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THE BASIC EMOTIONAL IMPACT OF ENVIRONMENTS[1]

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Summary.—Available literature provides ample evidence that there are basic responses which are elicited by stimuli but which are independent of sense-modality distinctions. Everyday observations of intermodality associations, studies of synesthesia and of physiological reactions to different stimuli, and semantic differential studies all showed evidence of such primary responses. Semantic differential studies, in particular, have shown that human judgments of diverse samples of stimuli can be characterized in terms of three dimensions: evaluation, activity, and potency. We have termed the corresponding emotional responses pleasure, arousal, and dominance. Simple self-report measures of these emotional reactions were developed by using questionnaire studies in which *Ss* described a variety of situations using semantic-differential type scales.

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In a general approach to understanding man's interaction with various environments, it is essential to identify those responses that are the immediate result of stimulation and which occur in varying degrees in all environments. Further, a systematic environmental psychology requires a parsimonious description of such responses. Perceptual responses do not yield a parsimonious list since it is necessary to consider several dimensions of response within each sense modality. We therefore turned to intermodality responding in an effort to identify responses common to all types of stimuli, regardless of the sense modality stimulated.

Studies of synesthesia, physiological reactions, and the semantic differential show that there are basic response dimensions that cut across sense modalities. More specifically, this evidence shows that emotional (affective, connotative, feeling) reactions represent the common core of human response to all types of environments. This study presents the rationale and the supporting evidence for the designation of pleasure, arousal, and dominance as the three basic emotional reactions, and includes the development of specific measures for them.

Evidence Concerning Intermodality Responses

Whereas evidence of intermodality responses is available from a variety of experimental studies, it is also available in everyday observations. For example, relations among sensations from different modalities are often culturally pre-

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scribed. Note the commonly accepted thermal associations for various tastes (e.g., spicy foods are considered "hot"), or the general opinion that reds, oranges, and yellows are "warm" colors whereas blues, greens, and violets are "cool." An interesting cultural variation is exemplified by the Iranian system of thermal associations to various foods. All food and drink are categorized as either hot or cold, independent of temperature or spiciness, but referring to a heavy versus light feeling which results from eating or drinking. Yogurt and cucumber, for example, are cold foods; meats and more oily foods are hot. Furthermore, cold foods customarily are eaten during warm seasons, and hot foods are eaten during cold ones.

Synesthesia

Intermodality associations have been demonstrated in experimental studies where stimulation in one sense was observed to affect perception in another. Based on such associations, experimental *Ss* matched stimuli across different sense modalities with above chance agreement. Along these lines, Hazzard (1930) asked *Ss* to describe 14 different odors and found that a large percentage of the adjectives used characterized stimulation in other modalities (e.g., light, bright, lively, heavy, rough). Intermodality associations may also be evident in actual perceptual experiences in one sense while another is being stimulated (e.g., visual imagery associated with auditory stimulation). Alternatively, perceptions in one modality may be modified, as in a change in the threshold value for that modality, by stimulation in another modality (e.g., Loveless, Brebner, & Hamilton, 1970).

Among earlier studies, intermodality associations were explored with photistic visualizers, that is, persons who visualize tactile and auditory stimulations. Such persons were found to visualize exciting music in bright forms or sharp and angular figures, and slow music in rounder forms (Karwoski & Odbert, 1938; Karwoski, Odbert, & Osgood, 1942; Luria, 1969). In a randomly selected group, 18% of the *Ss* claimed to actually see the music that was played to them. This group differed significantly from the others in the complexity of colors they associated with each piece of music. Nevertheless all *Ss* significantly agreed in associating color-names and mood-adjectives with the music (Odbert, Karwoski, & Eckerson, 1942). In Uhlich's (1957) study, among 848 *Ss*, 14% of the male and 31% of the female *Ss* reported auditory-visual synesthetic experiences.

In one study employing randomly selected *Ss*, "Pitch could be determined which was experienced as having the same brightness as the scent of fresh lilacs . . . Similarity was experienced between the brightness of the scent of benzol, the brightness of a shade of grey, and the brightness of a pitch" (von Hornbostel, 1931, pp. 518-519). Holt-Hansen (1968) asked 16 *Ss* to identify the "pitch of fit" while drinking two different kinds of beer, by picking pure tones to correspond to each one. Working independently, *Ss* selected tones rang-

ing from 510 to 520 cps for one beer, and tones ranging from 640 to 670 cps for the other.

Zietz (1931) found that tones of various frequencies had different effects on afterimages. For instance, afterimages flickered as a function of a "vibrating" tone's frequency. For low frequency tones (200 cps), the afterimages were of darker, warmer, softer and duller colors, and vague contours. For tones of intermediate frequency (550 cps), afterimages had sharper contours and were in brighter, colder, clearer and harder colors. For high frequency tones (1100 cps), rounded afterimages were occasionally transformed into squarish forms. Zietz (1931) noted that the association was not necessarily one way—that visual experiences could likewise influence audition. For instance, when the room was well lit, his *Ss* judged tones to be of higher frequency than when the room was dark. Zietz' (1931) study exemplified the methods and findings of early synesthetic studies. One explanation of the colored hearing phenomena was that some types of auditory and visual stimuli were associated because they aroused the same emotions (Langfeld, 1929).

Experiments with children also showed consistent associations between auditory and visual experiences. Simpson, Quinn, and Ausubel (1956) asked 995 elementary school children, Grades 3 through 6, to tell what colors they thought of when they heard each of six tones. The children consistently reported certain color associations for tones of various frequencies (e.g., yellow and green in response to higher tones, red and orange in response to middle-pitch tones, and blue and violet for lower frequency tones). Further, the percent of reports of yellow as a function of tone frequency was a mirror image about the vertical for that of blue. Similarly, a plot of the percent report of red in response to various frequencies of tone was the mirror image for that obtained for reports of violet.

Other studies have explored the above chance matching of various sets of stimuli (e.g., Scheerer & Lyons, 1957). In one extensive series, congruent and incongruent sets of line drawings of gestural symbols, colors, nonverbal sounds, and words referring to spatial positioning (e.g., near, far) were developed. Langer and Rosenberg (1964) and Rosenberg and Langer (1965) found that *Ss* matched line drawings of postures and gestures with certain color names (e.g., red, blue) and sound symbols (e.g., clack, mumble) with beyond chance agreement. Rosenberg, Langer, and Stewart (1969), using a paired-associate learning paradigm, found that *Ss* learned congruent pairs (those matched by *Ss* in the earlier studies) of gestures and colors, and of postures and sounds, faster than incongruent pairs.

