reversed. It is wise for the dentist to consider the try-in in a mirror along with the patient if misunderstandings are to be avoided.

Effect of gold restorations. Visual weights to be managed in the dental composition are the teeth, spaces between the teeth, and added gold restorations. For example, the balance of an otherwise balanced set-up is upset completely by the addition of a gold restoration. The following steps may be taken on the opposite side: (1) A like restoration may be added on the other side in a similar position. This is a static and therefore a poor solution. It results in the appearance of a denture with a set of headlights. (2) A space may be left on the other side between the lateral and the cuspid. (3) A larger cuspid may be used on the other side. (4) More of the cuspid on the opposite side may be shown by moving it labially. (5) A lighter shade cuspid, giving the appearance of being larger, may be used.

If gold must be used, it should be confined to the distal of the central incisor or the mesial surface of the lateral incisor, because this area is closer to the midline (visual fulcrum) and therefore easier to balance. It should never be used on the mesial surfaces of central incisors because this gives separation to the appearance of a "pair" of centrals and splits the one composition into two compositions. The use of a definite diastema between the central incisors is contraindicated for the same reason, although if the resulting cohesive relationship between these incisors (nearness) is stronger than that between the central and lateral incisors, a very minute diastema may be successfully employed.

It is much simpler not to use gold restorations because they most often result in an unbalanced composition. Enough other devices are presented herein to insure a realistic appearance. Such unseemly gold display is being eliminated in restorative dentistry and should be eliminated from denture esthetics as well.

The lack of balance of direction (Fig. 27) is often the result of cross-bite ridge relationship in which the upper tooth, usually the cuspid, is not placed lingually in relation to the lower cuspid. This directional balancing sin is no less offensive than the lack of balance of visual weights. The debate continues over the need for "balanced occlusion," but there can be no debate over the need for "balanced esthetics." An esthetic denture has its midline placed in a stable position and the visual weights and directions on either side are in a state of equilibrium.

LINE IN DENTURE ESTHETICS

Referring to the opening premise that the eye differentiates because of contrast in color, line, or texture, it is obvious that the management of the factor of line is an important element in arrangement of an esthetic denture. Line is involved in the shape of a tooth, the relationships between adjacent teeth, between the teeth and the matrix, between the teeth and the background, and between the teeth and the dark space area between upper and lower teeth when the mouth is open. Line is also involved in the line formed by the incisal edges and buccal cusp tips of the teeth, in the occlusal plane, and the perspective illusion created by the total composition.

Mold. In dentistry the shape of the tooth is included under the term "mold." In addition to the mesiodistal shape of the denture tooth, the labiolingual shape and surface characteristics are included in the characteristics of a given mold.

The subjective characteristics of age, sex, and personality are usually referred to in conjunction with characteristics of mold. The practice of ascribing these characteristics to teeth may be challenged. "Methods based on these theories may at first appear to have some logical basis for their acceptance, but to obtain agreement on the personality of a tooth presents unusual difficulties."¹² It is definitely true, however, that certain tooth characteristics render some molds more amenable to blending into the desired type of composition that is the objective for a specific patient.

Far too much emphasis has been placed on the importance of selecting a particular shape of tooth for a particular patient, because the real importance lies in an understanding of what happens when all the teeth are together, interacting within the dental composition. The practice of trying to select a tooth the same shape as an upside down face may have some merit as a previously registered impression of the total presented physiognomy, but each of the facial types presented as guides to

tooth shape are somewhat ambiguous. "Who has seen a square face?" Facial shapes are extremely varied and the mold types suggested are so limited that their application requires heroic acts of judgment. Further, the selection of a tooth on this basis almost requires a measurement at certain planes of the head, because the apparent shape of the head is constantly being revised by those in the beauty industry. The beauticians have a head shape classification that differs from the accepted dental system. In their classification, head shapes are classified as square, round, diamond, and long. They teach that by applying darker or lighter make-up in certain areas, restyling the hair and lipstick outline, they can give the head the illusion of being an entirely different shape. A patient's face diagnosed as "square" in the morning may be "ovoid" in the afternoon.

