JYVÄSKYLÄ STUDIES IN EDUCATION, PSYCHOLOGY AND SOCIAL RESEARCH 9

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TAPIO NUMMENMAA

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URN:ISBN:978-951-39-8323-9
ISBN 978-951-39-8323-9 (PDF)
ISSN 0075-4625

Pieksämäki 1964
Sisälähetysseuran Raamattutalon kirjapaino

PREFACE

Facial expressions can be, and have in experimental work indeed been considered from several points of view. These expressions can be regarded as »outer» signs of »inner» emotional states. They also have an effect, i.e. they produce changes in the behavior of the persons who see them. Further, facial expressions can be considered as a sign language. Maybe one could say that this is what they »are». This language has a vocabulary, which contains both expressions that are simple and easy to interpret, and others that are more complex but, if correctly interpreted, rich in information. These expressions are »written» in a peculiar way — they appear on the face for shortish periods of time. And some of these expressions, but not necessarily all of them, can be translated into verbal ones. This is the point of view that will be adopted in the present monograph. We want to study the vocabulary and grammar of the language of the face, and to see how facial expressions can be translated into language proper. But not much will be said in the following about either emotional states or the effects produced by the use of this language. To some extent these points of view are discussed in Chapter VI.

The purpose of the present monograph is to describe and organize the results of a series of small experiments. These were initiated by an experiment which the present writer carried out in collaboration with Mr. U. Kauranne. In this experiment we tried to find out the 'basic dimensions' of facial expression. — Of the experiments to be reported in this monograph, the results of one have appeared in print (Exp. I), the results of three (Exp's II, III, and IV) in mimeographed form, while the results of Exp. V are published here for the first time. Consequently, where there is a previous, detailed report available, the experimental details will not be described in this monograph. But for easy reference in all cases the most important tables and figures have been republished here. As a result of fitting the results into larger contexts, the interpretations given here will not always be identical

with those given in the original papers. This is partly also caused by re-analyses of the earlier data.

I feel very much indebted to Mr. Simo Ristola who very kindly agreed to produce the facial expressions both for the Nummenmaa—Kauranne study as well as for the new series used in Exp's II, IV, and V. Mr. Olavi Nöjd has, sparing neither time nor energy, done all the photographic work required.

I thank Prof. Martti Takala and Mr. Urpo Kauranne for the very useful discussions I have frequently had with them. Thanks are also due to Miss Aamu Nyström, Mr. Juhani Karvonen, and Mr. Raimo Konttinen for the help they have given in carrying out some of the experiments, as well as to Mr. Risto Holopainen who prepared the experimental devices for Exp. III. I also wish to thank my wife, Liisa Nummenmaa, and Mr. Peter Jarrett, who have, in this order, read the manuscript and checked the translation.

Valtion Humanistinen Toimikunta has supported the investigations by research grants.

A person writing in a language which is not his own must always watch his step. Giving a name for a monograph, especially, is a task both formidable and troublesome. The present writer has, instead of giving a name of his own invention, borrowed a subheading from F. H. Allport's Social psychology.

Jyväskylä, February, 1964.

Tapio Nummenmaa

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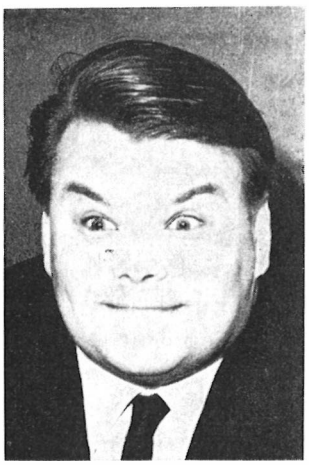
I

Introduction



What would the reader's reaction be if he really saw from a distance a face wrinkled like the one above? He might think that »the chap seems to have been pleasantly surprised», or something like this — at any rate he would probably try to construe, in terms of emotion, an interpretation of what is going on »in» the person involved. If he knows the person he may even ask him and verify the interpretation.

But it is a different thing if the reader himself is involved in a discussion with the person making faces. Then he has less time for interpretations or conjectures about emotional states. Being the receiver of a message is different from being just a casual onlooker. Especially in the latter case a facial expression tempts the onlooker to interpretations; in the former he may, whether aware of it or not, do the same, but probably he is more apt to make interpretations of, and reactions

to, the 'intentions' of the speaker. One could conceive of the smiles and frowns and other facial expressions as cue stimuli given at choice points in the maze of discussion; if these are »obeyed» the discussion proceeds otherwise than if they are not. (Interpretations of different types, i.e., interpretations concerning emotional states, intentions, and personality traits, have been discussed, though unfortunately in Finnish, by Takala (1962). See also pp. 46—49).

We have begun with a simple description of communication by means of facial expressions. But even so it is illustrative of two broad classes of studies of facial expression. Most studies of facial expression have dealt with interpretation. The purpose may be, for instance, to investigate what kinds of expressions the Ss can recognize and to what degree they agree in their verbal descriptions of the expressions, what kinds of cues do the subjects utilize when doing this, et cetera. One particular type of experiment, of which we will have more to say later on, is a multidimensional scaling experiment. — In the 'interpretative' studies the experimenter does not always or necessarily try to connect the expressions with some hypothetical emotional states, but sometimes he does.

But there are also investigations, the purpose of which is something else: to study facial expressions as stimuli that reinforce behavior. Even here the stimuli must be identified somehow — if »smile» is to be the reinforcing stimulus, the experimenter has to know what a smile is and how to produce it. The collection of different expressions used in studies of this kind has been rather limited. In all those mentioned by Krasner (1958) in his review the reinforcing stimulus was smile (combined with something else) — maybe this is so because a smile is one of the most easily identified facial expressions. The reactions the experimenter is interested in are not names for or descriptions of facial expressions; they are some other reactions, not even necessarily verbal ones.

Whether one is interested in finding what is »at the back of» the facial expressions — emotional states — or in finding out what their »meaning» is — in terms of changes they produce in behavior — it remains a crucial task to relate the sign language of the face to the language proper. What »words» are there in this sign language? In which combinations do these appear? Can several expressions be given simultaneously? How can this language be translated into verbal language? How and where are the expressions »written» on the face? It is questions of this type we try to answer in the present monograph.

II

Multidimensional description of facial expression[1]

What are the basic qualities of facial expression? Opinions based on empirical evidence may have differed as to the more specific expressions but there are some on which many researchers have agreed. It would not serve our purpose to review these, but we reproduce, by way of an example, Allport's (1924) list, which probably contains many on which the area of agreement is great. Allport groups the expressions as follows.

I The Pain-Grief Group
II The Surprise-Fear Group
III The Anger Group
IV The Disgust Group
V The Pleasure Group
VI The Attitudinal Group

Allport's system, as well as other similar systems, is a collection of classes. He suggested a nominal scale, so to speak. Woodworth (1938), when reviewing earlier literature, aimed at finding some relations between the different classes. On the basis of earlier results by Feleky he tried to order the expressions on a continuum so that expressions that were easily confused came near each other. While so doing,

[1] A comprehensive review is not attempted here. Reviews of studies of facial expressions are found in Ruckmick (1936), Murphy, Murphy, & Newcomb (1937), Woodworth (1938), Woodworth & Schlosberg (1955), Kauranne (1960), and Abelson & Sermat (1962).

Woodworth also »condensed» the scale, re-classifying Feleky's classes into larger ones. Woodworth's scale was the following.

1. Love, Happiness, Mirth
2. Surprise
3. Fear, Suffering
4. Anger, Determination
5. Disgust
6. Contempt

There was a seventh category, »scattering», for expressions that did not fit any of the other six. Woodworth's scale can be regarded as an ordinal one. It may be interesting to observe that the classes are just about the same as those listed by Allport. This is seen from the comparison indicated in Table 1. It appears that the differences,

Table 1

Comparison of Allport's Classificatory System with Woodworth's Scale of Facial Expressions

Woodworth	Allport
1. Love, Happiness, Mirth	V The Pleasure Group
2. Surprise	II The Surprise-Fear Group
3. Fear, Suffering	I The Pain-Grief Group
4. Anger, Determination	III The Anger Group
5. Disgust	IV The Disgust Group
6. Contempt	
	VI The Attitudinal Group

Allport's group VI excepted, result mainly from differently placed class limits.

But Schlosberg (1941) showed that the »ends» of the Woodworth scale were quite often confused with each other. He observed that even though the main variation is along the continuum unpleasant-pleasant, there is an additional continuum involved that prevents category 2 (Surprise) from being confused with category 5 (Disgust) and 6 (Contempt). This continuum he called attention-rejection. In other words, Schlosberg pointed out that the Woodworth scale does not correctly describe the distances between the expressions. »Love, Hap-

piness, Mirth» is rather near, not far from, »Contempt». And he also observed that these distances can best be described in terms of two dimensions. At this stage the dimensions were more or less abstractions made by the experimenter, and so Schlosberg (1952) had several groups of Ss judge several sets of facial expressions along the hypothetical dimensions. Even though Schlosberg felt that the attention-rejection continuum was difficult to define verbally, the resulting two-dimensional description agreed rather well with the expectations that were based on the positions of the stimuli on a Woodworth type scale twisted to make a circle.

Later Schlosberg (1954) introduced an additional dimension, tension-sleep, to the system. But this causes trouble, and the introduction of a new series of facial expressions, the »Lightfoot Series», (Engen, Levy, & Schlosberg, 1957) only adds to the difficulties. It is true, as is shown by Engen, Levy, & Schlosberg (1958) that all these three dimensions, i.e., unpleasant-pleasant, attention-rejection, and sleep-tension, are reliably judged from the Lightfoot pictures. But they do not seem to be independent of each other. Kauranne (1960) as well as Abelson & Sermat (1962) observed that attention-rejection correlates rather highly with sleep-tension. But in addition to this, it seems that neither of these dimensions is independent of unpleasant-pleasant. Judging from the results and scale values given by Engen, Levy, & Schlosberg (1958) the dimension unpleasant-pleasant certainly seems to have a V-formed relationship with both attention-rejection and sleep-tension (see also footnote on pages 12—13). The reason may be that the Lightfoot Series does not cover the full range of expressions as thoroughly as, for instance, the Frois-Wittman Series used in Schlosberg's 1952 study. This conclusion is supported by the study of Abelson & Sermat (1962). They performed a multidimensional scaling experiment using 13 selected Lightfoot pictures. Their results were, in brief, the following. Of the five dimensions extracted the first predicted Schlosberg's dimension unpleasant-pleasant well, and the second predicted both sleep-tension and attention-rejection well, sleep-tension a bit better. Unpleasant-pleasant and sleep-tension were the ones eventually preferred by the writers. The other three dimensions were left uninterpreted. This study gives us interesting information about the relationship between the dimensions interpreted as unpleasant-pleasant and sleep-tension. They are independent in one sense, namely in the sense that their scalar product is zero, but they are clearly dependent in the sense that the scale values on sleep-tension

can be predicted from the values on unpleasant-pleasant.[1] The conclusion seems to be that there is one »contentual» dimension, unpleasant-pleasant, which also is »intensitive» in itself, but another intensitive dimension is needed to explain the distances between the stimuli. If the axes are rotated and translated to a new zero point in the way described in the footnote on this page, no »purely» intensitive axis is needed in the description.

The conclusion from the foregoing would seem to be that the basic qualities of »pleasure», »anger», »surprise-fear», and »disgust-contempt» can be identified from facial expressions. These expressions can be described in terms of two dimensions, unpleasant-pleasant and attention-rejection. The present writer, to avoid dispute where it is futile, is perfectly willing to admit the possibility of a sleep-tension dimension independent of the other two. This dimension makes sense in a way, but the experimental evidence in its favor is certainly not convincing.

Most of the work to be introduced in this monograph is based on a study by Nummenmaa & Kauranne (1958). Therefore the results of

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[1] This can be demonstrated as follows. We treat the »pleasant» stimuli (N:o 20, 7, 37, 36, 28, 51, and 29) and the »unpleasant» stimuli (N:o 56, 30, 13, 16, 32, and 15) separately, and calculate the regression of the dimension interpreted as sleep-tension (Dimension II) on the dimension interpreted as unpleasant-pleasant (Dimension I) separately for pleasant and unpleasant stimuli. Calculating the equations of the straight lines giving the least sums of squares of deviations, and combining the results, we get

$$\begin{aligned} y &= -1.55x - 1.37 \quad \text{for } x \leq -.02 \\ y &= 1.36x - 1.32 \quad \text{for } x \geqq -.02 \end{aligned}$$

as the regression of Dimension II on Dimension I. If we estimate Y, calculate the variances of Y' and Y, we get

$$\sigma_y^2 = .68; \quad \sigma_{y'}^2 = .46, \text{ and } \sigma_{y.x}^2 = .22$$

It can be seen that two thirds of the sleep-tension variance can be explained on the basis of the unpleasant-pleasant dimension. The conclusion follows that the semi-axes interpreted as unpleasant and pleasant are both »intensitive». Observe that if the axes are translated and rotated to the position defined by the V-formed regression line (see Figure 1), we would get a very simple structure. Then the axes would obviously be interpreted as »Pleasant» and »Unpleasant».

this study will be briefly described. These investigators wanted to study how many dimensions are needed to account for the main differences between different facial expressions, and what these dimensions are. The stimuli were 27 facial expression pictures taken for the purposes of the experiment. The stimuli are shown in Figures 2 and 3. Two experiments (in fact, three, but the third is not relevant here) were carried out. In the first of these, 52 male Ss judged the subjective similarities between all possible pairs (there are 351 of them) of stimuli on a scale ranging from zero (the expressions are not at all similar) to four (the expressions are completely similar). The second experiment was a free-response naming experiment in which 30 female Ss described the expressions. These descriptions were used for purposes of interpretation. The results from similarity judgments were treated in the following way. The means of the judgments were transformed to a scale ranging from zero to one, and the resulting »similarity

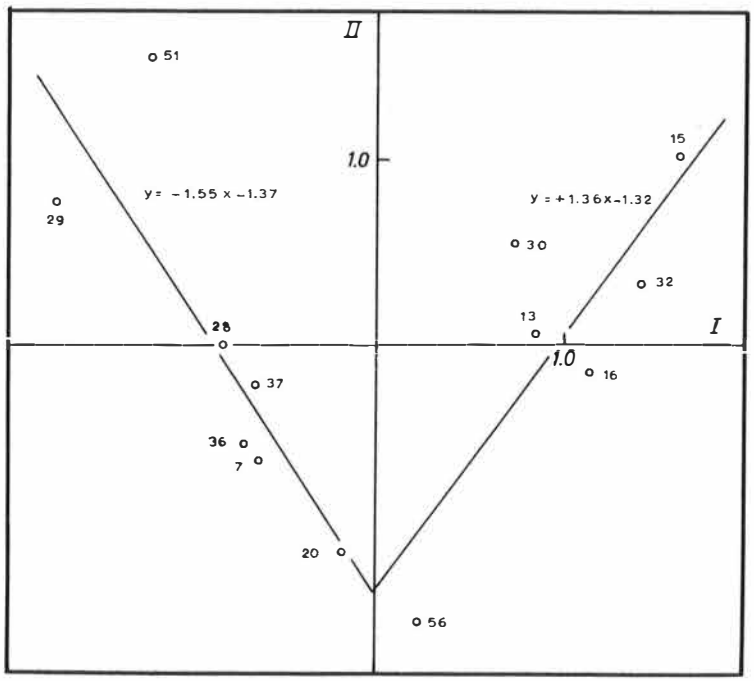

Figure 1

The relationship between unpleasantness-pleasantness (I) and sleep-tension (II); after the results of Abelson and Sermat.

matrix» was factor analyzed by Thurstone's (1953) centroid method. The similarity matrix is given in Table 24 in the appendix. This is a procedure suggested by Ekman (1954 b) who calls it similarity analysis.[1] The factor matrix was rotated orthogonally, and the resulting matrix is given in Table 2. The descriptions given by the second group of Ss were used for the interpretation of the factors. The following factors were identified: Pleasure, Anger, Surprise-Fear, and Rejection.