In one of the most thorough studies of synesthetic tendency, Osgood (1960) noted:

> There is ample evidence for visual-verbal synesthesia within our own culture. As early as 1921, Lundholm (1921) reported data on the "feeling tones" of lines: that SAD was represented by large, downward-directed curves; that MERRY was represented by small, upward-

directed lines; that GENTLE was represented by large, horizontally-directed curves, and so on. Poffenberger and Barrows (1924) confirmed and extended the relationships reported by Lundholm. Karwoski, Odbert, and Osgood (1942) were able to demonstrate similar relationships between word meanings and the synesthetic drawings of photistic visualizers. More recently, Scheerer and Lyons (1957) . . . and McMurray (1958) have reported Western intracultural consistencies in relating line drawings and/or verbally defined visual dimensions to connotative meanings or feeling-tones. As far as I am aware, the present study is the first attempt to demonstrate that the visual-verbal synesthetic relationships characteristic of our own language/culture community are shared by peoples who speak different languages and enjoy different cultures—the Navajo, the Japanese, and the Mexican-Spanish living in the American Southwest. The over-all similarities in synesthetic tendencies across these groups are impressive—when the synesthetic relationships that are significant (.01 level) intraculturally are tested for cross-cultural agreement, approximately 90% of the relationships prove to be in the same direction. We can conclude with confidence then that the determinants of these synesthetic relations are shared by humans everywhere—to the extent that our sample of "everywhere" is representative. . . . The present study and others along the same line (Kumata, 1957; Kumata & Schramm, 1956; Suci, 1957; Triandis & Osgood, 1958) strongly support the position that, for certain aspects of cognitive behavior at least, "world view" may remain relatively stable despite differences in both language and culture. . . . The phenomena which seem to display generality across human groups regardless of language or culture are essentially connotative—the affective "feeling tones" of meaning which contribute to synesthesia, metaphor and the like. . . .

Finally, we may inquire into the reasons behind similarities in connotative systems despite language/culture differences. First, by virtue of being members of the human species, people are equipped biologically to react to situations in certain similar ways—with autonomic, emotional reactions to rewarding and punishing situations (evaluation), with strong or weak muscular tension to things offering great or little resistances (potency), and so on—and hence they can form connotative significances for perceived objects and their linguistic signs varying along the same basic dimensions. Such connotative reactions enter into a wide variety of meaningful situations, are therefore broadly generalized, and provide a basis for synesthetic and metaphorical transpositions. Beyond this shared connotative framework, there are many specific relations between human organisms and their generally similar environments whose stability can be the basis for synesthetic and metaphorical translations. These may be either innate to the species or developed by learning under similar conditions. An example of the former (innate) basis may be the common association of the red end of the spectrum with warmth and activity and the blue end with coldness and passivity. An example of the latter (acquired) basis may be the common association of visually large with auditorily loud—it is simply a characteristic of the physical world that as any noise-producing object approaches or is approached, increases in visual angle are correlated with increases in loudness. These "homotropisms" and experiential contingencies may be expressed in language but are independent of the structure of any particular language (pp. 166-168).

It is precisely these emotional-connotative associations which underlie the heterogeneous findings of intermodality responding. Although some intermodality associations observed in synesthetic studies can be attributed to learned associations, there are more basic and transcultural affective reactions that account for most synesthetic associations.

Physiological Reactions

The existence of some basic response dimensions becomes evident also in physiological studies where certain effects are found to be common to stimulations in all the sense modalities. Studies of the physiological correlates of the experiences of pleasure and pain led to the identification of pleasure-pain centers in the midbrain. Electrical stimulation of areas of the hypothalamus and certain mid-brain nuclei is pleasant, and stimulation of lower parts of the midline system is painful (Heath, 1954, 1963, 1964a, 1964b; Olds, 1956). There is, then, a well-defined physiological mechanism associated with the experience of pleasure-pain and this mechanism is common to all the sensory modalities.

Lindsley (1951) postulated the concept of arousal as a basic response which is independent of the sense modality stimulated. This concept received considerable attention from other workers (e.g., Berlyne, 1960; Duffy, 1957) and was initially proposed to account for the intensity but not the quality or direction of a behavior. In the same vein, Hebb (1955) identified arousal with the concept of drive in the Hullian (1951, 1952) learning theory. Malmo (1959) most clearly defined this early conception of arousal of the entire organism as activation of the ascending reticular activating system. Excitation of the ascending reticular activating system was measured directly by EEG desynchronization, that is, fast EEG activity with concomitant decrease in alpha waves. Since the ascending reticular activating system in turn excited other parts of the nervous system and was therefore responsible for the arousal of the entire organism, it was possible to look for other physiological and behavioral correlates of EEG desynchronization. Among these secondary measures, the most promising involved the sympathetic nervous system—GSR, rise in arterial blood pressure, and pupillary dilation. Respiratory activity, oxygen consumption, pulse rate, muscle tension, and thermal properties of the skin also provided indexes of behavioral activities. Although the latter indexes have rarely been used, they do follow from this conception of arousal.

In reviewing the concept of arousal in 1960, Berlyne wrote that this is "one of the variables that would have to be assigned a value if the psychological condition of a human being or higher animal at any particular time were to be adequately described. It is a measure of how wide awake the organism is, of how ready it is to react. The lower pole of the continuum is represented by sleep or coma, while the upper pole would be reached in states of frantic excitement" (Berlyne, 1960, p. 48). Similarly, Corcoran (1963) defined arousal as the inverse of the probability of *S* falling asleep.

Research evidence challenged this unitary conception of arousal. The work of Lacey (1950), and Lacey, Bateman, and Van Lehn (1953) showed that there were individual differences in characteristic modes of arousal response, and differential responsiveness of the GSR, pulse rate, or pupil dilation, for instance, to var-

ious categories of stimulation. Therefore, these various secondary indexes of arousal were not generally intercorrelated.

Additional work by Feldman and Waller (1962) showed that whereas "electrocortical" arousal depended on the reticular formation, "behavioral" arousal depended on the hypothalamus. Experimentally, these two aspects of arousal could be made to occur independently of one another (Bradley, 1958; Wikler, 1952). In addition, Lacey (1967) found a third aspect of arousal, "autonomic," which was functionally independent of the other two. The relative independence of these three aspects of arousal challenged the original conception of a unitary dimension of total organismic arousal.