The shape of the individual tooth is unimportant because of two other perception principles. The first of these is the primacy of the whole. The shape of an element becomes secondary to the shape of a series of the elements. The "parts" become a new whole (Fig. 28). The second factor is the presence of a border, which binds the elements within into a separate organized entity. For example, a painting may be purchased in a particular shape and size to fit the area in which it will hang, but there is no recorded instance of a painting purchased because the elements within the painting are the same shape as the wall (Fig. 29). The frame confines the attention of the eye to the contents within the frame. In dentistry, the wall (face) and frame (lips) are provided for us by nature. The attention of the eye is confined to the contents within the lips. It is impossible to give careful consideration to the teeth and the face shape at the same time. Teeth selected on the premise of face shape are as good as or better than those of any of the other systems, but such selection is definitely not an exact science.

Mold requirements. The mold selected should be one in which the central incisor will dominate the space available for the anterior teeth, and should have a pleasing proportion. The shape should not be of extreme characteristics and should easily be reshaped to harmonize with the factors necessary to unify it with the realism factors. The lateral incisor must be enough smaller than the central incisor that central dominance exists. The 16:1 head:tooth ratio is a convenient guide for selecting the size of the central incisor for patients without unusually corpulent faces. The entire set-up must be viewed in the mouth to evaluate the size of the teeth, but the pre-planning should reduce the number of errors made in tooth size.

For immediate dentures, nature's mold selection is a good place to start. Pre-extraction records can be invaluable guides to mold and also to tooth position.¹³

Each dentist should select a few molds of different characteristics that are available in three or four sizes and learn how to modify them. He will have all the molds necessary to produce esthetically harmonious dentures and will no longer need to open the mold guide with all its confusing and terrifying array of shapes. It is not the shape of the individual tooth that counts, but what happens to the tooth in the total composition.

Line in the dental composition. In pure lines, the strongest relationship that can exist between two lines is a perpendicular relationship because it exhibits the greatest possible contrast. The most harmonious relationship that can exist between two lines is a parallel relationship because it exhibits the least possible contrast. The perpen-

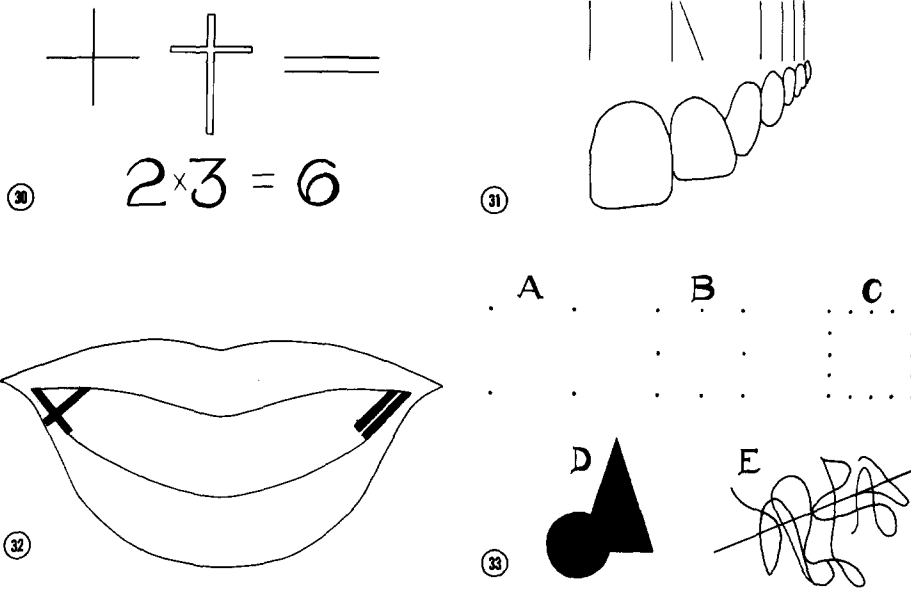


Fig. 30. The relationship of lines: The perpendicular line relationship is the strongest because it has the greatest contrast. This relationship has strong psychologic overtones such as when seen as a "cross." The parallel line relationship is the softest because it offers the least contrast and is therefore the most harmonious relationship of lines. It is used as an "equal" sign.