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[1] Similarity analysis has been used in many of the experiments to be reported in the present monograph. The procedure has always been as described above. Because this method has been criticized by several writers and because, on the other hand, it has been further developed by Ekman and his collaborators (Ekman, Engen, Künnapas, & Lindman, 1963), a few remarks are called for. Messick & Abelson (1957, p. 11) pointed out that »such an analysis probably routinely results in spurious added dimensions». This is true, at least in the sense that this method gives twice as many unipolar factors as the methods developed by Torgerson (1952, 1958) or Shepard (1962 a, b) give bipolar factors. But it is questionable whether there are other »really» added dimensions. This does not seem to be the case with facial expression data. Usually, as is shown by the empirical data of this monograph, the unipolar factors of similarity analysis correspond with the poles of bipolar factors obtained otherwise. On the basis of the results of the similarity analysis one could not say which factors would combine to give one bipolar factor. It is possible to do so by inspecting the similarity matrix, though. Helm (1959, p. 25) points out, when discussing Ekman's results (1954 a), that »It seems apparent that Ekman's results cannot be considered to describe color space, since distances between points on the factor plots are not related to perceived distances by the analysis which he carried out». It is evident that similarity analysis does not give a metric space, and this was never claimed by Ekman. Shepard (1962 b) points out, when presenting a comparison between results obtained by a scaling method developed by himself and those of Ekman (1954 a) that »Since the present solution achieves both a greater economy of description and a closer agreement with previous spatial representations for the same stimuli, the conclusion seems warranted that similarity ratings should in general be treated as proximity measures rather than as correlations, i.e., scalar products». On the other hand, Ekman, Engen, Künnapas, & Lindman (1963) have developed the similarity model further. They write (on page 12): »In fact, our investigations of similarity have one of their main roots in some early work by one of the present authors, aiming at revealing the dimensionality of a complex subjective variation (Ekman, 1954 a, b, 1955). In those experiments estimates of subjective similarity between percepts were obtained, and the matrices were treated by the methods of factor analysis. This treatment implied a similarity model, ac-

The results are also shown in Figures 2 and 3, which give the factor plots. The authors identified the Pleasure factor as one pole of Schlosberg's dimension unpleasant-pleasant and the Anger factor as the other one, observing also that the Anger factor is more limited in content than the unpleasant end of Schlosberg's dimension. The authors also identified the Surprise-Fear factor as the attention-pole and the Rejection factor as the rejection-pole of Schlosberg's dimension attention-rejection.

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cording to which the similarity estimate is a cosine function of the angle between percept vectors, but admittedly this assumption was made for convenience rather than on the basis of rational considerations. The method worked in so far as rather meaningful results were obtained, but there was no better reason at that time for accepting the model underlying the »method of similarity analysis». The dissatisfaction caused by this situation initiated both the subsequent investigations of the mechanisms of similarity and the development of the multidimensional ratio scaling method, part of which has been used in the present investigation. These two lines of development have been integrated in the present study, which provides a basis for a rational »method of similarity analysis». Solving Equation 11 for $\cos\varphi_{ij}$ we obtain the formula

$$\cos\varphi_{ij} = \frac{s_{ij}}{4}(s_{ij} + \sqrt{8 + s_{ij}^2}). \qquad (13)$$

By this formula a matrix of similarity estimates may be transformed into a matrix of cosines, which may be treated by the methods of factor analysis. .... The revised method of similarity analysis is restricted to a purely qualitative variation, but this is enough in many cases of essentially unknown psychological dimensionality; it may, for instance, be a useful method in studies of olfaction.» The new method, thus, is qualitative, just as the earlier version was, but instead of being arbitrary it is now »rational». However, this theoretical distinction seems to be without very much empirical difference, since the function mentioned in the equation above, gives $\cos\varphi_{ij} = 0$ when $s_{ij} = 0$, and $\cos\varphi_{ij} = 1$ when $s_{ij} = 1$, and is not very strongly curved.

The present writer will adopt the following strategy. Similarity analysis, even in its earlier form, will be considered useful in preliminary work. Consequently, the earlier similarity analyses will be reported here. However, some re-analyses have been done and will be properly reported. Shepard's (1962 a, b) method would have been ideal here, because similarity judgments can be used as proximity measures, but the computer program is not available in Finland. Therefore partial re-analyses according to the ideas presented by Torgerson (1958) were performed (see footnote on page 17).

Table 2

The Experiment of Nummenmaa and Kauranne (1958). Results of the Similarity Analysis: Orthogonally Rotated Factor Matrix.

Stimulus	Factor			
	I	II	III	IV
1	.38	.58	.06	.01
2	.67	.24	.30	.16
3	.71	.41	.10	.02
4	.29	.79	−.01	−.06
5	.23	.89	.01	−.04
6	.39	.02	.16	.66
7	−.23	.80	.20	.27
8	.47	.71	.05	.02
9	.72	.41	.12	.10
10	.00	.91	.14	.20
11	.43	.73	.11	.03
12	.44	.15	.14	.63
13	.40	.08	.10	.73
14	−.28	.74	.23	.26
15	.50	.15	.21	.50
16	.06	.16	.85	.03
17	.21	−.01	.77	.11
18	.49	.22	.56	.17
19	.68	.27	.20	.18
20	−.08	.94	.03	.21
21	.19	.45	.73	.00
22	.24	.24	.84	.04
23	.01	.93	.02	.14
24	.58	.17	.23	.44
25	.73	.24	.20	.35
26	.53	.06	.11	.66
27	.72	.14	.15	.37

Thus, even though the methods as well as the stimulus pictures used by Schlosberg (1952) and Nummenmaa & Kauranne (1958) were quite different, there is a close agreement between the results.

Since the method of similarity analysis has its drawbacks (see footnote on pages 14—15), and since the unipolar factors are not in every respect comparable with bipolar ones, whether the latter are the result of a multidimensional scaling procedure (Abelson & Sermat, 1962) or obtained otherwise (Schlosberg, 1952), the present writer has re-

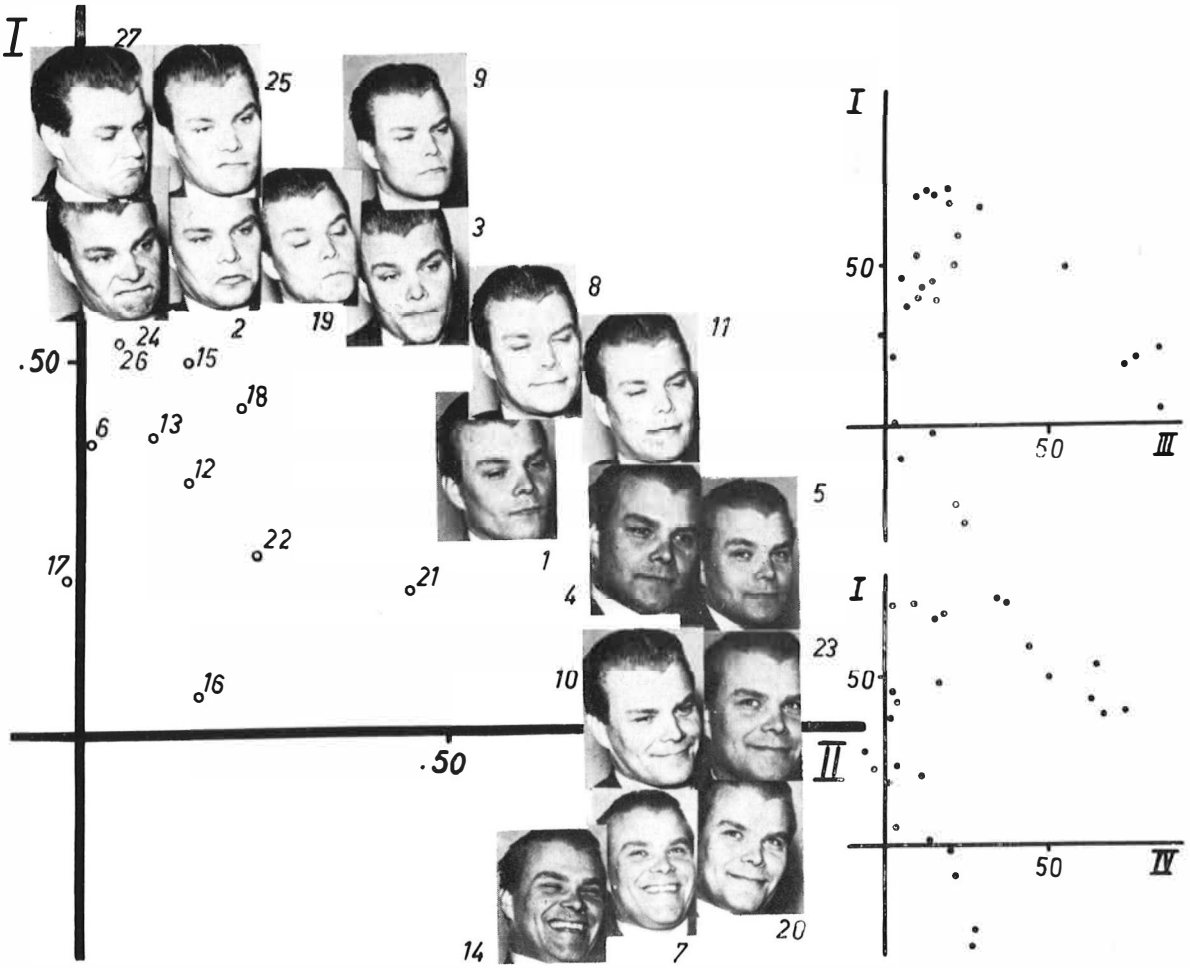

Figure 2

Expressions of pleasure and rejection; after Nummenmaa and Kauranne.

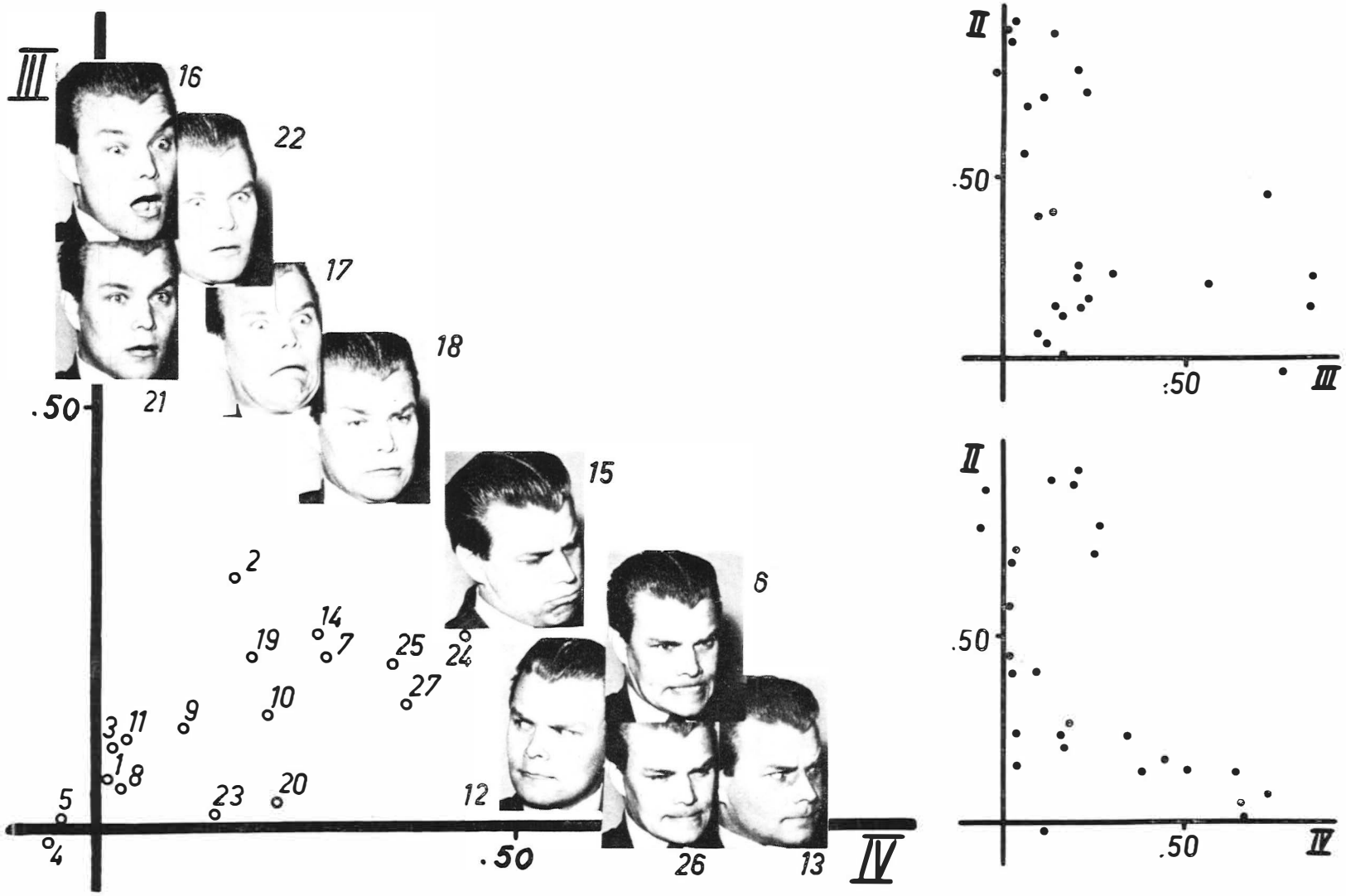

Figure 3

Expressions of surprise and anger; after Nummenmaa and Kauranne.

analyzed the data of Nummenmaa & Kauranne. This re-analysis was performed according to the methods presented by Torgerson (1958).[1]

The following considerations influenced the selection of the stimuli for the re-analysis of the data of Nummenmaa & Kauranne: a) there should be two stimuli for each of the four factors and b) the stimuli should be of different intensities. The latter was to demonstrate that the dimensions are intensitive in themselves. Unfortunately the intensity of the expressions was in no way measured in the original experiment. Instead of performing a new experiment in which the intensity would have been judged, the present writer tried to select expressions that were »clearly» different in this respect. The following selection of eight stimuli was done (see the next page).