In reviewing these studies Lacey (1967) stated: ". . . the evidence shows that electrocortical arousal, autonomic arousal, and behavioral arousal may be considered to be *different forms* of arousal, each complex in itself . . . [and which] *in general* occur simultaneously. In other words, the assertions of activation and arousal theory seem to be true only in an actuarial sense. The limitations of our present knowledge make it impossible to say at present with what frequency and under what conditions these 'arousals' do occur together. This difficulty arises primarily, I think, because the representativeness of laboratory experiments is so limited" (pp. 15-16).

Although available physiological evidence fails to establish the exact nature of the arousal response, support is provided for the notion of basic cross-modality responding. Further, it is important to note that a combined index of several aspects of physiological arousal has been found to correlate highly with verbal self reports of arousal state (Thayer, 1967, 1970). This finding is important in the present context in establishing the link between a physiological arousal system and verbal reports of arousal.

The Semantic Differential

The physiological mechanisms reviewed support the idea that there are basic reactions that cut across sense modality distinctions and distinguish pleasure and arousal as two such dimensions. It is reassuring to find an entirely separate source of evidence that corroborates this conclusion. Work with the semantic differential (Osgood, Suci, & Tannenbaum, 1957; Snider & Osgood, 1969) helped to characterize human judgments of, or reactions to, stimuli of any degree of complexity, regardless of the number of cues or the modalities affected. These studies defined arousal (the activity factor that was obtained from studies with this method) and pleasure (the evaluation factor) as basic responses to stimuli, and also suggested a third dimension (potency).

Initial work with the semantic differential was aimed at denoting a limited set of factors which could be used to describe the meaning of concepts. Subsequent work with this same technique, however, revealed a far greater generality of the identified factors. For instance, in one of the earlier experiments by

Tucker (1955), artists and non-artists judged various kinds of paintings and rated them on semantic differential scales. The three factors which characterized the various paintings were named activity (which included high loadings from dynamic-static, active-passive, vibrant-still), evaluation (which included high loadings from smooth-rough, profound-superficial, meaningful-meaningless), and potency (which included high loadings from hard-soft, strong-weak). Solomon's (1954) study of judgments of sonar signals again yielded the same three factors: evaluation (pleasant-unpleasant, good-bad, pleasing-annoying), potency (large-small, heavy-light), and activity (busy-resting, violent-gentle).

More specifically, for emotional reactions, a similar set of three basic dimensions were obtained by Bush (1973). She selected 264 adjectives to sample the entire domain of feeling responses and scaled these with a multidimensional scaling technique. Three dimensions resulted from the analysis and corresponded to the three factors of the semantic differential. These dimensions were named pleasantness-unpleasantness, level of activation, and level of aggression. Even though Bush (1973) named the third factor "aggression," she noted that, "Perhaps the only clear parallel between Dimension 3 and dimensions in other studies is to potency of the semantic differential. The difference between words high and low on the dimension seems to be arousal for defense and autonomy, e.g., outraged versus needed, which is interpersonal potency by most definitions" (p. 55).

Subsequent work by Osgood (1966) and other investigators reviewed by Mehrabian (1970, 1972a) provided evidence for a similar description of social cues, e.g., nonverbal cues such as facial and vocal expressions, postures, and movements. The results showed that implicit interpersonal cues that are most prevalent in the social interaction process can be described in terms of three basic dimensions that are similar to those obtained from earlier studies of verbal cues by Osgood, Suci, and Tannenbaum (1957).

The semantic differential factors are not, therefore, limited to verbal responses. Furthermore, Evans and Day (1971) provided evidence supporting the contention that the semantic differential activity factor corresponds to an arousal response. GSR (but not heart rate) loaded highly on the activity factor of the semantic differential and not on either of the other two factors. *Ss* were responding to polygons varying in complexity.

To summarize, studies of intermodality associations, synesthesia, physiological responses to stimuli, and the semantic differential all suggest that there exists a limited set of basic emotional responses to all stimulus situations independent of the sensory modality involved. Judgmental responses of evaluation and activity on the semantic differential are hypothesized to correspond to the emotional responses of pleasure and arousal, respectively. The judgmental response of potency corresponds to an emotional reaction that may be labeled dominance versus submissiveness, such that low stimulus potency elicits a feeling of domi-

nance, and high stimulus potency elicits a submissive feeling. Pleasure, arousal, and dominance constitute a parsimonious description of the common core of human emotional responses to all situations. These affective responses, in turn, account for the phenomenon of synesthesia in that stimuli involving different sense modalities may nevertheless elicit the same emotional response.

Additional terms describing a diversity of emotional reactions to situations may be defined in terms of these three basic dimensions. Thus, for example, the feeling of *fatigue* may be described as one that is low on pleasure, arousal, and dominance. On the other hand, *excitement* may be characterized as an emotional state of high pleasure, arousal, and dominance. *Anxiety* and *stress* rate high on arousal but low on pleasure and dominance. *Relaxation*, *contentment*, and *comfort* rate high on pleasure and dominance but low on arousal. *Anger* and *hostility* rate high on arousal and dominance but low on pleasure. These are tentative hypotheses intended to illustrate the use of the three basic emotional factors for the description of the many kinds of emotional reactions.

Three Emotional Dimensions

Pleasure

Pleasure-displeasure is a feeling state that can be assessed readily with semantic differential measures or with behavioral indicators such as smiles, laughter, and in general, positive versus negative facial expressions. The latter can be reliably scored on a dimension of pleasantness, which is independent of both their aroused and dominant-submissive quality, and thus provide an important behavioral index, particularly in social interaction (Mehrabian, 1972b).

Within the present conceptualization, pleasure is distinguished from preference, liking, positive reinforcement, or approach-avoidance. These latter responses have been shown to be affected not only by pleasure but by arousal and dominance as well. To take one example, Evans and Day (1971) found that looking time at (an approach response to) polygons correlated with their arousing quality but not with pleasure or dominance. The three emotional responses were measured by ratings on semantic differential scales.

Arousal

Consistent with Berlyne's (1960) definition, arousal is conceptualized here as a unitary emotional response dimension ranging from sleep to frantic excitement. This dimension is readily assessed with semantic differential measures. Data obtained using this technique have shown that variations in the arousing quality of situations is indeed a primary and unitary factor.