Fig. 31. Conflict of line: The line formed by the distal outline of the lateral incisor is a frequent offender in the line relationship in harmonious dental composition.

Fig. 32. Cuspid-lip relationship: Cuspid-lip relationship may create a soft (parallel) or strong (perpendicular) effect by the relationship it has to the lower lip.

Fig. 33. Factors of closure and simplicity: The mind recognizes objects in terms of the simplest forms that it is able to apply. In *A*, *B*, and *C* the dots are seen as a square. *D* is interpreted as a circle and a triangle. In *E* the simplicity of direction of the straight line makes it stand out in a welter of lines.

dicular lines have other strong psychologic connotations, such as when seen in the cross. The parallel lines connote harmony; no contrast exists, and the distance between them remains constant. In fact, they are used as the "equal" sign in mathematics (Fig. 30).

The line relationship between adjacent teeth should be harmonious, that is, striving toward parallelism—and therefore harmony. The chief offender is usually the line formed by the distal outline of the lateral incisor (Fig. 31), but the buccal surface of the first bicuspid is a very close second. It is often necessary to reduce the distolabioincisal contour and the incisal third of the distal outline of the lateral incisor to eliminate the conflicting line. The neck of the lateral incisor may be kept out labially to minimize the line conflict. The conflict offered by the bicuspid can usually be handled by repositioning the tooth. The line formed by labial outline of the cuspid is especially important because, when viewed from in front, it is a prominent line and it is close to the line formed by the lower lip as it curves upward toward the commissure. It actually completes the smiling line. It is close enough to the lip line

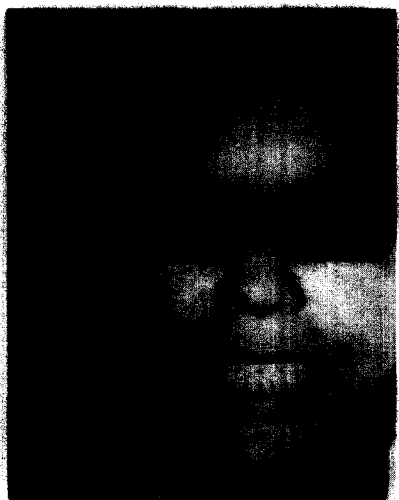


Fig. 34. Relines: The practice of restoring lost occlusal vertical dimension by relining only the lower denture may raise the occlusal plane to an unrealistic position.

to enter into a visual relationship, to be seen at the same time. If the incisal edge is tipped lingually, the line formed by the labial surface of the cuspid is more nearly parallel to the line of the lower lip and exhibits a soft relationship. As the cuspid is tipped further labially at the incisal edge, it becomes more perpendicular to the lip line and exhibits a strong relationship (Fig. 32).

The repetition of the vertical lines of the proximal surfaces of the anterior teeth establishes a strong verticality of lines. A tooth with a deviation from this axis will have a magnified and more powerful effect. Therefore, these tooth axes and lines must be handled very judiciously.

At the smile position, if the incisal edges of the anterior teeth parallel the line of the lower lip as in the smiling line, a harmonious relationship exists (parallelism). A line out of harmony with the lip lines presents a jarring contrast. A line need not be complete to be perceived. The perceptual factor of closure is responsible. A series of dots or incomplete lines can be perceived by the mind as a shape. Additionally, the factor of simplicity is at work. The mind simplifies.¹⁴ It organizes its perception in terms of forms it recognizes. It instantly recognizes structures and organization. Four dots become a square. An irregular shape is seen as a triangle and circle or cone and ball. Further, it recognizes the simplest form it sees in a welter of confusing lines or forms (Fig. 33). When the statement is made that the teeth should be set on a certain type of line or curve, these are the factors that make it possible. The incisal edges and cusp tips can create a line in the dental composition.