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[1] There will be several of these re-analyses. Because all these are carried out in the same fashion, the general procedure is described only once here. In all cases the procedure has consisted of the following steps.

1. On the basis of the results of the earlier similarity analyses some stimuli were selected for the re-analysis. The only exception is Exp. III, which was originally planned for multidimensional scaling based on the judgment of stimulus triads. The present writer did not wish to make complete re-analyses — the analyses were performed by means of a simple desk calculator — and therefore only some stimuli were selected. The selected ones were of course those that were supposed to show the structure clearly.

2. The scale of the similarity numbers (from 0 to 1) was reflected about its midpoint, and the numbers obtained in this way were considered as comparative distances.

3. A constant was added. This constant was found by the simple method described by Torgerson (1958, p. 271).

4. The scalar products were calculated (see Torgerson, 1958, p. 258, Eq. 16).

5. The matrix of scalar products was analyzed by Thurstone's centroid method. Centroid method is not very suitable for the analysis of smallish matrices (see Harman, 1960). But the structure will be so clear in the analyses to be reported in this monograph that the most important properties of these will come out anyhow.

6. Usually only the final result, i.e. the factor matrix, is given. The original similarity matrices are given in the appendix.

7. A note on nomenclature: »Multidimensional scaling» always in the present monograph refers to the analyses performed by the methods presented by Torgerson. To avoid confusion, similarity analysis will not be called multidimensional scaling (which, in fact, it is not). When the results of multidimensional scaling are discussed, »dimensions» will be spoken of, while for those of similarity analysis, »factors» will be the term used.

Factor	Interpretation	Intensity judged by the present writer	
		Weak	Strong
I	Rejection	3	19
II	Pleasure	10	7
III	Surprise	21	16
IV	Anger	13	6

The results are given in Table 3 and Figure 4. It can be seen, in the first place, that each of the previous »qualities» or factors is clearly differentiated from the others and, in the second place, that the dimensions, if the rotation of the axes indicated by the broken lines is performed, are indeed pleasure-anger and surprise-rejection. These dimensions certainly seem to be fundamentally the same as those of Schlosberg's 1952 study. One observes that the presumably most intense expressions, with the exception of stimulus 19, are the vertices of a diamond-shaped parallelogram. This, in addition to giving us the shape of the stimulus surface, means that the dimensions are »intensitive».

The conclusion from the experiment by Nummenmaa & Kauranne (1958) is that the expressions shown in Figures 2 and 3 can be described in terms of two bipolar dimensions: pleasure-anger and surprise-rejection. These dimensions are supposed to be intensitive. The stimuli cover a diamond-shaped area in the plane defined by the

Table 3

The Experiment of Nummenmaa and Kauranne (1958). Multidimensional Scaling Results: Factor Matrix.

Stimulus	Dimension	
	I	II
3	−.13	.22
6	−.30	−.28
7	.33	.21
10	.22	.21
13	−.33	−.09
16	.23	−.28
19	−.22	.14
21	.19	−.17

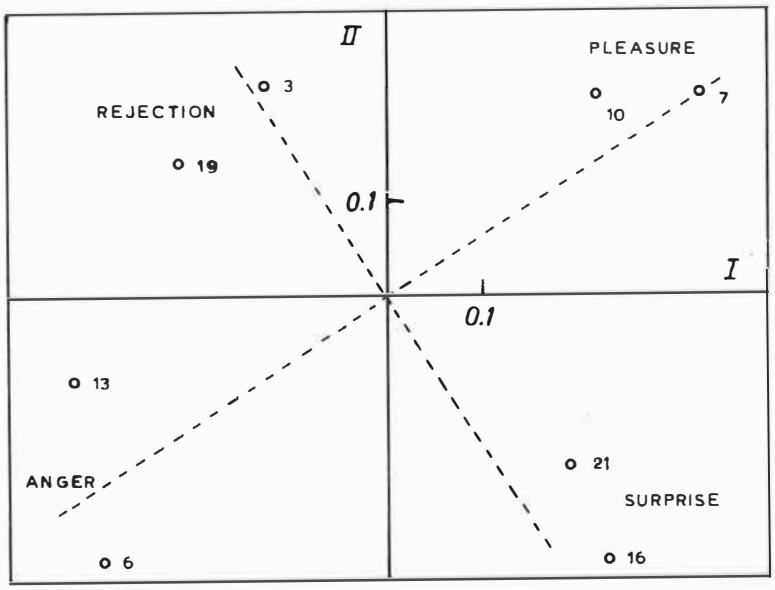


Figure 4

Multidimensional scaling results. Re-analysis of the data of Nummenmaa and Kauranne.

two axes. No claim is made here that these would be the only basic dimensions. These dimensions describe a particular set of expressions. Moreover, and this is important, they can be used as a starting point for the experimental work to be described in the following chapters.

III

Facial and verbal expressions: isomorphy of structures

We saw in the preceding chapter that, subject to certain conditions, facial expression is a variation around two main themes: unpleasant-pleasant and attention-rejection, or, as we shall from now on, referring to the Nummenmaa—Kauranne study, call them: pleasure-anger and surprise-rejection. In the Nummenmaa—Kauranne study the Ss gave descriptions that were used for the interpretation of the factors. But are these verbal expressions also variations around the same central themes? Exp. I was carried out study this (Nummenmaa, 1960).

Let us first consider what kind of names the Ss really gave in the Nummenmaa—Kauranne study. Table 4 shows the modal descriptions of the 27 facial expressions given by the subjects.

The reader notices that some frequencies are small, one of them is just one. The agreement between the Ss was in fact greater, because this list and these frequencies do not include expressions synonymous, perfectly or partially, with those indicated; it was these very words that were given at the frequencies listed below. We regard these words as the 'translations' of the facial expressions shown in Figures 2 and 3, admitting that there are some poor translations.

The Finnish words indicated in Table 4 were used as stimuli in an experiment in which 55 male Ss judged the subjective similarities between all possible stimulus pairs. The experiment was conducted and the results analyzed in the manner described on p. 13—14. The result, i.e. the orthogonally rotated factor matrix, is given in Table 5.

The interpretation of the factors is not quite as straightforward as it was in the Nummenmaa—Kauranne study, but the factors are clear

Table 4

Exp. I. The Stimulus Words

The number of earlier facial expression stimulus	The verbal expressions		The frequency with which each of the verbal expressions was given. N = 30.
	Finnish	English	
1	välinpitämätön	indifferent	4
2	halveksuva	contemptuous	18
3	arvosteleva	critical	5
4	tyytyväinen	contented	4
5	huvittunut	amused	10
6	raivostunut	furious	14
7	iloinen	glad	18
8	ivallinen	ironical	3
9	miettivä	thoughtful	5
10	onnellinen	happy	5
11	tarkkaava	attentive	1
12	epäluuloinen	suspicious	7
13	vihastunut	angered	3
14	riemukas	joyful	8
15	murjottava	moping	5
16	hämmästynyt	amazed	14
17	kauhistunut	terrified	18
18	surullinen	sad	8
19	ylimielinen	arrogant	5
20	myhäilevä	smiling	4
21	yllättynyt	surprised	5
22	pelästynyt	frightened	12
23	leppoisa	mild	2
24	inhoava	detesting	6
25	ylenkatsova	supercilious	4
26	kiukustunut	angry	5
27	kyllästynyt	bored	3

enough. To begin with the ones easier to interpret, factor II seems to be that of Surprise—Fear, factor III is Anger, factor IV is Pleasure, and factor V is Rejection. One observes particularly that the Surprise—Fear factor does not break down into two, those of surprise and fear, but remains one single factor. The first factor is more problematic, though. The words »thoughtful» (stimulus N:o 9) and »attentive» (stimulus N:o 11) have the highest loadings. Maybe this factor could be called Attention. But the present writer is not inclined to pay too much

Table 5

Exp. I. Results of the Similarity Analysis: Orthogonally Rotated Factor Matrix.

Stimulus	Factor				
	I	II	III	IV	V
1	−.01	.02	.45	.23	.45
2	.14	.07	.56	.02	.69
3	.52	.06	.38	.21	.32
4	.18	−.01	.15	.88	.00
5	.08	.06	−.04	.78	.33
6	.00	.67	.61	.02	.05
7	.04	.04	−.08	.96	.19
8	.08	.14	.50	.12	.59
9	.86	.10	.23	.30	.05
10	.07	.02	.06	.91	.08
11	.71	.11	.10	.31	.13
12	.57	.22	.23	.01	.38
13	.02	.65	.71	.00	.00
14	.00	.02	−.01	.84	.22
15	.41	.28	.64	−.09	.19
16	.22	.63	−.13	.32	.35
17	.10	.81	.09	.00	.30
18	.40	.35	.37	−.01	.08
19	.03	.05	.48	.13	.75
20	.22	−.04	.18	.88	.04
21	.13	.62	−.10	.50	.30
22	.26	.75	−.17	.04	.36
23	.25	−.05	.18	.83	.05
24	.08	.24	.55	−.02	.58
25	.06	.05	.53	.06	.76
26	.06	.61	.71	.04	.01
27	.15	.24	.65	.01	.30

attention to this factor, since the words defining it are among those on which the agreement among the Ss was very small.

The present writer (1960) drew the following conclusion in the original article: »The study as such perhaps does not give any very exact proofs, as the matching of the verbal and facial expression stimuli was a somewhat vague procedure. On [the] basis of the results, however, one could maybe suggest that the dimensions of the content of emotional communication may be relatively independent of the means of transmitting this content». To this it would be well to add a further

observation, but we first consider the results of the re-analysis of the data.

The stimulus words chosen for the re-analysis were words that correspond to the facial expression stimuli used in the re-analysis of the data of Nummenmaa & Kauranne; the numbers of these stimuli are thus found on page 18. The method is described in the footnote on page 17. The results are given in Table 6 and Figure 5.

Table 6

Exp. I. Multidimensional Scaling Results: Factor Matrix.

Stimulus	Dimension	
	I	II
3	−.25	.26
6	−.33	−.31
7	.45	.13
10	.42	.21
13	−.42	−.21
16	.18	−.24
19	−.27	.24
21	.23	−.13

A comparison of these results with those given in Table 3 and Figure 4 shows that the structures are almost identical. Except for some differences in the intensities of the expressions, the systems are alike and the conclusion given on p. 22 is again confirmed.

Ekman (1955) has carried out an experiment, which in fact served as a model for both the Nummenmaa—Kauranne study and Exp. I. He had the Ss judge subjective similarities between words denoting alleged emotional states. From similarity analysis he extracted eleven factors, of which he interpreted nine. These were: Pleasure, Discomfort, Agitation, Longing, Animation, Fear, Affection, Disgust, and Anger. Ekman's analysis gives many more factors than were found in Exp. I. And we now make the further observation to the conclusion mentioned on page 22. It relates to the fact that conceivably the facial expressions given in Figures 2 and 3 are a much more exhaustive collection of expressions of this type than are the words listed in Table 4. And to avoid here the more or less awkward task of deciding which words (or

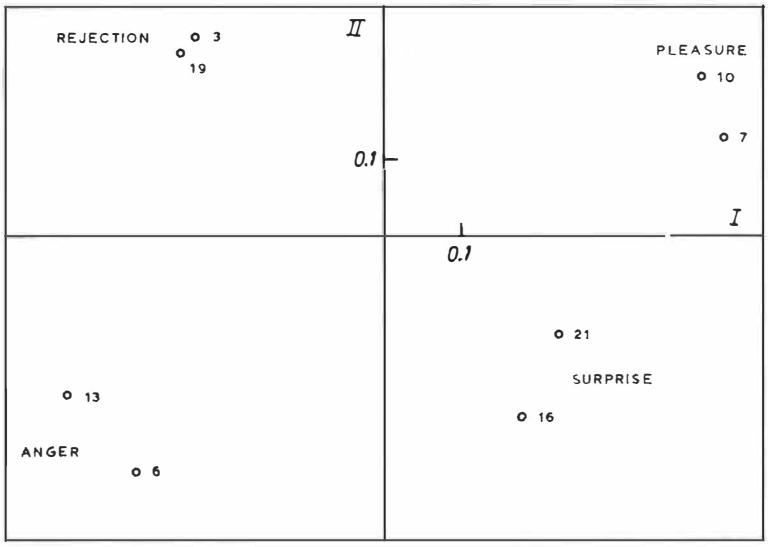


Figure 5

Multidimensional scaling results. Exp. I.

facial expressions) are »emotional» (the matter will however be discussed in Chapter VI), we add the notion of translating the facial expressions into verbal language. This simplifies the matter, and the final conclusion from Exp. I is: Two sets of messages, one of them sent by means of facial expressions and the other one by means of verbal expressions, have, on the condition that the messages are pairwise »translatable», isomorphic structures as revealed by multidimensional scaling methods.