Several nonverbal measures have also been identified which are intercorrelated and essentially define a measure of responsiveness or arousal in social situations (Mehrabian, 1970; 1972b, Appendix A). These are vocal activity (including positive as well as negative), facial activity (including positive and negative expressions), speech rate, and speech volume.

In considering the problems that are associated with physiological measures of arousal, Berlyne (1967) commented, "All this need not worry us unduly, although it certainly calls for circumspection, as long as we regard arousal as a dimension and not as a phenomenon—not, that is, as a process that goes on in one location in the central nervous system" (p. 12).

Thus, even though there is insufficient knowledge of the relations between the primary and secondary physiological measures of arousal (especially over a variety of situations), Berlyne's (1960) definition of arousal still has considerable heuristic value. Further, as already noted, there is evidence showing a correlation of verbal reports of arousal or activity with physiological indexes of arousal (Evans & Day, 1971; Thayer, 1967, 1970).

Dominance

Dominance-submissiveness is a feeling state that can be assessed from verbal reports using the semantic differential method. This dimension is the inverse of the judged potency of the environment, as measured by the semantic differential. Behaviorally, dominance is measured in terms of postural relaxation (i.e., body lean and asymmetrical positioning of the limbs) and is independent of pleasure and arousal (e.g., Mehrabian, 1970, 1972b).

Analogous concepts have been used by some investigators to describe the effects of environments. Spivack (1969) described different aspects of hospital environments in terms of the degree to which they restricted variability in patients' behaviors. Proshansky, Ittelson, and Rivlin (1970) proposed "freedom of choice" as one dimension to describe hospital environments and related it to more familiar concepts such as privacy, territoriality, and crowding. Privacy and territoriality permit greater freedom of choice, whereas crowding can limit freedom. Proshansky, Ittelson, and Rivlin (1970) suggested that crowding need not necessarily have negative connotations—when it limits freedom it is negative, but when it does not limit freedom or even enhances a freer feeling, e.g., as in instances of deindividuation discussed by Festinger, Pepitone, and Newcomb (1952), then it is preferred.

Since the way in which the concept of dominance is used in the present context is somewhat novel, some elaboration of its definition is appropriate. An individual's feeling of dominance in a situation is based on the extent to which he feels unrestricted or free to act in a variety of ways. This feeling can be hampered by settings which limit the forms of behavior and enhanced by settings which facilitate a greater variety of behaviors. For instance, an individual has greater freedom, and therefore a feeling of dominance, in his own territory (e.g., listening to music at home relative to doing so in a concert hall; or reading the same book in his office rather than in a library). A kitchen or an office that is well stocked with a variety of tools facilitates more behaviors (and enhances a feeling of dominance) than one which is sparsely equipped. Flexible interior decora-

tions, such as movable room partitions, adjustable levels of lighting, or movable furniture allow many arrangements suited to a greater variety of activities. Thus, relative to others which are fixed and difficult to change, such flexible arrangements are conducive to a feeling of dominance.

Physical stimuli which are rated as more intense, more ordered and powerful on the semantic differential are associated with a submissive feeling for the person encountering them. For instance, an intense and/or large stimulus can constrain behavior by masking the contribution of other stimuli which might elicit other behaviors.

For social environments, once again the dominance of the participant can be described in terms of familiar concepts. Formal social situations constrain behavior more than informal ones. Thus, ceremonial occasions in which implicit homage is paid to a higher or more potent idea or entity (e.g., a religious meeting) are typically associated with well-defined forms of behavior which are judged acceptable and distinguished from other unacceptable ones. For instance, a person has less freedom of choice (is less dominant) in the presence of others of higher status. Note the difference in the extent of behavioral freedom of a patient compared to that of a physician on a hospital ward. This is consistent with the more general idea that there is an inverse relationship between a dominant feeling and the potency of the environment.

This dimension of emotional response to environments has received little attention from investigators. There is a lack of data on how the physical aspects of a situation determine the feeling of dominance or on how dominance influences other behaviors. For this reason the above comments are offered tentatively at this point and are only suggested by evidence from the semantic differential (Snider & Osgood, 1969).

Psychometric Properties

These three emotional responses are conceptualized as the basic dimensions of emotion, meaning that all three dimensions are necessary to adequately describe any emotional state. Any value on one of the basic dimensions *can* occur simultaneously with any value on another of the dimensions. High dominance does not necessitate high pleasure, for instance, as in the case of an embattled general or harried executive. Thus, each dimension is, in principle, functionally independent of the other two; none of the three dimensions could be subsumed by the others.

Nevertheless, the specific set of situations or stimuli studied can yield nonzero correlations among the three dimensions. Thus, it it hypothesized here that there are no sizable intercorrelations among the three dimensions when the emotion-eliciting stimuli are representative of stimulus situations in general.

The semantic differential further indicates that the three dimensions are bipolar. That is, the pleasure dimension extends from extreme displeasure to ex-

treme pleasure, and similarly for arousal and dominance. This bipolarity has been challenged by Nowlis' (1965) research with the Mood Adjective Check List (MACL), which includes separate scales for pleasantness, unpleasantness, activation, deactivation, control, and lack of control. If the three scales of pleasantness, activation, and control were indeed bipolar, we would expect high, inverse correlations between the corresponding separate MACL scales. Nowlis (1965), however, found low, nonsignificant correlations in a large study in which *Ss* were asked to describe their present mood.

This apparent contradiction was explained by Bentler (1969). He hypothesized that the adjective checklist format (the type used in the MACL) suffers from a significant acquiescence bias, that is, the tendency on the part of some subjects to see all adjectives as self-descriptive. As in Nowlis' (1965) study, Bentler presented *Ss* with the scales of the semantic differential in a single adjective checklist format. Opposite ends of the same continuum (e.g., pleasantness and unpleasantness) were uncorrelated. The expected high, inverse correlations did emerge, however, when the acquiescence bias was statistically partialled out. Thus, if the acquiescence bias is statistically accounted for, it can be shown that the pleasure, arousal, and dominance dimensions are indeed bipolar.

The Nowlis (1965) MACL, then, constitutes one verbal report measure of the three dimensions, provided that the acquiescence bias is statistically controlled. Verbal measures relating to pleasure and arousal are also provided by Johnson and Myers (1967) who developed Thurstone-type scales of happiness, anger, fear, depression, and arousal. The latter scales have already been used in environmental studies (e.g., Radloff & Helmreich, 1968). Finally, our own studies described below provide verbal measures which were constructed to be free of acquiescence bias.