The occlusal plane is another critical "line" in the composition and must be located in the proper position, usually at the line of the commissures with the mouth slightly open but at rest. The practice of restoring lost vertical dimension by relining only the lower denture may elevate the occlusal plane to be an unrealistic height, and for this reason is to be condemned (Fig. 34). The plane must not be allowed to drop as it progresses posteriorly to prevent another sin against reality and beauty.



Fig. 35. The occlusal plane: The occlusal plane must rise as it progresses posteriorly.

Fig. 36. Negative space: The space between the upper and lower teeth is sufficient to give the illusion of teeth being present in some illustrations.

Fig. 37. The negative space: This space may be as important as the object depicted. Is this an illustration of a vase or two profiles?

The use of the bite plane is a simple tool that helps guard against this (Fig. 35). Finally, the lines of the matrix at the gingival must be curved to prevent a sin against reality.

The negative space. Many illustrators avoid trying to depict the actual teeth when depicting a smiling face.¹⁵ They provide the illusion of teeth by portraying the dark space of the mouth behind the teeth (Fig. 36). This "negative" space is as important a space in a composition as is the "positive" space or object being depicted (Fig. 37). It is in altering the shape of the incisal edges contrasted against this black background that the dynamism and realism factors can be best analyzed for their effect (Fig. 38, *A* and *B*). The shape of this negative space should be carefully considered, including the effect contributed by the lower anteriors (Fig. 39). Incisal modifications for those uninitiated in tooth modification can be readily remembered and employed by a simple "one, two, three guide." *One* is the central incisor that expresses age. *Two* is the lateral incisor that expresses sex characteristics. *Three* is the cuspid that expresses vigor (Fig. 40). Parenthetically, a "one, two, three" guide for posterior teeth is also useful. *One* is the first bicuspid whose chief function is esthetics. *Two* is the first molar whose function is mastication. *Three* is the second molar whose function is occlusal balance. The second bicuspid may be discarded or assigned to "one" or "two" depending on the situation. These may seem to be oversimplifications, but simplicity is necessary for one who is taking the first steps at altering a tooth arrangement.

Gradation and hierarchy principles must be observed by the lines of the arch form as it progresses posteriorly.

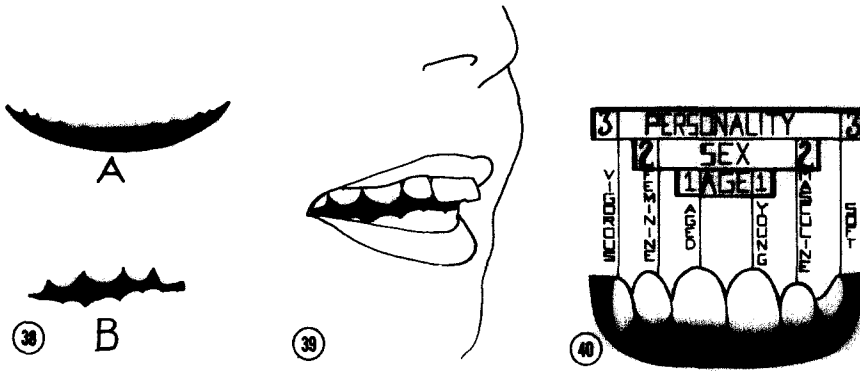


Fig. 38. (A) A static negative space. (B) A dynamic negative space.

Fig. 39. Evaluating the negative space: The negative space in Fig. 38, B appears here between the teeth. An examination of this space facilitates examination of the set-up for vitality and realism.

Fig. 40. The one, two, three guide: The central incisor, lateral incisor, and cuspid and their relationship to the negative space can impart the age, sex, and personality characteristics as indicated.