IV
Simple and complex expressions

The multidimensional scaling methods are one way of seeking »explanatory» concepts. The number of these is as a rule less than the number of stimuli involved. The variables corresponding to these concepts account for the common variance of the stimuli. One could define as follows: If one and only one explanatory concept is enough for describing an expression, the expression is simple. If several are needed, the expression is complex. In a multidimensional model the expressions falling, possibly after a rotation to simple structure, on any of the axes could be considered as simple or elementary expressions, and the expressions not falling on any of the axes as complex or combined expressions. For example: Schlosberg (1952, Fig. 1), describes one particular expression (picture 10) as that of pleased surprise. Also Ekman (1955) in his study of verbal expressions described and analyzed some particular expressions in terms of the basic factors.

If facial expressions are regarded as messages, a simple expression would be a message that cannot be replaced by two or several other expressions, whereas an expression would be complex if several simple ones bundled together give an expression synonymous with it.

Granted that in Schlosberg's (1952) study the stimuli are scattered all over a surface, there are other studies (in particular, Abelson & Sermat, 1962; and also Nummenmaa & Kauranne, 1958) in which there are no expressions clearly combining two simple expressions. Therefore, Exp. II (Nummenmaa, 1962 b) was planned to investigate the following problem: Is it possible to express two 'emotions', chosen beforehand, simultaneously by facial expressions? A new set of pictures was obtained. This time Mr. Ristola who posed for the expressions tried expressly also to produce complex expressions. It was agreed that he should try to produce 'simple' facial expressions of pleasure, anger, and surprise, as well as combinations of those, taken two at a time. Some

seventy photographs were taken, and from these the fifteen most promising were chosen. Those fifteen expressions are shown in Figure 6, and the assumed translations of these expressions are listed in Table 7.

Table 7

Exp. II. Assumed Content of the Expressions. Stimulus Numbers Refer to Fig. 6.

Content of Expression	Stimulus Number
1. Pleasure	1, 7, 12
2. Surprise	3, 4, 8
3. Anger	2, 11, 15
4. Pleasant surprise	5, 6
5. Anger with a feeling of pleasure	13, 14
6. Surprise accompanied by anger	9, 10

Table 8

Exp. II. Distributions of the Multiple-Choice Descriptions. (The »Expected» Categories Have Been Indicated by Heavy Print.)

Stimulus	Description							
	Pleasure	Surprise	Anger	Pleasure and Surprise	Pleasure and Anger	Surprise and Anger	Pleasure and Surprise and Anger	Total
1	**19**			1				20
2			**12**		6	2		20
3		**17**		2		1		20
4		**6**		14				20
5	2	2	1	**15**				20
6	4			**14**			2	20
7	**17**				3			20
8		**8**				10	1	19[1]
9		1	6		2	**7**	4	20
10			5		1	**12**	1	19[2]
11			**15**		3		2	20
12	**17**			2	1			20
13	2		1	5	**9**		3	20
14	1	1	4		**7**	3	4	20
15			**11**		3	2	4	20

[1] One subject did not indicate his choice.

[2] One subject chose two descriptions and both responses were discarded.

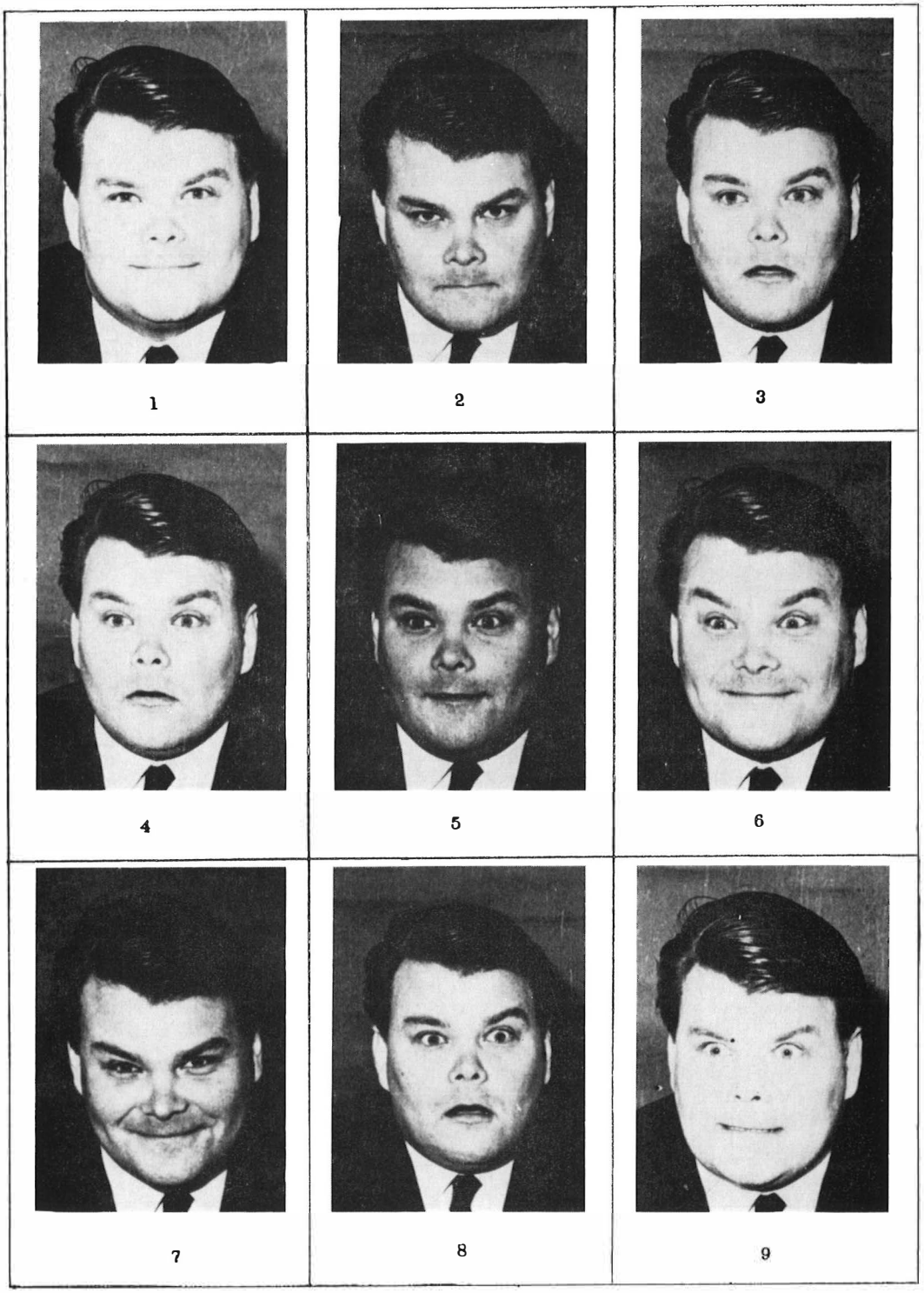


Figure 6

The stimuli used in experiment II.

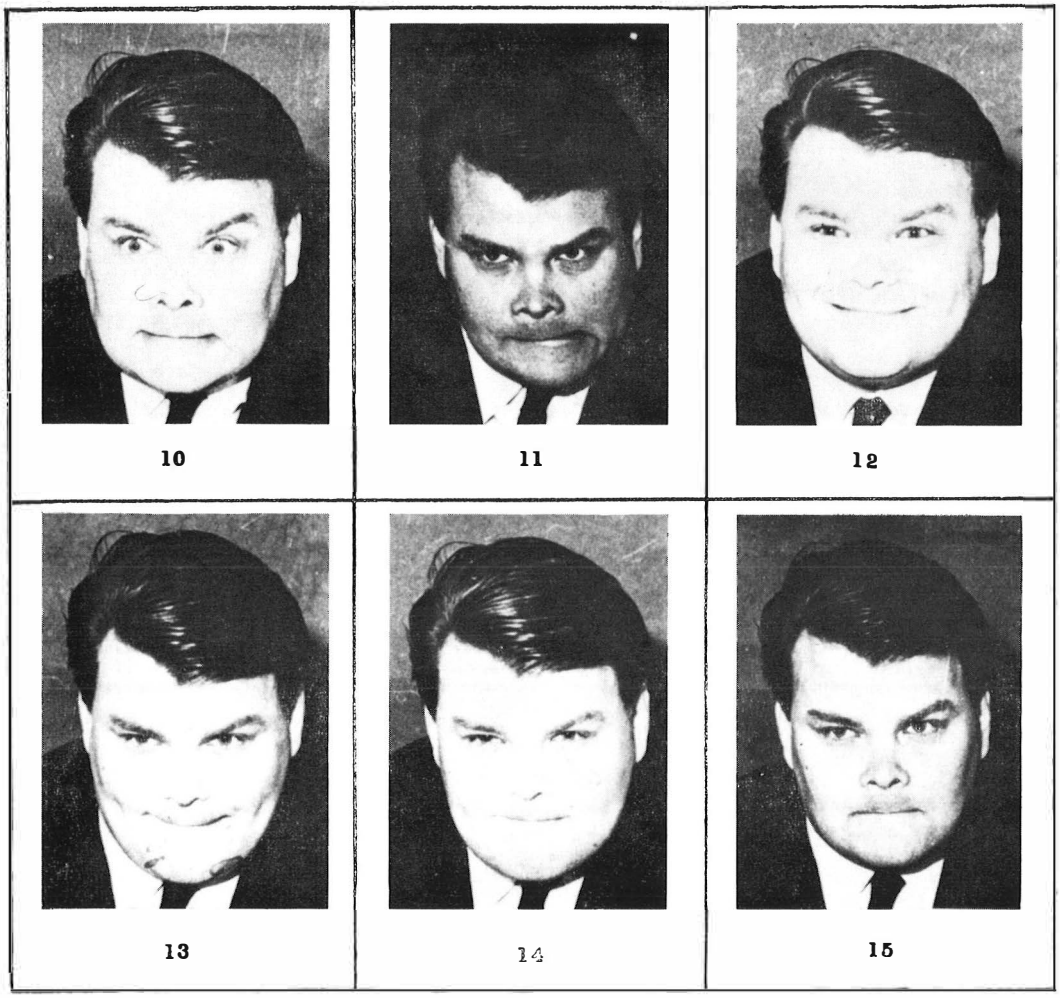


Figure 6 (continued)

The stimuli used in experiment II.

Exp. II was carried out using these pictures as stimuli. Two experiments were conducted. In the first of these, twenty Ss, both male and female, judged the subjective similarities between all possible stimulus pairs. The experiment was conducted and the results analyzed in the manner described on pages 13—14. After having done the similarity judgments, the same Ss saw the stimuli once more, now one at a time, and were required to select from a set of seven options the word or combination of words that best described the facial expression in question. These options as well as the distributions of choices are shown in Table 8.

The »expected» categories have been indicated by heavy print in Table 8. This table shows that the modal category is in all cases but one (Stimulus 8) the expected category. Admittedly, there is much scattering. So far the experiment supports the notion that two expressions chosen beforehand can be expressed simultaneously. The results of the similarity analysis will shed more light on this. These results are given in Table 9 which gives the orthogonally rotated factor matrix. The interpretation of these

Table 9

Exp. II. Results of the Similarity Analysis: Orthogonally Rotated Factor Matrix.

Stimulus	Factor		
	I	II	III
1	.11	.08	.79
2	.77	.24	.21
3	.11	.84	.18
4	.04	.90	.34
5	.00	.62	.65
6	.04	.33	.78
7	.11	.04	.86
8	.14	.77	.14
9	.68	.34	.13
10	.85	.33	.02
11	.85	.04	.00
12	.08	−.02	.97
13	.62	−.02	.61
14	.80	−.04	.38
15	.79	.24	.12

factors is straightforward. The first factor is Anger, the second is Surprise, and the third is Pleasure. But we are especially interested in seeing if the presumably complex expressions will have loadings on two factors each. This, indeed, is the case. Whereas each of the »simple» stimuli has a negligible loading on all factors but one, the combined expressions usually have loadings on two factors, that is, on those two that represent the alleged components of the combined expression in question. This is very clear as regards the stimuli 5 and 6 (pleasant surprise), and stimuli 13 and 14 (anger with a feeling of pleasure), but less so as to the stimuli 9 and 10 (surprise accompanied by anger).

Again a re-analysis was performed. Stimuli 3, 5, 10, 11, 12, and 13 were selected for this purpose. The method is described in the footnote on page 17. The results are given in Table 10 and Figure 7. The simple expressions

Table 10

Exp. II. Multidimensional Scaling Results: Factor Matrix.

Stimulus	Dimension I	Dimension II
3	.33	.34
5	.45	.07
10	−.36	.20
11	−.58	.05
12	.27	−.40
13	−.11	−.26

(stimuli N:o 3, 12, and 11) can be considered as vertices of a triangle, the complex expressions (stimuli N:o 5, 10, and 13) falling on about the midpoints of the sides. This result confirms those of the similarity analysis.

The conclusion from Exp. II is as follows: A person, or Mr. S. Ristola at any rate, can express two emotions at the same time. At least the combinations of pleasure, surprise, and anger, taken two at a time, are possible. From which part of the face each of these is identified will be analyzed in Chapter V. We shall see that new results are obtained if experiments are done using both simple and complex expressions as stimuli.