Development of Self-report Measures of Three Emotional Dimensions

Study 1

In our first step to develop verbal measures of the three emotional dimensions, the 28 adjective pairs presented in Table 1 were written. Based on intuitive grounds, they represented a tentative set of descriptors for the three emotional dimensions. Forty verbally described situations were also written to provide a diverse sample of physical settings that would elicit a large variety of emotional states. Although the situations were not systematically developed, their large number provided some assurance that they constituted a representative sample of environments. Some examples of situations are given below:

> You are water skiing behind a speedboat on a mountain lake. As you go by you watch the sun glinting on the water and look at the thickly wooded shore of the lake as it quickly passes. There are only a few other boats out and they are down near the other shore of the lake. The water is smooth and glassy and the air is fairly warm with a slight breeze.

You are walking around your vegetable garden in which rows of carrots, tomatoes, cabbage, and onions grow. A flock of birds fly over your head in a neat formation.

You are teaching in a children's day care center. All the boys are running, hitting each other and screaming; a little girl sits a few feet away from them, banging on a drum.

You are at the funeral of a distant relative. It takes place at the funeral home and everyone is dressed in dark colors. The minister's voice drones on in the service. The casket up in front is the only decoration in the otherwise plain room.

You are in your office alone. There are piles of books and paper lying around that you have been working on all day. Other than your equipment (telephone, typewriter, etc.) the room is almost barren.

It is evening and you are sitting at a window looking out over the lights of the city. It is a misty, cold night and everything looks small and far away.

In this first study, 134 University of California undergraduates served as *Ss*. Each of them was presented with a random selection of 8 situations and was asked to describe how he would feel in each one by using the 28 adjective pairs in Table 1. These items were randomly ordered; half of them were reversed in direction; and the entire set was presented to *Ss* in a format similar to that shown in Table 4. The accompanying instructions to *Ss* are also given in Table 4.

TABLE 1

ROTATED FACTOR MATRIX OF THE PRELIMINARY SET OF EMOTIONAL RESPONSE SCALES*

Emotional Response	Factor 1: Pleasure	Factor 2: Arousal	Factor 3: Dominance
Happy-unhappy	.89	−.01	.07
Pleased-annoyed	.89	−.03	.03
Satisfied-unsatisfied	.86	−.07	.02
Contented-melancholic	.83	−.02	.00
Hopeful-despairing	.79	.05	.03
Relaxed-bored	.80	.06	−.13
Comfortable-uncomfortable	.85	−.20	.10
Excited-irritated	.72	.34	.03
Secure-insecure	.69	−.25	.23
Stimulated-relaxed	−.16	.82	.07
Excited-calm	−.20	.80	.03
Frenzied-sluggish	.07	.77	.00
Jittery-dull	.02	.74	−.13
Wide awake-sleepy	.11	.77	.11
Aroused-unaroused	.23	.78	−.07
Alert-peaceful	−.34	.70	.13
Excited-soothed	−.30	.77	.09
Vigilant-uninterested	.38	.66	−.09
Irritated-depressed	.08	.16	−.04
Controlling-controlled	.16	−.05	.72
Powerful-overpowered	.21	−.10	.71
In control-cared for	−.12	.08	.69
Important-awed	−.06	−.15	.64
Dominant-submissive	.10	.20	.71
Autonomous-guided	−.05	−.04	.62
Influential-reverent	−.19	.12	.66
Domineering-helpless	.33	−.02	.69
Daring-cautious	.29	.12	.39
% Variance	27	21	12

*The correlations used to compute this factor analysis were based on 1072 observations.

The resulting 28 × 28 matrix of correlations was factor analyzed and a principal component solution was obtained. There were four factors with eigenvalues exceeding unity although the fourth factor consisted only of a single item. Oblique rotation of these factors yielded the loadings for the first three factors that are shown in Table 1, where items have been rearranged to facilitate the distinctions among the three sets of emotional responses. Factor 1 (Pleasure) accounted for 27%, Factor 2 (Arousal) for 21%, and Factor 3 (Dominance) for 12% of the total variance. Factor 1 correlated −0.02 with Factor 2, and 0.19 with Factor 3; Factor 2 correlated 0.05 with Factor 3.

Study 2

To improve the emotional descriptors, a second study was performed. Additional situations were written, providing a total list of 65 varied descriptions of environments. Based on the results of the first study, 18 adjective pairs were selected from Table 1 that best measured the respective emotional dimensions. Five additional adjective pairs, designed to measure dominance, were written. This final set of 23 items is presented in Table 2.

A new sample of 163 University of California undergraduates each rated approximately 20 situations that were randomly selected from the set of 65 situations. They used the adjective pairs of Table 2 in a rearranged random order

TABLE 2

ROTATED FACTOR MATRIX OF THE SECOND SET OF EMOTIONAL RESPONSE SCALES*

Emotional Response	Factor 1: Pleasure	Factor 2: Arousal	Factor 3: Dominance
Happy-unhappy	.88	−.01	.13
Pleased-annoyed	.89	−.06	.08
Satisfied-unsatisfied	.87	−.02	.11
Contented-melancholic	.78	−.01	.13
Hopeful-despairing	.71	.04	.19
Relaxed-bored	.84	.07	.00
Stimulated-relaxed	−.22	.80	.02
Excited-calm	−.09	.82	.02
Frenzied-sluggish	.01	.79	.02
Jittery-dull	.02	.70	−.09
Wide awake-sleepy	.15	.79	.05
Aroused-unaroused	.21	.77	−.04
Controlling-controlled	.06	−.04	.76
Dominant-submissive	.06	.15	.75
Influential-influenced	.06	−.07	.72
Important-awed	−.05	−.14	.69
Autonomous-guided	.08	−.01	.63
In control-cared for	−.07	.10	.62
Powerful-overpowered	.21	−.10	.64
Bold-cautious	.29	.10	.45
Protecting-protected	−.48	.27	.35
Free-restrained	.72	.04	.26
Unimpressed-impressed	−.70	−.42	.16
% Variance	32	17	12

*The correlations used to compute this factor analysis were based on 3261 observations.

where half the items within each emotional category were inverted to control response bias. *Ss* were given the same instructions as in Study 1.