COLOR IN DENTURE ESTHETICS

The study of color is an immensely complicated study in itself. The word "color" in the dictionaries is followed by from five to seven pages devoted to this one word. Fortunately, all of the mountain of information written on the subject is not closely related to the subject of dental esthetics. However, an understanding of the basic components of color will eliminate some of the current dental misconceptions that so seriously handicap the profession.

The three main components of a color are its hue, intensity, and value. Hue refers to the characteristics of a color that give it its identity and differentiate it from other colors. Red is a hue; so are yellow, blue, and the other colors that are known by name. Light waves contain all the colors of the spectrum. When the light waves strike an object some of the rays are absorbed and some are reflected. It is the reflected light waves that give the reflecting object its color. For example, if the light waves strike an object which absorbs all except those of the blue area of the spectrum, only the blue light waves are reflected to the eye and the object is therefore seen as a blue object. A blue pigment is actually a pigment which absorbs all of the color spectrum in the light wave except the blue which it reflects, but it is obviously more convenient and much simpler to refer to it as having the color property of being blue.

Intensity refers to how much of the actual pigment is in the color being described. If the color has a strong concentration of hue pigment, it is a strong color. For example, a strong red has a heavy hue pigment concentration. A weak red may have the same quality of hue pigment, but it also has other colors or neutrals mixed with it which dilute the effect of the red pigment.

Value describes the lightness or darkness of a color. Black and white are described colloquially as "not colors." They result from light waves that hit objects



Fig. 41. A value scale: A range of grays from black to white used to gauge gray tone in photography.

that do not absorb portions of the spectrum but reflect the entire light wave. The objects that reflect the most light waves are "white." The objects that reflect the fewest light waves are "black." If white and black pigments are mixed, the resulting color will be a medium gray, halfway between black and white. If this medium gray is again mixed with black, a darker gray results. If the medium gray is mixed with white, a lighter gray results. This admixture of the resulting grays with either white or black can be continued to produce a scale of grays ranging from black through an even gradient of grays from darkest to lightest, until white is reached. This resultant black to white gradient is called the value scale (Fig. 41).

Because each color is a product of reflection of light waves, the light waves involved in the transmission of the color have a separate property of lightness or darkness that can be placed on the value scale. Thus, each color has a value, and the value becomes lighter as the color becomes mixed with white. If a black and white photograph is made of an outdoor scene, all the features in the photograph are represented as grays ranging from black to white. These grays represent the values of the hues of the objects being photographed. It is the quotient of value with which we are most concerned in dentistry.

Value in denture esthetics. Hue (color) is not of critical importance. The intensity or concentration of the hues in dental shades is so low that hues can almost, but not quite, be disregarded. The problem of matching porcelain jacket crowns to natural teeth, a missing tooth to a denture, or a denture to a face is one of selecting the proper value, not the proper color. The selection of the correct lightness or darkness results in successful shade selection.

The selection of the proper value shade is not as complicated as it may seem. Values run from white to black, but the darkest value of a color such as yellow may be a light gray. It is assumed that no one would select pure white, or pure yellow from the value scale of a color as a shade for a tooth. The two or three whitish or darkish gradients nearest the white or darkest ends of the value scale are similarly unusable. This leaves only the middle third of the value scale of a color from which to choose. The lightest of the middle three values on the value scale is the lightest used in dentistry. The skin coloring of most people falls in the middle category, so it can be assumed that the middle value shade will fit the majority of people, and that the lighter or darker shades apply only to extremes. When an understanding exists of the other factors affecting color, the range of the middle shade can be extended to the point that the selection of a "lighter" or "darker" shade is almost a rarity. This is not a recommendation for gray teeth; whatever small amount of hue, or "color" that is present in the tooth eliminates this possibility. Nonetheless, whatever hue is selected must be of the proper value to enable the dental composition to assume its rightful place in the total facial pattern.