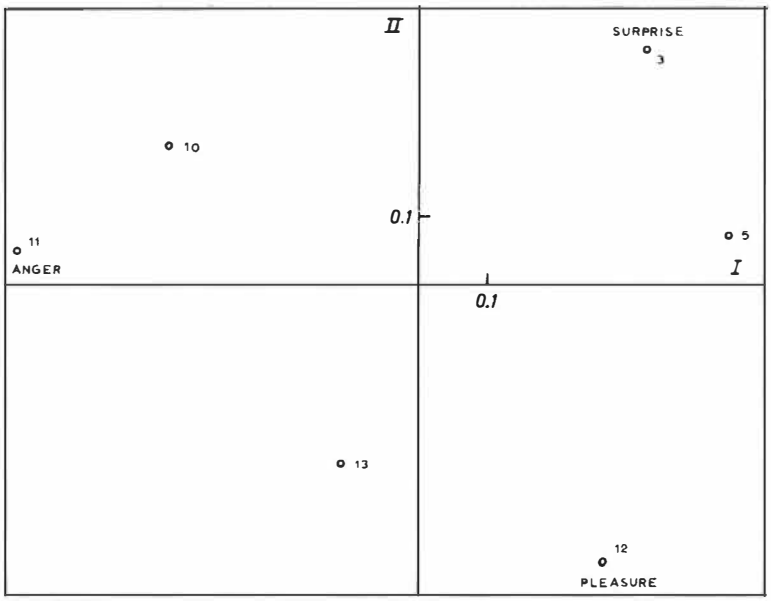


Figure 7

Multidimensional scaling results. Exp. II.

The multidimensional model gains predictive power if we can say of a given stimulus where it will be located in the multidimensional system. This is of course what the experimenter can do and does on the basis of his earlier experience and knowledge. But there is another possibility which relates to the complex expressions. Let us assume that we combine some simple expressions and thus form a complex expression. Then we should know how this expression is related in reference to the simple expressions, i.e. the basic dimensions.

Exp. III (Nummenmaa, 1962 a) was carried out to study exactly this problem: Can we say, given a set of simple expressions and combinations of these, where the complex expressions will be located in the multidimensional space defined by the simple expressions? To be certain that the elements of which the complex expressions are composed are known to us, it was decided to use some simple verbal and simple facial expressions and 'mechanical' combinations of these as stimuli. The verbal expressions consisted of single words; the facial expressions were shown by photographs. The combined stimuli simply consisted of a picture shown together with a word. The subjects were

supposed to imagine that the person seen in the photograph first shows a facial expression and then indicates his feelings with the word in question. The subjects were instructed to make their judgments (see below) even if a combination seemed unnatural. The stimuli as well as the task are, to be sure, quite artificial. The twelve stimuli used in this experiment are shown in Figure 8. The facial expression stimuli were chosen from among those used by Nummenmaa & Kauranne; they are expressions of pleasure (stimulus 7), surprise (stimulus 16), and anger (stimulus 6). The verbal stimuli are the »translation» of these facial expressions (see Table 4).

Three experiments were carried out. In the first of these, thirty female Ss judged the subjective similarity between all possible stimulus pairs. The experiment was conducted and the results analyzed in the manner described on pages 13—14. In the second experiment the same Ss, after having done the similarity judgments, also judged the stimuli as to whether they considered the expressions »possible» in everyday life; when the answer was in the affirmative, the Ss also had to indicate whether the expression in question was common or rare. Table 11 gives the results of these judgments. In the third experiment also 30 female Ss, not the same as the ones mentioned above, served as subjects. The stimuli were presented in all possible combinations of three, and the Ss made two judgments for each triad indicating which two of the stimuli were the most similar and which two the most different. Two of these subjects did not finish the task in the time allowed and their responses were discarded.[1] The handling of the data followed Torgerson's (1958, Ch. 11) exposition.

Let us first consider the judgments concerning the frequency of occurrence of the expressions. The results are given in Table 11. If we accept the standard limit, 50 %, of an absolute threshold, we see

[1] A number of erroneously made judgments were found. Sometimes the same two stimuli were given as the most similar and the most different, sometimes a subject wrote four stimulus names for one triad. The ${}_kP_{ij}$ matrices were based on the correctly performed judgments; the number of erroneous judgments was at most three per triad. When converting the percentages to normal deviates the percentages 100 and 0 had to be treated in some way; they were simply treated as if they had been 99 and 1, respectively. The experimental devices erroneously contained one triad (7, 9, 10) twice and did not contain one triad (7, 9, 11) at all. The three differences in distances ${}_kX_{ij}$ for the triad (7, 9, 11) were estimated on the basis of all available equations. The matrix of scalar products is given in Table 28 in the appendix.

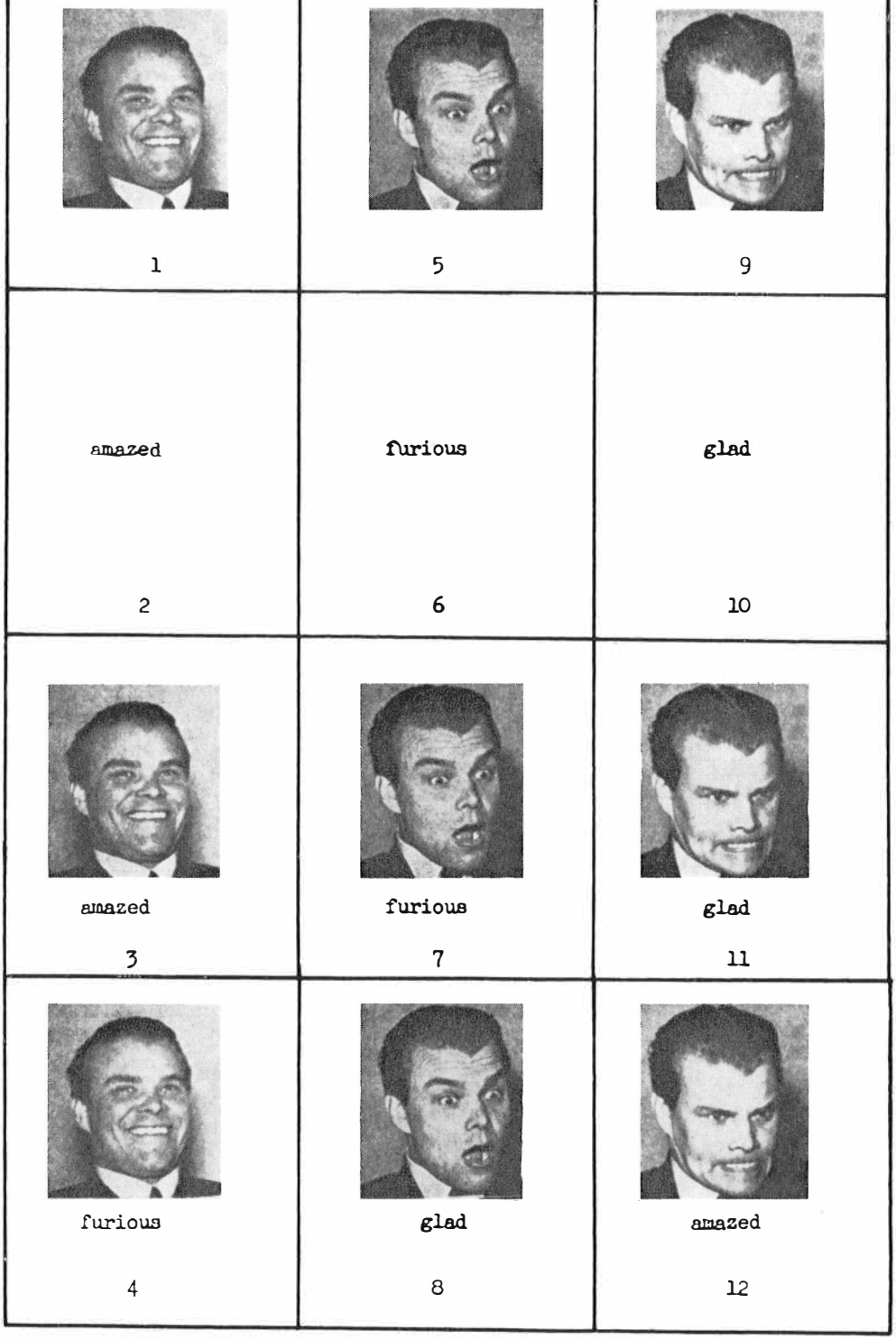


Figure 8

The stimuli used in experiment III.

Table 11

Exp. III. Distributions of the Multiple-Choice Judgments of the Frequency of the Occurrence of the Expressions in Everyday Life.

Stimulus	Frequency			
	Often	Rarely	Never	Total
1	30			30
2	23	7		30
3	17	11	2	30
4	5	7	18	30
5	22	7	1	30
6	13	15	2	30
7	5	13	12	30
8	13	11	5	29[1]
9	10	18	2	30
10	30			30
11	5	5	20	30
12	2	14	14	30

[1] One subject did not give a judgment.

that two of the stimuli clearly fail to reach this. These stimuli (No:s 4 and 11) are the combinations of pleasant expressions with those of anger. We recall from the results of Exp. II that this combination is perfectly possible. It is the 'mechanical' combination that here renders this combined expression incomprehensible. Maybe the conclusion would be that there is some interaction here; the combination of these two is possible and perfectly identifiable, but the expressions cannot be combined mechanically, each undergoes some changes. But we are mainly interested in predicting the outcome of the multidimensional scaling experiments. Let us consider the results of these. How, in the first place, would we assume the complex stimuli to be located in the space defined by the simple ones. The prediction for the similarity analysis is straightforward: the complex stimuli should get »medium» loadings on two factors each. But one should notice that here it is quite possible that the subjects automatically tend to work on the basis of »identical elements» alone; when comparing, say, a simple expression with an impossible complex one, they might write down medium values if the simple expression in question is also one of the elements of the complex one. The result then would be trivial. The

Table 12

Exp. III. Results of the Similarity Analysis: Orthogonally Rotated Factor Matrix.

Stimulus	Factor I	II	III	IV	h^2
1	−.01	.90	.05	.33	.93
2	.14	.29	.92	−.14	.97
3	.05	.77	.41	−.35	.89
4	.58	.59	−.22	.13	.75
5	.14	.39	.87	−.16	.95
6	.92	−.03	.12	.18	.90
7	.60	.06	.55	−.28	.74
8	.02	.63	.64	.28	.89
9	.96	.02	.01	.12	.94
10	.02	1.00	.06	.02	1.00
11	.63	.44	−.15	−.30	.71
12	.70	.02	.57	.12	.80

results of the similarity analysis are shown in Table 12, which gives the orthogonally rotated factor matrix. The interpretation of the factors: the first factor may be called Anger, the second is Pleasure, and the third is Surprise. The fourth remains uninterpreted. The combined expressions, whether possible or impossible, have moderate and often equal loadings on two factors each. The communalities of the simple expressions are very high; the communalities of the complex expressions are lower. The results are thus as follows: the locations of the complex expressions are determined on the basis of the elements; the subjects automatically work on the basis of identical elements; and all of the variance of complex expressions cannot be interpreted in terms of basic expressions.

We then turn to the results of the multidimensional scaling experiment which in this connection is perhaps the more interesting one. What, as to the complex stimuli, would we predict? One possibility is that, in the same way as in Exp. II (see Figure 7), the complex expressions are located at approximately the mid-points of the line segments joining the simple expressions in question. The results from the multidimensional scaling experiment are shown in Table 13 and Figure 9.

Table 13

Exp. III. Multidimensional Scaling Results: Orthogonally Rotated Factor Matrix. The Axes Have Also Been Translated to a New Zero Point.

Stimulus	Dimension		
	I	II	III
1	1.80	0.00	0.00
2	0.19	1.63	0.15
3	1.00	0.69	−0.30
4	−0.22	−0.81	−1.47
5	0.00	1.62	−0.11
6	−2.35	0.02	−0.28
7	−1.33	1.13	−0.82
8	0.73	0.79	0.15
9	−2.55	0.14	0.13
10	1.59	0.13	0.10
11	−0.72	−0.47	1.68
12	−1.51	0.77	0.77

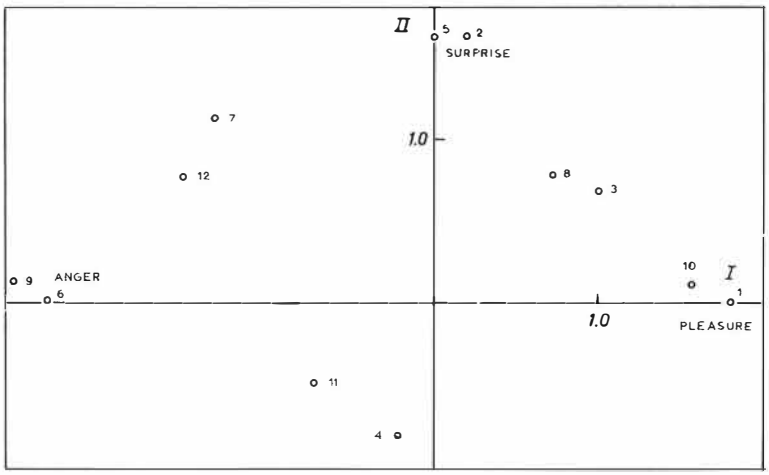


Figure 9

Multidimensional scaling results. Exp. III.

To produce a clear interpretation, the first two axes were translated to a new zero point and rotated to place the simple expressions on the axes. The first dimension is the pleasure-anger continuum and the positive pole of the second is surprise. The stimuli representing anger and pleasure are much further apart from each other than from the surprise stimuli. We notice that, neglecting the third dimension, which incidentally is not easily interpreted at all, the stimuli 1 and 10 (pleasure), 3 and 8 (pleasure + surprise), and 2 and 5 (surprise) all fall on a straight line, as do the stimuli 9 and 6 (anger), 12 and 7 (anger + surprise), and 5 and 2 (surprise). But the stimuli 1 and 10 (pleasure), 4 and 11 (pleasure + anger), and 6 and 9 do not; the complex stimuli are pushed away from the line connecting the expressions of pleasure and anger. One observes that these expressions, i.e. No:s 4 and 11, are precisely the »impossible» ones. If the third dimension is also taken into consideration, it is seen that these stimuli are, in fact, located very far from everything, even from each other. The hypothesis was thus confirmed for the possible expressions but not for the impossible ones. The third dimension may in part be something like an »interaction» dimension; no interpretation is possible in terms of stimulus content alone.