The resulting 23 × 23 matrix of correlations was factor analyzed and a principal component solution was obtained. There were three factors with eigenvalues exceeding unity. Oblique rotation of these factors yielded the loadings shown in Table 2. Again, the items in Table 2 have been arranged to facilitate the distinctions among the three sets of emotional responses. It is seen that the first factor measured pleasure, the second, arousal and the third, dominance. Factor 1 (Pleasure) accounted for 32%, Factor 2 (Arousal) for 17%, and Factor 3 (Dominance) for 12% of the total variance. Factor 1 correlated .05 with Factor 2, and .26 with Factor 3; Factor 2 correlated .13 with Factor 3.

Study 3

This study served to cross-validate our final scales developed from the second study. The best six items for each dimension, listed in Table 2, were selected for the final scales. These 18 items were randomly ordered and three items within each of the three scales were inverted to control response bias. *Ss* were 214 University of California undergraduates, each of whom rated a different subset of 6 situations selected from the list of 65 situations.

The resulting 18 × 18 matrix of correlations was factor analyzed and a principal component solution was obtained. Once again, there were three factors with eigenvalues exceeding unity. Oblique rotation of these factors yielded the loadings that are shown in Table 3. The factorial composition in all respects was a

TABLE 3

ROTATED FACTOR MATRIX OF THE FINAL SET OF EMOTIONAL RESPONSE SCALES*

Emotional Response	Factor 1: Pleasure	Factor 2: Arousal	Factor 3: Dominance
Happy-unhappy	.92	.01	.01
Pleased-annoyed	.91	−.09	−.02
Satisfied-unsatisfied	.92	−.04	−.01
Contented-melancholic	.85	.01	.02
Hopeful-despairing	.79	.02	.09
Relaxed-bored	.84	.08	−.05
Stimulated-relaxed	−.29	.75	.05
Excited-calm	−.11	.82	.01
Frenzied-sluggish	−.04	.80	.05
Jittery-dull	.04	.77	−.04
Wide awake-sleepy	.24	.79	.00
Aroused-unaroused	.06	.80	−.03
Controlling-controlled	.11	−.06	.76
Dominant-submissive	−.01	.28	.67
Influential-influenced	.02	−.01	.79
Important-awed	.00	.02	.46
Autonomous-guided	.03	−.09	.69
In control-cared for	−.12	−.02	.68
% Variance	27	23	14

*The correlations used to compute this factor analysis were based on 1284 observations.

satisfactory replication of the findings from the second study. Pleasure, Arousal, and Dominance accounted for 27, 23, and 14% of the total variance, respectively. The Pleasure factor correlated —0.07 with the Arousal, and 0.03 with the Dominance factor; Arousal correlated 0.18 with Dominance.

Table 4 presents the final version of the measures for the three emotional response factors, and is based on the results from all three studies. To compute factor scores for an *S* who rates his emotions in a situation using the scales of Table 4, a simple and satisfactory approach is to average his responses to all six items of each scale.

TABLE 4

SEMANTIC DIFFERENTIAL MEASURES OF EMOTIONAL RESPONSE TO ENVIRONMENTS*

Instructions to *Ss*
Take about two minutes to really get into the mood of the situation; then rate your feelings in the situation with the adjective pairs below. Some of the pairs might seem unusual, but you'll probably feel more one way than the other. So, for each pair, put a check mark (Example: -----:--√--:-----) closer to the adjective which you believe to describe your feelings better. The more appropriate that adjective seems, the closer you put your check mark to it.

Pleasure		
Happy	----:----:----:----:----:----:----:----:----	Unhappy
Pleased	----:----:----:----:----:----:----:----:----	Annoyed
Satisfied	----:----:----:----:----:----:----:----:----	Unsatisfied
Contented	----:----:----:----:----:----:----:----:----	Melancholic
Hopeful	----:----:----:----:----:----:----:----:----	Despairing
Relaxed	----:----:----:----:----:----:----:----:----	Bored
Arousal		
Stimulated	----:----:----:----:----:----:----:----:----	Relaxed
Excited	----:----:----:----:----:----:----:----:----	Calm
Frenzied	----:----:----:----:----:----:----:----:----	Sluggish
Jittery	----:----:----:----:----:----:----:----:----	Dull
Wide awake	----:----:----:----:----:----:----:----:----	Sleepy
Aroused	----:----:----:----:----:----:----:----:----	Unaroused
Dominance		
Controlling	----:----:----:----:----:----:----:----:----	Controlled
Influential	----:----:----:----:----:----:----:----:----	Influenced
In control	----:----:----:----:----:----:----:----:----	Cared for
Important	----:----:----:----:----:----:----:----:----	Awed
Dominant	----:----:----:----:----:----:----:----:----	Submissive
Autonomous	----:----:----:----:----:----:----:----:----	Guided

*A numerical scale of +4 to —4 is used for each dimension (e.g., +4 is assigned for extremely happy, and —4 for extremely unhappy). *Ss*' responses are averaged across the six items of each of the three factors. In the actual administration of these measures, three items within each factor are inverted and all the items are presented in a random order.

DISCUSSION

Our review of the relevant literature showed that various combinations of pleasure, arousal, and dominance may adequately represent the diverse human emotional-connotative reactions to environments. The data presented here was therefore not intended to replicate that evidence. Thus, no effort was made in our initial selection of emotional descriptors to include a list of adjective-pairs

that would exhaustively describe the great diversity of human emotions. Rather, we proceeded directly to construct scales that would most directly and uniquely measure each of the three factors.

Across the three studies conducted, the intercorrelations among the three emotional response dimensions ranged from —0.07 to 0.26. These low correlations provided support for our assertion that the three dimensions constitute an essential base for the description of the great diversity of emotional responses that occur in everyday situations. Indeed, the scales of Table 4 can be used readily to assign exact coefficients to any emotional state, e.g., anxiety, in terms of the three emotional response factors. Various emotional states can be induced in *S*s and they can next rate their specific emotional state on the scales of Table 4. Separate factor scores of pleasure, arousal, and dominance can then be computed from each *S*'s ratings of a specific emotion. Finally, a multiple regression analysis can be used to compute exact weighting coefficients and to write an equation in which a specific emotional state is expressed as a linear function of pleasure, arousal, and dominance.