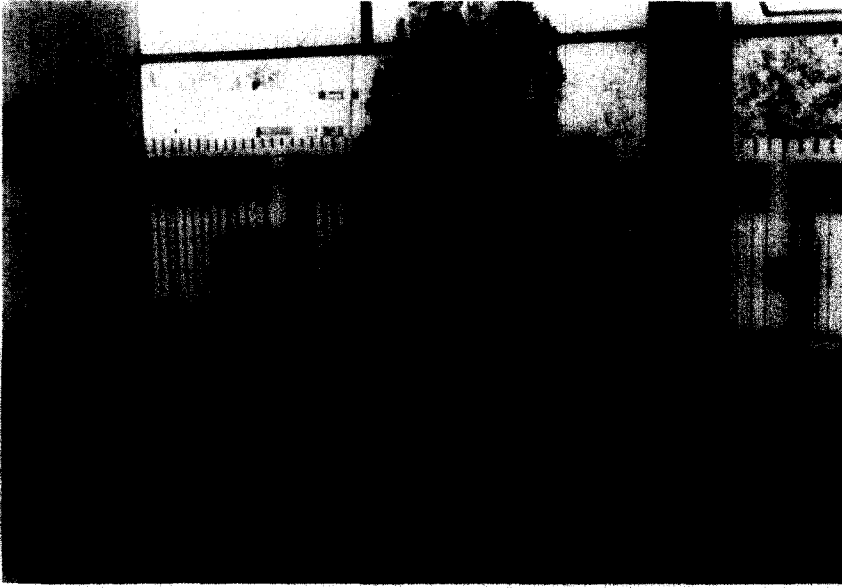


Fig. 42. A suggested office arrangement for setting up the teeth and making detailed considerations regarding esthetics.

Factors affecting color. Other factors do affect the intrinsic color properties involved. The lightness or darkness of the tooth is affected by the amount of light striking the tooth that will be reflected to the eye of the beholder. The texture of the tooth becomes important in this regard, as do the glaze and the incisogingival angulation of the tooth. A tooth of a given shade without a glaze or with a highly convoluted reflective surface will reflect less light than one with a glazed surface or less convoluted reflective surface, and will therefore appear darker, even though they are identical in shade. A tooth receiving more light will appear lighter than a tooth of the same shade receiving less light.

The background against which a color is seen has a definite effect on the color concerned. A dark background makes a color seem lighter than the same color against a light background.

The principle of illumination is again mentioned. Lighter objects appear larger (closer) than darker objects. A tooth may be made to look farther forward by using a lighter shade. Similarly, a tooth moved farther forward will look lighter.

Light source. The need for a specialized light is of value *only* when someone else is providing the specific shade, and it is mandatory that both parties discussing the same shade should therefore be considering the shade in the same type of light. It is unlikely that the patient will always be facing north, or smile only under special light bulbs. As she goes about her daily routine she will appear in dozens of different lighting conditions. The lighting conditions will affect the color of hair, skin, and clothing to a relatively equal degree. Conclusions reached about shade will be valid under the varying conditions as long as the total composition is properly handled. In addition, the try-in must be done when the lipstick is on, because of the important role lipstick plays as background, mouth shape outline, and unifying border.

Effect of lipstick on color. One other color factor operates in tooth shade selection, especially for female patients. When a strong color is placed next to a neutral color, the complement of the strong color is called forth in the neutral color. Ladies wear lipstick. Lipstick may be a strong red. Teeth are a neutral color. The complement of red is green. The tooth next to the lipstick may look green. Fortunately, complementary colors neutralize each other. The complement of green is red. Therefore, the tooth selected must contain enough red (pink) to neutralize the undesired greenish tinge. The ladies, having intuitively learned this, are careful to apply rouge (red) to the cheeks as well as to the lips to avoid looking pale (green). The vogues of feminine make-up styles are beyond the comprehension of mere science. As the trend toward lighter lipsticks occurs, a new product appears. This is a greenish liquid used to neutralize the pink in the cheeks.