The conclusion seems to be that if we know the content of some simple verbal and facial expressions, and if we know whether the Ss will judge the combinations of the expressions to be meaningful or meaningless, we can predict where the combinations of these expressions are located in a multidimensional system.

V

Cues for simple and complex expressions

Where on the face are the cues a person is utilizing when he is interpreting a particular expression? This is the question we shall consider next. Special attention will be paid to the complex stimuli, as it appears that on this subject we can perhaps say something new.

Coleman (1949, p. 1) summarizes some earlier comparisons of the mouth region with the eye region as follows: »Studies dealing with the relative contribution of various facial regions to emotional expressions indicate that the upper half of the face is superior for certain expressions such as surprise and fear. Other expressions such as laughing and smiling may be more adequately judged from the lower half of the face. In general, the upper half is approximately as good as the lower half for judging facial expressions of emotion and the full face is superior to either half . . .» He came to a similar conclusion in his own studies (pp. 31—32):

»Certain specific facial expressions of emotion were more readily identified from the eye region, and others were more reliably identified from the mouth region. Acted expressions tended to favor the mouth region . . . In general, identification of the facial expressions of emotion were not made more reliably from either the mouth region or the eye region.»

In the original exposition on Exp. II the present writer (1962 b) conjectured that, since an emotion may be expressed either by the eye region or the mouth region, or, of course, both, maybe the eye region can express an emotion different from that which the mouth region is expressing. And, in fact, he agreed with Mr. Ristola who was posing for the expressions that he, i.e. Mr. Ristola, tried to express the differ-

ent emotions in the combined expressions (see Figure 6) by using different regions of the face. The element of pleasure in the combined expressions was, we supposed, predominantly expressed by the mouth region, and the element of surprise was predominantly expressed by the eye region. (This is entirely in line with the studies reviewed by Coleman). Consequently, anger, when expressed in combination with pleasure, was expressed by the eye region, and when with surprise, by the mouth region. The results of Exp. II, it will be recalled, showed that Mr. Ristola really succeeded in producing complex expressions. But it was a mere surmise that the eye region and the mouth region were indeed used to express different expressions. And Exp. IV (Nummenmaa, 1963) was carried out to clear this question up. We shall call the notion outlined above »the differential use of regions hypothesis» and it is this hypothesis we want to study.

The stimuli were selected from among those used in Exp. II. Three simple expressions, one of each kind (stimuli No:s 1, 2, and 8) were discarded to make the number of judgments required smaller. Thus, we are left with twelve stimuli representing six different contents of emotional communication. We have, so to speak, six pairs of synonymous expressions. The eye region from the first picture of each pair and the mouth region from the second picture of the same pair were covered with black paper, the dividing line being on the bridge of the nose. These are the stimuli. If the differential use of regions hypothesis were strictly true, these stimuli would now be simple expressions. Thus, for instance, the upper part of the face expressing pleasant surprise should have an expression of surprise and the lower part an expression of pleasure. Table 14 gives a detailed account of the stimuli.

Twentynine Ss, both male and female, judged the subjective similarities between all possible stimulus pairs. The experiment was carried out and the results analyzed in the manner described on pages 13—14. The results, i.e., the orthogonally rotated factor matrix, are given in Table 15. The interpretation in terms of the simple expressions is this: The first factor is Anger, the second is Pleasure and the third is Surprise. But we are especially interested in seeing whether stimuli N:o 5, 6, 9, 10, 13, and 14 will each have loadings on two factors (as did the corresponding whole expressions in Exp. II) or on one factor only (as could be expected were the differential use of regions hypothesis true). In the main, the former seems to be the case. This is very clear as regards the stimuli 5 and 6 (pleasant surprise), and stimuli 13 and 14 (anger with a feeling of pleasure), but not so clear

Table 14

Description of the Stimuli Used in Exp. IV.

Number of the stimulus in Exp. II	Content of stimulus on the basis of the results of Exp. II	Region of the face used as stimulus in Exp. IV	Assumed content of stimulus in Exp. IV, according to the differential use of regions hypothesis
3	surprise	mouth	surprise
4	surprise	eye	surprise
5	pleasant surprise	mouth	pleasure
6	pleasant surprise	eye	surprise
7	pleasure	eye	pleasure
9	surprise accompanied by anger	eye	surprise
10	surprise accompanied by anger	mouth	anger
11	anger	eye	anger
12	pleasure	mouth	pleasure
13	anger with a feeling of pleasure	mouth	pleasure
14	anger with a feeling of pleasure	eye	anger
15	anger	mouth	anger

Table 15

Exp. IV. Results of the Similarity Analysis: Orthogonally Rotated Factor Matrix.

Stimulus	Factor		
	I	II	III
3	.37	.00	.55
4	.22	.27	.73
5	.02	.61	.39
6	.02	.53	.52
7	−.03	.86	.13
9	.47	.09	.70
10	.75	.20	.04
11	.66	.27	.03
12	.11	.80	−.02
13	.46	.56	−.01
14	.32	.71	.05
15	.79	.09	.08

as to the stimuli 9 and 10 (surprise accompanied by anger). Each of the simple expressions (with the possible exception of stimulus N:o 3) has a negligible loading on all factors but one, whereas the upper and lower parts taken from the combined expressions usually have loadings on two factors, that is on those two that represent the components of the compound expression in question. The combination of surprise with anger seems to be an exception.

Before drawing any final conclusions we still consider two re-analyses. One of them was performed on the six eye region stimuli and the other on the six mouth region stimuli. The results of the former are given in Table 16 and Figure 10, the results of the latter in Table 17 and Figure 11.

Table 16

Exp. IV. Multidimensional Scaling Results: Factor Matrix.

	Dimension	
Stimulus	I	II
4	−.20	−.05
6	−.14	.14
7	.20	.25
9	−.29	−.12
11	.23	−.27
14	.22	.01

The results are very clear and can be described as follows. Both the stimuli representing the upper (Figure 10) or the lower (Figure 11) parts of faces expressing simple expressions can be considered as vertices of a triangle. The combinations, whether upper or lower parts of the face, of pleasure and surprise and of pleasure and anger, are located at about the mid-points of the respective sides of the triangles. But this is not the case with the combination of surprise and anger. The upper part (stimulus 9) seems to be an expression of surprise, and the lower part (stimulus 10) an expression of anger. We thus have at least one case where the differential use of regions hypothesis may hold true. Here it is crucial, of course, to know whether these stimuli, i.e. stimuli 9 and 10, really are complex. But on the basis of the results of Exp. II they would seem so.

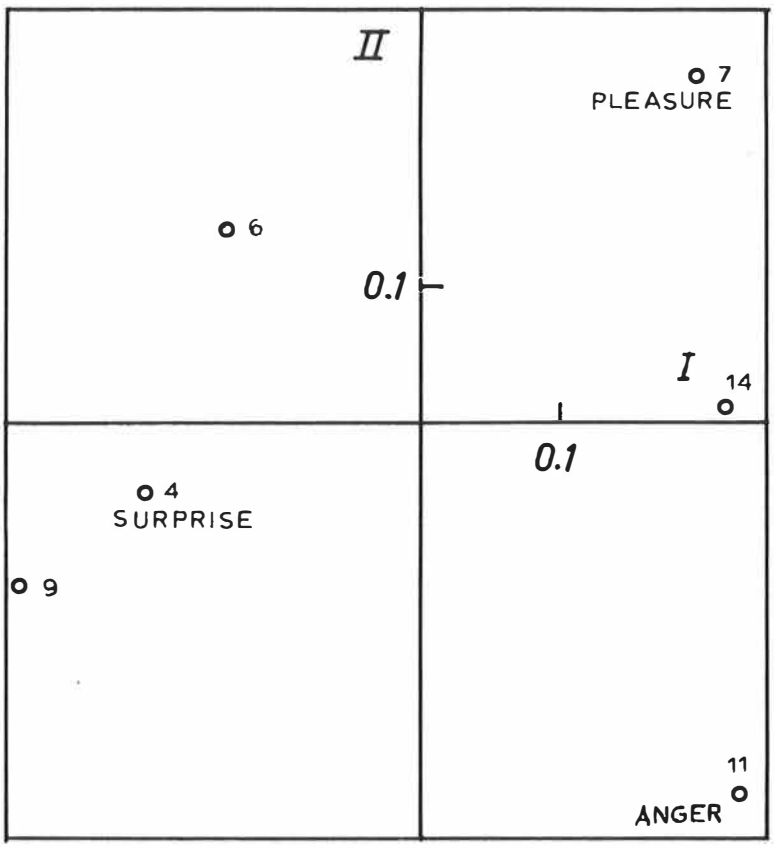


Figure 10

Multidimensional scaling results. Exp. IV; facial expressions identified from the eye region.

Table 17

Exp. IV. Multidimensional Scaling Results: Factor Matrix.

Stimulus	Dimension	
	I	II
3	.13	−.36
5	.30	.13
10	−.26	.01
12	.14	.27
13	−.07	.15
15	−.24	−.13

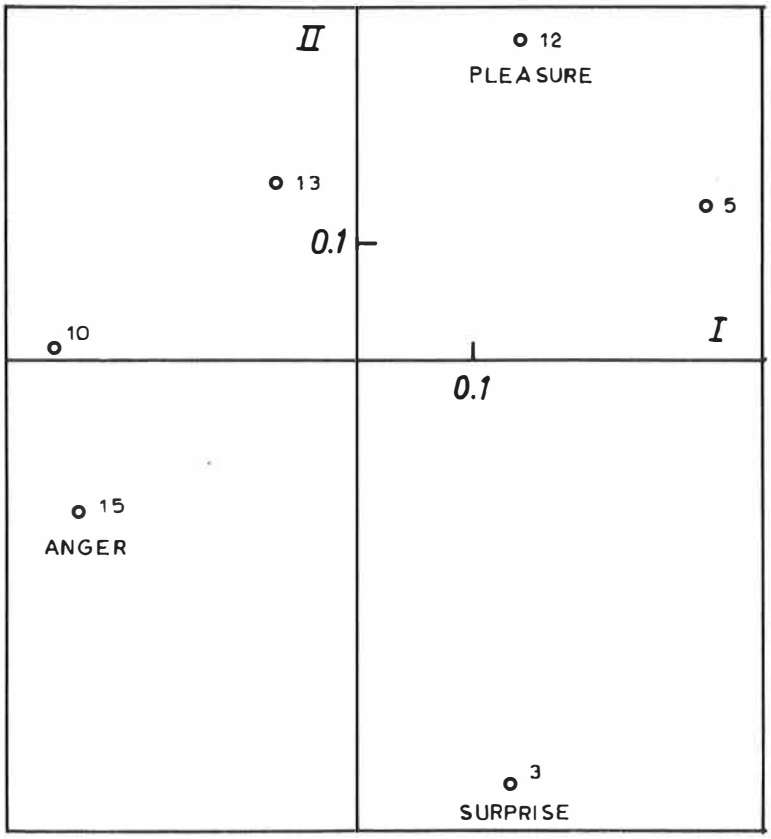


Figure 11

Multidimensional scaling results. Exp. IV; facial expressions identified from the mouth region.

The conclusion from Exp. IV is thus: the language of the face is redundant to a certain degree; each message, whether an elementary expression or a complex one, is transmitted at least twice, once by the eye region and once by mouth region. This is the rule for combinations of pleasure with both anger and surprise. The combination of anger with surprise is different: surprise is expressed by the eye region, anger with the mouth region.

Because Exp. IV did not include any verbal descriptions of the expressions, Exp. V was performed. The purpose of this experiment was to get more detailed information about the cues utilized by the subjects when interpreting facial expressions.

The stimuli were 12 of those used in Exp. II and the same 12 that were used in Exp. IV, i.e., stimuli 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14 and 15 of Exp. II. But for the purposes of Exp. V each picture was cut into four parts, these being the areas of the eyebrows, eyes, nose, and mouth, respectively. One set of stimuli thus consisted of the set of 12 eyebrows, etc. The four different sets of stimuli are shown in Figures 12—15.

Four groups of Ss, 30 in each, participated in the experiment. The task of each group was simply to give verbal multiple-choice descriptions of the stimuli. The task was, in fact, exactly the same as the description experiment in Exp. II. The distributions of the choices are given in Tables 18—21. Table 22 gives a summarized statement of the results shown in Tables 18—21, and Table 23 summarizes Table 22, giving us the final result. In Table 23 we see tabulated the number of times the modal value of descriptions of a part of the face is the same as that of descriptions of the full face. The results are remarkably simple: The simple expressions are to some extent at least

Table 18

Exp. V. Distributions of the Multiple-Choice Descriptions of the Expressions Identified from the Region of the Eyebrows. The Modal Categories from Exp. II Have Been Indicated by Heavy Print.

Stimulus	Description							Total
	Pleasure	Surprise	Anger	Pleasure and Surprise	Pleasure and Anger	Surprise and Anger	Pleasure and Surprise and Anger	
3	11	**7**		7	1	4		30
4	5	**9**	1	13		1	1	30
5	9	4	5	**3**	5	3	1	30
6	1	18	1	**7**		2	1	30
7	**1**	3	13	2	6	4	1	30
9	8	3		6	7	**3**	3	30
10	1	8	1	9	3	**3**	5	30
11	1	2	**18**	1	2	6		30
12	**8**	2	2	6	4	4	4	30
13	1		14	1	**4**	8	2	30
14	5		7	2	**5**	10	1	30
15	1	1	**12**	3	4	4	5	30

Table 19

Exp. V. Distributions of the Multiple-Choice Descriptions of the Expressions Identified from the Region of the Eyes. The Modal Categories from Exp. II Have been Indicated by Heavy Print.

Stimulus	Description							Total
	Pleasure	Surprise	Anger	Pleasure and Surprise	Pleasure and Anger	Surprise and Anger	Pleasure and Surprise and Anger	
3	13	**7**		6	1	2	1	30
4		**18**	2	8		2		30
5	1	11	1	**11**	3	1	2	30
6	3	3		**17**	1	2	4	30
7	**20**		3	3	1	1	2	30
9	1	17	2	1	1	**7**	1	30
10		6	3			**16**	5	30
11			**25**	1	2	2		30
12	**22**		1	7				30
13	4	2	5	1	**8**	6	4	30
14	6	1	3	2	**10**	3	5	30
15	2	1	**15**	1	5	6		30

Table 20

Exp. V. Distributions of the Multiple-Choice Descriptions of the Expressions Identifed from the Region of the Nose. The Modal Categories from Exp. II Have Been Indicated by Heavy Print.