Beside their possible use in the description of specific emotional responses, the emotional response factors can be viewed as mediating the diverse behavioral approach-avoidance reactions to environments. Such approach-avoidance reactions are exemplified by the variety of means whereby an individual shows his preference or lack of preference for a situation, e.g., willingness to stay in it, to explore it, to verbally express his liking for it, his approach toward or avoidance of persons in that environment (variations in affiliation), or his approach toward or avoidance of tasks in the environment (variations in work performance). Two hypotheses relate the emotional response factors to these various approach behaviors: (a) The pleasure felt in a situation is a direct correlate of the approach behaviors vis-a-vis that situation, for example, more affiliative behavior was found in more pleasant environments (Griffitt & Veitch, 1971). (b) The approach to a situation is an inverted U-shaped function of the arousal experienced there, such that very high or very low states of arousal are avoided, but stimuli or settings eliciting moderate levels of arousal are preferred (e.g., Munsinger & Kessen, 1964).

Finally, the three emotional factors can also be used to categorize environments. Psychologists have traditionally grouped stimuli on the basis of the sense modalities which stimuli affect (e.g., temperature, sound intensity). However, the description of any ordinary environment would be extremely cumbersome in this way because of the multitude of dimensions involved, together with the temporal variations that occur along each of these dimensions. For instance, how many dimensions are needed to describe the environment of a person riding in an open sports car through the countryside; and how often would one need to assign new values to the person's experience on each of these dimensions? In contrast to the latter approach, the description of the same experiences in terms of

emotional responses can be accomplished quite readily. The person in the sports car may be said to be in a highly arousing, pleasant, and dominance-eliciting environment.

Although this method for the description of environments is unusual, it should be noted that stimuli are generally response defined, e.g., a stimulus is said to be reinforcing, stressful, or frustrating. Indeed, studies of perception distinguish stimuli on the basis of their differential impacts on the different sense organs. Our suggested alternative, then, is an extension of the response-defined approach to the description of stimuli or situations and has the advantage of providing a parsimonious set of environmental descriptors. Thus, the scales in Table 4 can be presented to *S*s with the instructions that they rate their emotional reactions to a particular situation and average reports of emotional reactions along each of the three factors of emotional response could then be used to describe that situation.

REFERENCES

BENTLER, P. M. Semantic space is (approximately) bipolar. *Journal of Psychology*, 1969, 71, 33-40.

BERLYNE, D. E. *Conflict, arousal, and curiosity.* New York: McGraw-Hill, 1960.

BERLYNE, D. E. Arousal and reinforcement. In D. Levine (Ed.), *Nebraska Symposium on Motivation, 1967.* Lincoln, Nebr.: Univer. of Nebraska Press, 1967. Pp. 1-110.

BRADLEY, P. B. The central action of certain drugs in relation to the reticular formation of the brain. In H. H. Jasper, L. D. Proctor, R. S. Knighton, W. C. Noshay, & R. T. Costello (Eds.), *Reticular formation of the brain.* Boston: Little, Brown, 1958. Pp. 123-149.

BUSH, L. E., II. Individual differences multidimensional scaling of adjectives denoting feelings. *Journal of Personality and Social Psychology*, 1973, 25, 50-57.

CORCORAN, D. W. J. Individual differences in performance after loss of sleep. Unpublished doctoral dissertation, Univer. of Cambridge, 1963.

DUFFY, E. The psychological significance of the concept of "arousal" or "activation." *Psychological Review*, 1957, 64, 265-275.

EVANS, D. R., & DAY, H. I. The factorial structure of responses to perceptual complexity. *Psychonomic Science*, 1971, 22, 357-359.

FELDMAN, S. M., & WALLER, H. J. Dissociation of electrocortical activation and behavioural arousal. *Nature*, 1962, 196, 1320-1322.

FESTINGER, L., PEPITONE, A., & NEWCOMB, T. Some consequences of de-individuation in a group. *Journal of Abnormal and Social Psychology*, 1952, 47, 382-389.

GRIFFITT, W., & VEITCH, R. Hot and crowded: influences of population density and temperature on interpersonal affective behavior. *Journal of Personality and Social Psychology*, 1971, 17, 92-98.

HAZZARD, F. W. A descriptive account of odors. *Journal of Experimental Psychology*, 1930, 13, 297-331.

HEATH, R. G. (Ed.) *Studies in schizophrenia.* Cambridge, Mass.: Harvard Univer. Press, 1954.

HEATH, R. G. Electrical self-stimulation of the brain in man. *American Journal of Psychiatry*, 1963, 120, 571-577.

HEATH, R. G. Pleasure response of human subjects to direct stimulation of the brain: physiologic and psychodynamic considerations. In R. G. Heath (Ed.), *The role of pleasure in behavior.* New York: Harper & Row, 1964. Pp. 219-243. (a)

HEATH, R. G. (Ed.) *The role of pleasure in behavior.* New York: Harper & Row, 1964. (b)

HEBB, D. O. Drives and the C.N.S. (conceptual nervous system). *Psychological Review*, 1955, 62, 243-254.

HOLT-HANSEN, K. Taste and pitch. *Perceptual and Motor Skills*, 1968, 27, 59-68.

HULL, C. L. *Essentials of behavior*. New Haven: Yale Univer. Press, 1951.

HULL, C. L. *A behavior system: an introduction to behavior theory concerning the individual organism*. New Haven: Yale Univer. Press, 1952.

JOHNSON, E., III, & MYERS, T. I. The development and use of the Primary Affect Scale (PAS). Research report of the Naval Medical Research Institute, 1967.

KARWOSKI, T. F., & ODBERT, H. S. Color-music. *Psychological Monographs*, 1938, 50, No. 2 (Whole No. 222).

KARWOSKI, T. F., ODBERT, H. S., & OSGOOD, C. E. Studies in synesthetic thinking: II. The role of form in visual responses to music. *Journal of General Psychology*, 1942, 26, 199-222.

KUMATA, H. A factor analytic study of semantic structures across three selected cultures. Unpublished doctoral dissertation, Univer. of Illinois, 1957.

KUMATA, H., & SCHRAMM, W. A pilot study of cross-cultural meaning. *Public Opinion Quarterly*, 1956, 20, 229-238.

LACEY, J. I. Individual differences in somatic response patterns. *Journal of Comparative and Physiological Psychology*, 1950, 43, 338-350.

LACEY, J. I. Somatic response patterning and stress: some revisions of activation theory. In M. H. Appley & R. Trumbull (Eds.), *Psychological stress: issues in research*. New York: Appleton-Century-Crofts, 1967. Pp. 14-37.