In the belief that dentists are as intuitive as women, a survey was made in 1966. Several manufacturers were asked to list their three best selling shades in decreasing order and also their three shades containing the most pink in decreasing order. Results of the survey are shown in Table I. This information proves nothing, but may be interesting as an expression of the selectivity of the human eye. Note also that the "best sellers" are usually a middle value with the second and third place sellers a little lighter and a little darker.

Shade selection. It should be clear now that armed with only a few molds and one shade, a dentist can handle the majority of denture patients. As it is in the selection of mold, so it is in the selection of shade; it is not the shade of the individual tooth that matters, it is the effect of the shade as it contributes to the relationship between the total dental composition and the total facial composition. The important factors which affect the selection of a shade are personality, background, facial features, total tooth area displayed, and the amount of light reaching the teeth. The intrinsic coloration and value of the shade are also important. All of these factors may be weighted as to their demands on the lightness value of the shade to be selected. They need not be broken down into myriad gradients. They can be comfortably expressed as three gradients, with one gradient being average, one above, and one below. Bear in mind that they are weighted as to their requirement of the lightness of the shade.

The personality factor, for example, may be broken down as strong, average, and soft. A strong personality is one that is outgoing, vivacious, dynamic, zippy, or full of energy. A weak personality would be the opposite. A strong personality indicates the need for a "strong" tooth arrangement and therefore is one indicator for a light shade.

When considering the Caucasian race, skin colors can be considered as light, average, or dark. A dark-skinned person will not require a light shade, because the dark background will make the shade selected appear lighter. In patients of races with darker skin tones, the shades will have to be adjusted downward.¹⁶ The element of age operates in the background factor because as the skin wrinkles with age it reflects less light and therefore appears darker.

The facial features are important because it is these features with which the dental composition must compete to play its proper role in the face. Large, intense

Table I. A 1966 survey of the relationships between number of sales and amount of pink in the shade of teeth

Manufacturer	Best-selling shades in decreasing order			Shades with most pink in decreasing order			
1.	a.	87	86	90	97	96	90
	b.	902	901	903	902	901	903
2.		Y2	Y3	R2	R5	R4	R3
3.	a.	104	102	106	109	110	104
	b.	B65	B62	B66	65	66	60
	c.	62	65	67	65	66	60
4.		65	62	66	65	70	60
5.		H	G	I	M62	G	M65
6.		62	66	65	62	—	—

eyes are a strong feature, a large nose is a strong feature. Dark hair is a strong feature. Light teeth are indicated to make the mouth harmonize with the total facial structure. Features may also be noted as strong, average, or weak.

Total tooth area is important because as more teeth are displayed, the effect of the composition is increased. This is not really the same as mouth size, because in the smile position some very broad mouths show only a very narrow space interlabially, and some smaller mouths show a large space interlabially. If only a small amount of teeth are shown, the lighter shade may be indicated because the impact of the mouth has to be created in a small area. For this reason, the small total tooth area is considered as the strong gradient, while the large total tooth area is weak in its demands for lightness of shade.

Light is the amount of illumination reaching the teeth, and is affected by the height of the lip line as well as thickness or fullness of the lips. It is the heavy-lipped individual with a low lip line who requires a lighter shade because, being a darker area, the shade is going to appear darker than its qualities would suggest. A lighter shade is therefore required to reach the desired degree of harmony. The mouth with a reduced amount of illumination on the teeth makes the strongest demand for lightness of shade. This factor may be described as being dark, average, or bright. The important factors are shown in Table II.

The value is the essence of the shade as previously described. All of these factors may be expressed briefly in a workable formula:

$$\frac{P + F + S + TTA + L}{5} = \text{shade value}$$

If the factors are assigned a numerical value from 1 to 3, with the 3 being assigned to the quotient demanding the lighter shade, an indication can be gained as to which of the three shades should be used.