Stimulus	Description							Total
	Pleasure	Surprise	Anger	Pleasure and Surprise	Pleasure and Anger	Surprise and Anger	Pleasure and Surprise and Anger	
3	1	**21**	2	1	3	1	1	30
4		**14**	4	8		3	1	30
5	1	7	7	**5**	6	4		30
6	16	1		**11**	1		1	30
7	**25**		1	4				30
9	1	11	3		4	**10**	1	30
10			14	1	2	**12**	1	30
11		1	**16**	1	1	10	1	30
12	**17**			10	1		2	30
13	6	1	3	6	**5**	2	7	30
14	7	4	3	4	**4**	5	3	30
15		2	**13**	2		11	2	30

Table 21

Exp. V. Distributions of the Multiple-Choice Descriptions of the Expressions Identified from the Region of the Mouth. The Modal Categories from Exp. II Have Been Indicated by Heavy Print.

Stimulus	Description							Total
	Pleasure	Surprise	Anger	Pleasure and Surprise	Pleasure and Anger	Surprise and Anger	Pleasure and Surprise and Anger	
3		**29**				1		30
4		**12**		15		2	1	30
5	18			**12**				30
6	12		2	**9**	6	1		30
7	**14**		3	7	4	1	1	30
9	1	1	9	2	9	**6**	2	30
10	1	1	7		11	**9**	1	30
11			**22**			7	1	30
12	6	1	1	9	6	1	6	30
13	5	2		8	**6**	3	6	30
14		1	5	1	**6**	11	6	30
15			**22**			4	4	30

Table 22

Exp's II and V. Summary of the Results of the Multiple-Choice Descriptions: Modal Categories.

Stimulus	Region of the Face				
	Exp. V				Exp. II
	Eyebrows	Eyes	Nose	Mouth	Full Face
3	Pleasure	Pleasure	Surprise	Surprise	Surprise
4	Pleasure and surprise	Surprise	Surprise	Pleasure and surprise	Pleasure and surprise
5	Pleasure	Surprise; Pleasure and surprise	Surprise; Anger	Pleasure	Pleasure and surprise
6	Surprise	Pleasure and surprise	Pleasure	Pleasure	Pleasure and surprise
7	Anger	Pleasure	Pleasure	Pleasure	Pleasure
9	Pleasure	Surprise	Surprise	Anger; Pleasure and anger	Surprise and anger
10	Pleasure and surprise	Surprise and anger	Anger	Pleasure and anger	Surprise and anger
11	Anger	Anger	Anger	Anger	Anger
12	Pleasure	Pleasure	Pleasure	Pleasure and surprise	Pleasure
13	Anger	Pleasure and anger	Pleasure and surprise and anger	Pleasure and surprise	Pleasure and anger
14	Surprise and anger	Pleasure and anger	Pleasure	Surprise and anger	Pleasure and anger
15	Anger	Anger	Anger	Anger	Anger

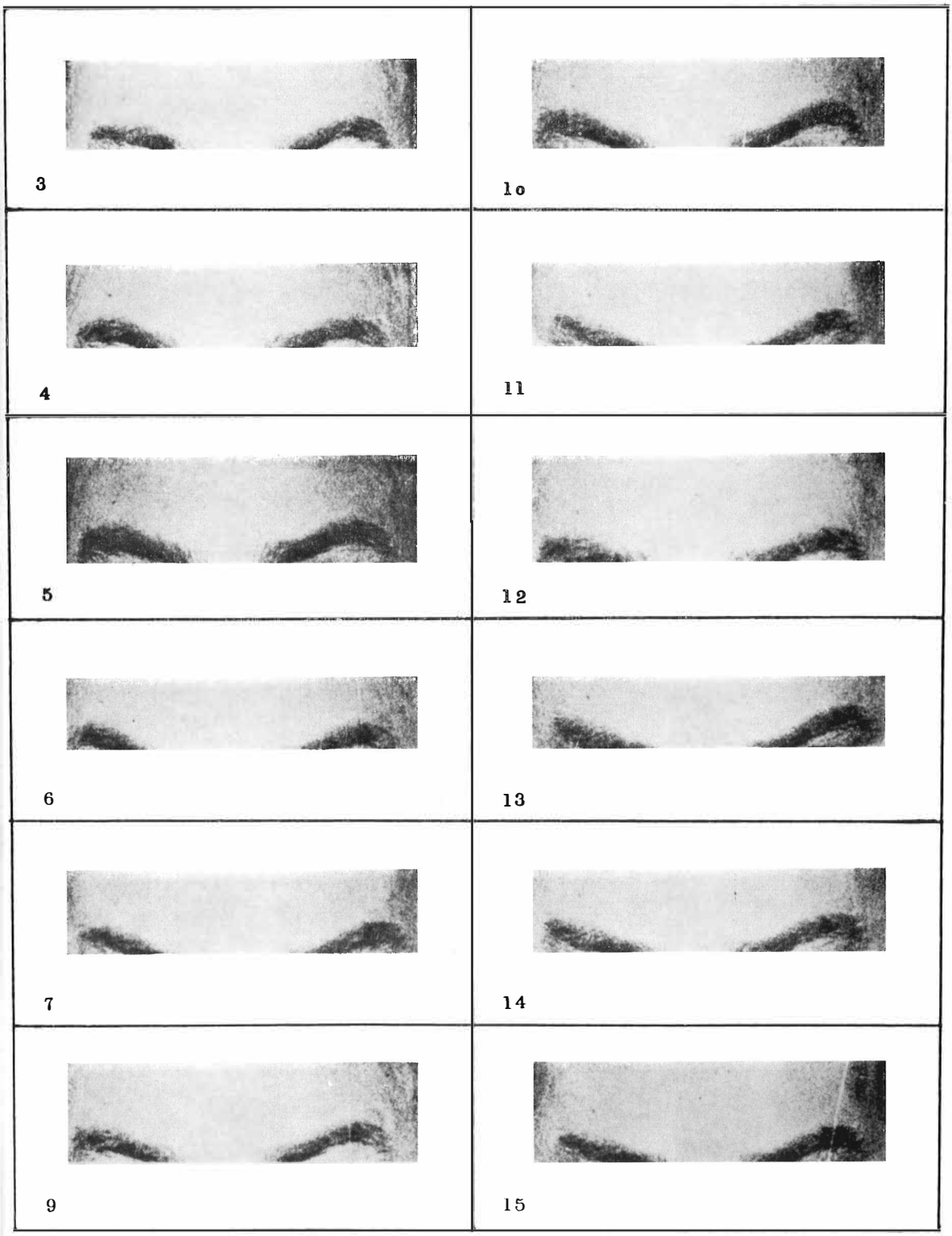


Figure 12

Stimuli used in experiment V. The numbers refer to Fig. 6.

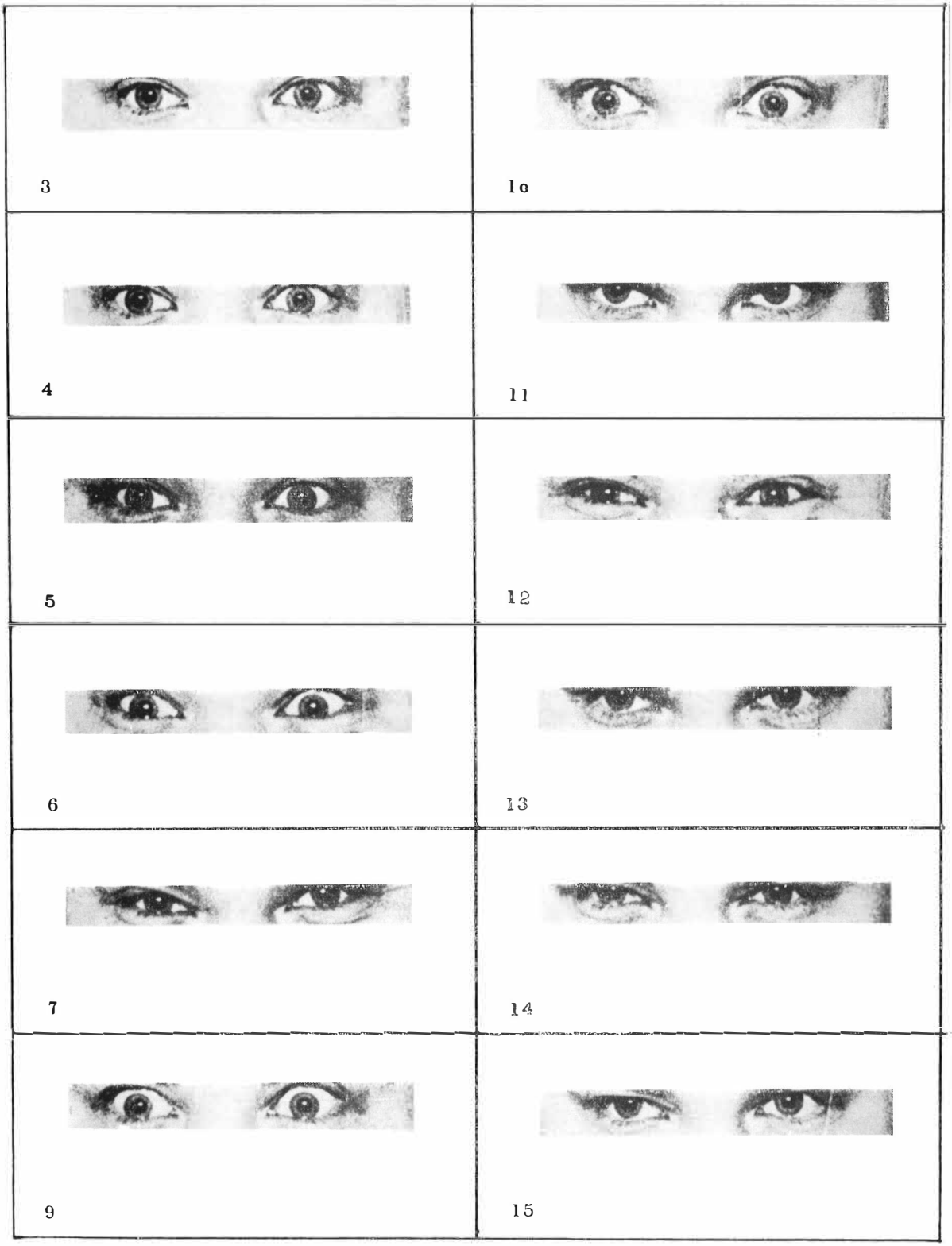


Figure 13

Stimuli used in experiment V. The numbers refer to Fig. 6.

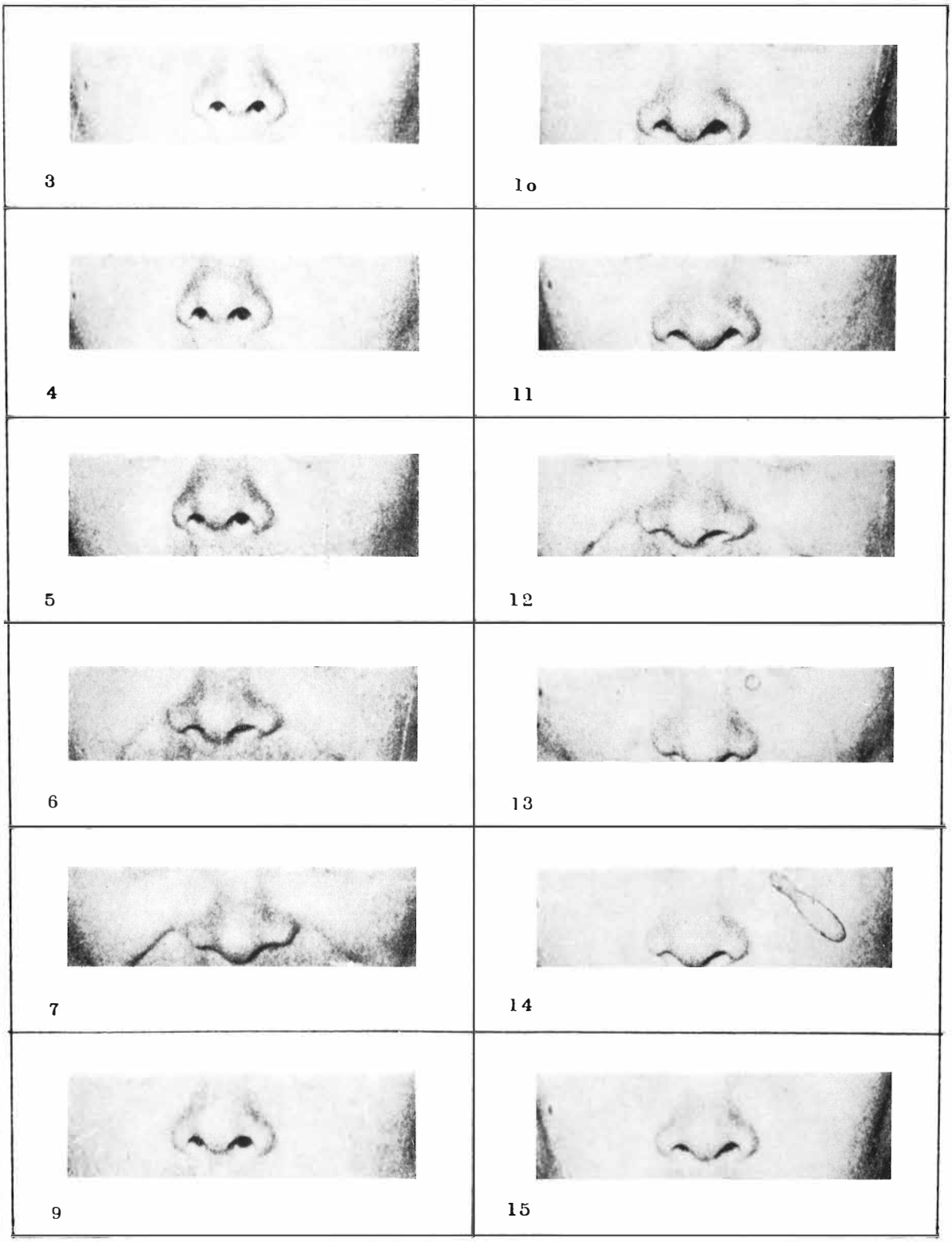


Figure 14

Stimuli used in experiment V. The numbers refer to Fig. 6.