LACEY, J. I., BATEMAN, D. E., & VAN LEHN, R. Autonomic response specificity: an experimental study. *Psychosomatic Medicine*, 1953, 15, 8-21.

LANGER, J., & ROSENBERG, B. G. Non-verbal representation of verbal referents. *Perceptual and Motor Skills*, 1964, 19, 363-370.

LANGFELD, H. S. Synesthesia. *Psychological Bulletin*, 1929, 26, 582-585.

LINDSLEY, D. B. Emotion. In S. S. Stevens (Ed.), *Handbook of experimental psychology*. New York: Wiley, 1951. Pp. 473-516.

LOVELESS, N. E., BREBNER, J., & HAMILTON, P. Bisensory presentation of information. *Psychological Bulletin*, 1970, 73, 161-199.

LUNDHOLM, H. The affective tone of lines: experimental researches. *Psychological Review*, 1921, 28, 43-60.

LURIA, A. R. *The mind of a mnemonist*. New York: Avon, 1969.

MALMO, R. B. Activation: a neuro-psychological dimension. *Psychological Review*, 1959, 66, 367-386.

MCMURRAY, G. A. A study of "fittingness" of signs to words by means of the semantic differential. *Journal of Experimental Psychology*, 1958, 56, 310-312.

MEHRABIAN, A. A semantic space for nonverbal behavior. *Journal of Consulting and Clinical Psychology*, 1970, 35, 248-257.

MEHRABIAN, A. Nonverbal communication. In J. K. Cole (Ed.), *Nebraska Symposium on Motivation, 1971*. Lincoln, Nebr.: Univer. of Nebraska Press, 1972. Pp. 107-161. (a)

MEHRABIAN, A. *Nonverbal communication*. Chicago: Aldine-Atherton, 1972. (b)

MUNSINGER, H., & KESSEN, W. Uncertainty, structure, and preference. *Psychological Monographs*, 1964, 78, No. 9 (Whole No. 586).

NOWLIS, V. Research with the Mood Adjective Check List. In S. S. Tomkins & C. E. Izard (Eds.), *Affect, cognition, and personality*. New York: Springer, 1965. Pp. 352-389.

ODBERT, H. S., KARWOSKI, T. F., & ECKERSON, A. B. Studies in synesthetic thinking: I. Musical and verbal associations of color and mood. *Journal of General Psychology*, 1942, 26, 153-173.

OLDS, J. Pleasure centers in the brain. *Scientific American*, 1956, 195(4), 105-116.

OSGOOD, C. E. The cross-cultural generality of visual-verbal synesthetic tendencies. *Behavioral Science*, 1960, 5, 146-169.

OSGOOD, C. E. Dimensionality of the semantic space for communication via facial expressions. *Scandinavian Journal of Psychology*, 1966, 7, 1-30.

OSGOOD, C. E., SUCI, G. J., & TANNENBAUM, P. H. *The measurement of meaning.* Urbana: Univer. of Illinois Press, 1957.

POFFENBERGER, A. T., & BARROWS, B. E. The feeling value of lines. *Journal of Applied Psychology*, 1924, 8, 187-205.

PROSHANSKY, H. M., ITTELSON, W. H., & RIVLIN, L. G. Freedom of choice and behavior in a physical setting. In H. M. Proshansky, W. H. Ittelson, & L. G. Rivlin (Eds.), *Environmental psychology: man and his physical setting.* New York: Holt, Rinehart, & Winston, 1970. Pp. 173-183.

RADLOFF, R., & HELMREICH, R. *Groups under stress: psychological research in Sealab II.* New York: Appleton-Century-Crofts, 1968.

ROSENBERG, B. G., & LANGER, J. A study of postural-gestural communication. *Journal of Personality and Social Psychology*, 1965, 2, 593-597.

ROSENBERG, B. G., LANGER, J., & STEWART, J. Nonverbal learning. *American Journal of Psychology*, 1969, 82, 181-190.

SCHEERER, M., & LYONS, J. Line drawings and matching responses to words. *Journal of Personality*, 1957, 25, 251-273.

SIMPSON, R. H., QUINN, M., & AUSUBEL, D. P. Synesthesia in children: association of colors with pure tone frequencies. *Journal of Genetic Psychology*, 1956, 89, 95-103.

SNIDER, J. G., & OSGOOD, C. E. (Eds.) *Semantic differential technique.* Chicago: Aldine, 1969.

SOLOMON, L. N. A factorial study of the meaning of complex auditory stimuli (passive sonar sounds). Unpublished doctoral dissertation, Univer. of Illinois, 1954.

SPIVACK, M. Psychological implications of mental health center architecture. *Hospitals*, 1969, 43, 39-44.

SUCI, G. J. An investigation of the similarity between the semantic spaces of five different cultures. Report for the Southwest Project in Comparative Psycholinguistics, 1957.

THAYER, R. E. Measurement of activation through self-report. *Psychological Reports*, 1967, 20, 663-678.

THAYER, R. E. Activation states as assessed by verbal report and four psychophysiological variables. *Psychophysiology*, 1970, 7, 86-94.

TRIANDIS, H. C., & OSGOOD, C. E. A comparative factorial analysis of semantic structures in monolingual Greek and American college students. *Journal of Abnormal and Social Psychology*, 1958, 57, 187-196.

TUCKER, W. T. Experiments in aesthetic communications. Unpublished doctoral dissertation, Univer. of Illinois, 1955.

UHLICH, E. Synasthesie und Geschlecht [Synesthesia in the two sexes]. *Zeitschrift fuer Experimentelle und angewandte Psychologie*, 1957, 4, 31-57.

VON HORNBOSTEL, E. M. Ueber Geruchshelligkeit. *Pflueger's Archiv fuer die gesamte Physiologie des Menschen und der Tiere*, 1931, 227, 517-538.

WIKLER, A. Pharmacologic dissociation of behavior and EEG "sleep patterns" in dogs: morphine, N-allylnormorphine, and atropine. *Proceedings of the Society of Experimental Biology and Medicine*, 1952, 79, 261-265.

ZIETZ, K. Gegenseitige Beeinflussung von Farb- und Tonerlebnissen (Studien ueber experimentell erzeugte Synaesthesie) [Mutual influences of color and sound experiences: studies in experimentally induced synesthesia]. *Zeitschrift fuer Psychologie*, 1931, 121, 257-356.

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