Two examples may illustrate the guidance offered by such an approach. An analysis of the critical factors for Mrs. A. follows:

Personality—warm, fairly open, but nothing extreme. Rated average	P = 2
Features—large, intense blue eyes, strong black hair worn in full style	F = 3

Table II. The important factors affecting shade selection*

Strength of indications for lightness	Factors affecting harmony of shade					
	Personality	Features	Skin	Total tooth area	Light	Shade
↑ 3 Strongest	Strong	Strong	Light	Small	Dark	Light
2 Average	Average	Average	Average	Average	Average	Medium
1 Weakest	Soft	Weak	Dark	Large	Bright	Dark

*The stronger the factor, the stronger is the requirement for lightness of shade. Factors are rated 1, 2, or 3, with 3 being the strongest indicator for lightness.

Skin—very light S = 3
 Total tooth area—small, heavy lips, very narrow interlabially TTA = 3
 Light—not much at all L = 3

$$\frac{P + F + S + TTA + L}{5} = \text{shade value}$$

$$\frac{2 + 3 + 3 + 3 + 3}{5} = \text{shade}$$

$$\frac{14}{5} = \text{shade}$$

$$2.8 = \text{shade}$$

A very light shade is indicated.

An analysis of Mrs. B. reveals:

Personality—average or tending toward soft P = 2
 Features—sandy blond hair, average eyes, and nose P = 2
 Skin—light S = 3
 Total tooth area—average mouth, tendency toward large, good interlabial distance TTA = 2
 Light—good light L = 1

$$\frac{2 + 2 + 3 + 2 + 1}{5} = \text{shade}$$

$$\frac{10}{5} = \text{shade}$$

$$2 = \text{shade value}$$

Note that this blonde person does not need a shade as light as the brunette to achieve esthetic harmony.

The coloration of the matrix is of little importance. Adequate carving must be done so that the ins and outs are realistic and the resulting light modeling will add variety to the apparent shade of the matrix. It must be stippled (textured) so that it does not reflect light. The visible denture base is no place to demonstrate skill in polishing. A reflection from the gingiva is most disconcerting and is a sin against the principle of reality.

It is important that the shade and other esthetic considerations be made in a nondental situation in which detailed judgments can be made when viewing the patient from the front (Fig. 42).

SUMMARY

The perceptual principles can free dentists from the confusion existing in the field of dental esthetics and enable them to confidently approach the task of enhancing their patients' appearance.

Principles may be applied to all and they eliminate the personal attributes of talent and the need for learning specific formulas for achieving an esthetic result.

"The determination of the form principles in a specific example of design means, in a sense, the elimination of the personal element. With this element removed the residue represents merely the planning knowledge possessed by the artist. . . . Invariably the higher or more perfect the art, the richer is the remainder when the personal element is removed."¹⁷

The eye is a perfectly competent evaluator and errors will become obvious if a long contemplative look is taken at the tooth arrangement during the try-in appointment.

A real need for a very detailed, almost histologic approach to dental esthetics exists. Indeed, the perceptive principles may be regarded as the cellular elements of which the tissue of denture esthetics is composed. As familiarity with the principles increases, so does proficiency in their application. With experience, the basic shape and characteristic of the dental tooth arrangement can be visualized even before a single tooth is placed in wax. All that remains is a detailed examination at try-in to look for minor perceptive conflicts, and this too becomes less of a task with the training of the eye to really see.

The field of dental esthetics is of critical importance to the well-being of patients, and one of dentistry's greatest challenges is to completely eliminate the delivery of static, poorly planned, clumsily executed dentures. This challenge is each individual dentist's responsibility and cannot be subcontracted. The laboratory technician is a valuable ally, but he has no decision-making role in the area of denture esthetics.

Fisher¹⁸ has best stated the objectives that must be achieved in denture esthetics. In his words, "It is the purpose of those who have labored diligently and long in the pursuit of a more workable basic principle in esthetics to encourage all of those whose tasks take them into the field of prosthodontics to consider the opportunity to lift the patient out of the category of a geometric figure and restore to him his true quality of a living and breathing man or woman, with an individual personality and either the dignity of his years or the freshness of his youth." This is the proper note on which to close, or perhaps to begin.

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