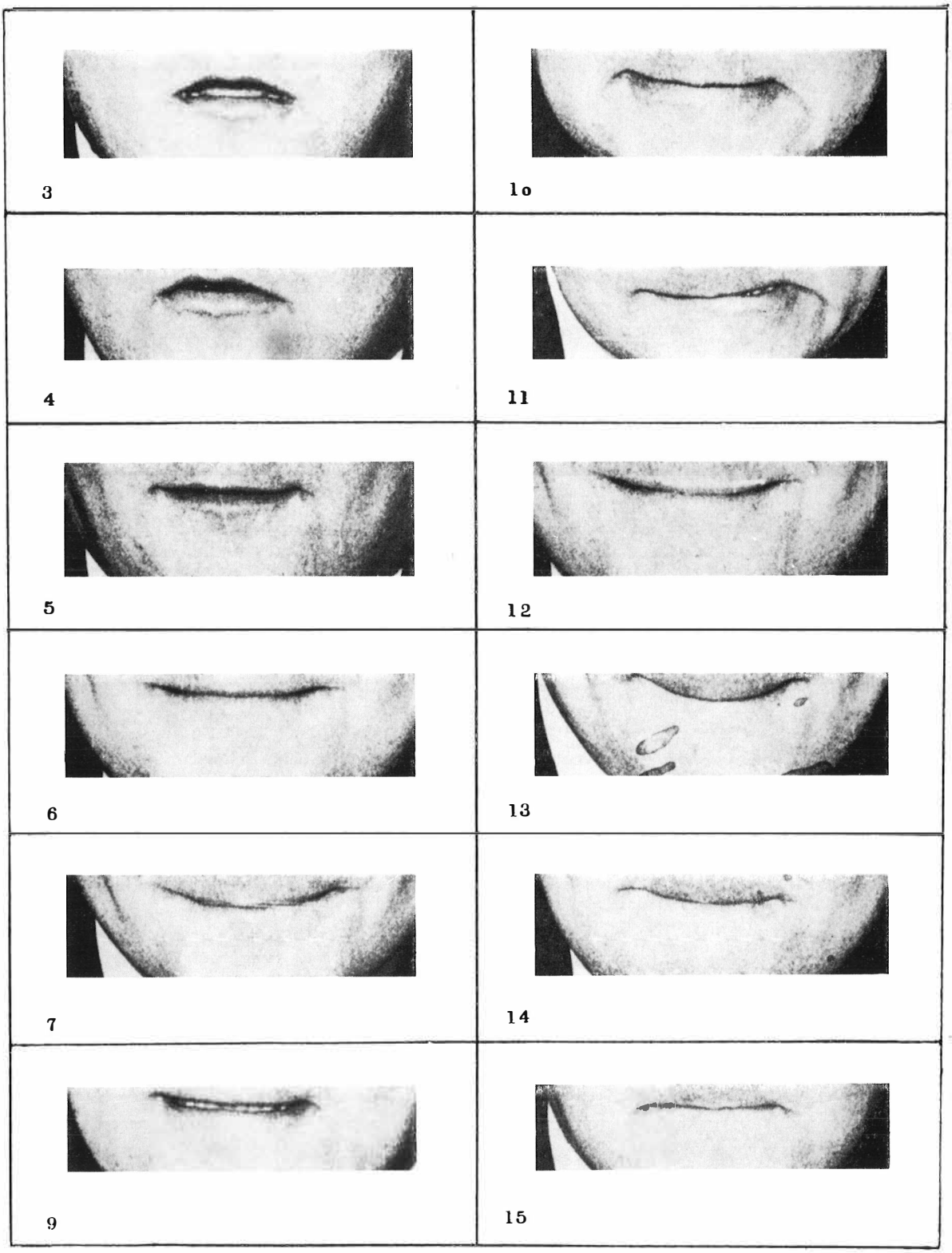


Figure 15

Stimuli used in experiment V. The numbers refer to Fig. 6.

Table 23

Exp's II and V. The Number of Times the Modal Category in Exp. V (Different Regions of the Face) Was the Same as That Found in Exp. II (Full Face). The Results Have Been Tabulated Separately for Elementary and Compound Expressions.

Region of the Face	Number of Modal Categories the Same as Those Found in the Descriptions of the Full Face	
	Elementary Expressions	Compound Expressions
Eyebrows	3/5	1/7
Eyes	4/5	4.5/7
Nose	5/5	0/7
Mouth	4/5	1/7

identifiable from almost any region of the face, but the complex expressions can only be identified from the eye region. Perhaps this in part answers G. W. Allport's (1955, p. 482) question: »Why do the eyes seem to us, as Köhler observes, the »visible center of another man's personality»? Is it because we obtain most of our information concerning him from our own eyes, and through some curious act of projection regard his eyes as equally important in the process of understanding? Is it because many of us locate our own sense of selfhood midway between our eyes, and seek, as it were, to fix our attention on the »self» that confronts us? Or is it because the subtleties of glance and ocular movement (including the motion of the lids and neighboring brow) are especially rich in expressive significance? Experimental work thus far seems to favor the mouth rather than the eyes as the principal agency of expression.[18] Why then are the eyes the focus of our attention?» The present writer does not want to say anything about the other interpretations given above, but the last, assuming that the eyes *are* the focus of our attention in the first place, certainly seems to be true. The eye region, even without eyebrows, is the only area from which a complex expression can be identified.

The conclusion from Exp. V is: certain simple expressions, especially perhaps anger and pleasure, can be identified from the areas of the eyebrows, eyes, nose, and mouth. But complex expressions can only be read in the eyes, which thus become the principal center of attention.

VI
Discussion

Emotion and expression

Facial expressions are conventionally spoken of as 'expressions of emotion', the last term being broadly understood as referring to a complex state involving bodily changes, but also being directed towards something; maybe some form of behavior is also indicated. If we speak of facial or verbal expressions of emotion, we are, in the ordinary sense of the word, discriminating between two kinds of things, i.e., emotional states, including both bodily and 'mental' aspects, and facial (or verbal) expressions of these. If we ask what are the 'things' that facial expressions refer to, the question breaks down into two parts. What sorts of interpretation are made on the basis of facial expressions? For what purpose does a person express something facially? The first question relates to the receiver, and the latter to the sender of a message.

It is conceivable that the receiver can make interpretations about emotional states, intentions, or personality characteristics. Takala (1962) suggests that if only a photograph of a face is shown, the receiver interprets it in terms of emotional states. If the expressions are intense, he argues, the receiver is inclined to ignore other aspects. If the facial expression is very scanty, he probably gets impressions about personality characteristics. More information than a mere facial expression would be needed to make interpretations about the intentions of a person.

Apparently the notion that facial expressions have something to do with emotional states is widely accepted. Sometimes it is this very aspect that is emphasized in studies of facial expression (e.g. Schlosberg, 1954; Abelson & Sermat, 1962). This notion emphasizes facial

expressions as being 'pictures of inner states'. If this notion is accepted the question arises whether any emotional state can be expressed by facial expressions. Or whether there is for any facial expression an emotional state which can be discriminated (not necessarily subjectively) from the others. In other words: Is there a one-to-one correspondence between the two systems? There are two possibilities here. One might claim that certain bodily states, or changes of these, are possibly followed by certain facial expressions. Or, on the other hand, one might claim that the multidimensional structures of both emotions and facial expressions are isomorphic. Sometimes the fact that facial or verbal expressions are easier to observe and handle than are the emotional states tempts a researcher to make claims for a one-to-one correspondence of the multidimensional systems. Schlosberg's (1954) theory of the dimensions of emotion is largely based on the study of facial expression. He (Schlosberg, 1941, 1952) experimentally observed two dimensions, added one, and by analogy generalized this system to describe emotions. Similarly Ekman (1955, p. 279) in an investigation writes:

»We all agree that sad, gay and happy denote emotional states which are rather clearly distinguishable. Just how many dimensions are necessary to account for the main differences between these and other presumably well-known emotions, and which are these dimensions? This is a problem which can be attacked experimentally. The present writer is entirely convinced that it cannot, at present, be solved in any definite way. But it may be possible to present partial solutions, to locate in a tentative manner some of the vectors of the reference system we need.» Then Ekman proceeded with the study of similarities between the verbal expressions we have mentioned on page 23. But there are difficulties. It will be recalled that Ekman interpreted nine factors, whereas Nummenmaa & Kauranne (1958), using the same experimental procedure, could only interpret four factors of facial expression. There are several possible interpretations for this. Differences between experimental methods are not one of them, because the method was the same in both studies. Conceivably words could be judged in a way different from that in which facial expressions are judged. But on the face of experimental evidence, it would not seem so. There is a reasonably close correspondence between the results obtained in the Nummenmaa—Kauranne study and in Exp. I, in which words corresponding to the expressions used in the Nummenmaa—Kauranne study were utilized. Another possibility: the collection of facial ex-

pressions used by Nummenmaa & Kauranne is not exhaustive enough. Again, this seems improbable, because no collections essentially richer seem to exist. The final possibility is the 'logical' one, that not all words in Ekman's list are, in fact, 'emotional'. If this is so, there is nothing to explain and the whole result is lacking in interest. The fact that verbal language is more powerful than facial language needs no experimental proof. But who is to tell which words are emotional and which are not? The experimenter in question thought they all were, and many, including the present writer, would agree with him. And there would be many other words of the same sort. But words are not necessarily 'only' emotional expressions. The trouble is that emotion and cognition, emotion and conception, are intermingled. Many verbal expressions refer to emotion, but not only to that; relations between persons, between things, etc., are involved. Anyway, the conclusion seems warranted that the two different systems of emotional expression may be of different dimensionalities (see pages 20—24), and logically it is not necessary that either system should have the same number of dimensions as that of the emotional states themselves.

We have seen that there are expressions that can be translated: »I am angry». This in ordinary speech means that a person is not statisfied with somebody and wants to correct the behavior of this person by hinting at the possibility of punishment. Again, there are expressions that translate: »This is disgusting» or »I reject this». If these are said of, and to, a person, they mean that the person expressing them wants no business with the one he talks to. Expressions of anger are often used to change the behavior of a person but not necessarily to cut off a contact. Expressions of rejection are often used to cut off a contact but not necessarily to change the behavior of the person. Roughly, anger would indicate approach, rejection avoidance. But if anger and rejection, which are both unpleasant and express dislike, can be distinguished, the position that interpretations are also made of probable courses of action is defendable, vague as inferences concerning these may be. Common usage makes a difference between two kinds of facial expressions, posed and natural ones. It is conceivable that for predictions concerning »emotional states» the »natural» ones might be better, and for predictions concerning »probable courses of action», the »acted» ones. This leads us to consider matters at the sender's end of communication.

The notion that facial expressions, and perhaps the acted ones in particular, are signs that can be used as a means of social communi-

cation is found in psychological literature quite often. Such contentions can be found in the writings of Allport (1924), Landis (1929), Woodworth (1938), Boring, Langfeld and Weld (1948), Kauranne (1960), Nummenmaa (1962 c) and probably in the writings of innumerable others. In the experiments reported in the present monograph only acted expressions were used as stimuli. The present writer takes the view that facial expressions are, whatever else they may be, signs that can be used in communication. And to say that they can be so used means that a person is capable of making a decision about when he is going to produce a particular expression. Exp. II convinces at least the present writer of the fact that the person posing for the photographs could make very detailed decisions about what he would express. When he decided, say, that he would express »anger with a feeling of pleasure» the expression that emerged was later so described by the subjects. When this person decided to express surprise, it was the expression, not he, that was 'surprised'. And no claims are made in this monograph about the correspondence between acted facial expressions and emotional states. The two sets of things for which correspondence, or rather, translatability from one to the other, is claimed are acted facial expressions and verbal expressions, and even this subject to the conditions defined in connection with Exp. I.

Dimensions of facial expression

We have dealt in Chapter II with three possible multidimensional descriptions of facial expression. And, if we deal with Schlosberg's 1952 study and 1954 paper separately, we have in fact four possible alternatives. Schlosberg originally (1952) suggested on experimental grounds that the basic dimensions are pleasant-unpleasant and attention-rejection. Later (1954) he suggested the additional dimension tension-sleep, but he and his collaborators could not show experimentally that this really is independent of the other two. Abelson & Sermat (1962) found two dimensions, and, having correlated them with Schlosberg's scales suggested that pleasant-unpleasant and sleep-tension are the best ones. The fact that sleep-tension and attention-rejection correlate highly is extremely perplexing. The result may be caused by the particular series of pictures used by Engen, Levy, & Schlosberg (1958) and Abelson & Sermat (1962).

Nummenmaa & Kauranne (1958) found what in terms of bipolar

dimensions would be pleasure-anger and surprise & fear -rejection. The interpretation was done on the basis of descriptions given by the subjects. These dimensions are the same as those that Schlosberg originally suggested, and it seems that these two are reliably identifiable. Whether there is an independent dimension of sleep-tension remains to be seen. Quite obviously the dimensions pleasure-anger and surprise-rejection are intensitive in themselves. What else could they be? What would the idea of a dimension refer to if not to intensity?

It is not necessary for the face of a person to have any expression, in the usual sense of the word, at all, whether the person in question is sleeping or awake. And it is quite conceivable that one might obtain a third dimension, independent from pleasure-anger and surprise-rejection, by including in the collection of stimuli faces bearing no expression at all, some of them representing »sleep» and some the state of being »awake». These would be far from each other and far from everything else, and could possibly form a continuum.

One final remark: the names one gives to dimensions of facial expressions also guide one's thinking about facial expressions. Names such as pleasant-unpleasant and sleep-tension (activation) have an association with the study of emotions, whereas names such as pleasure-anger and surprise & fear -rejection have more a social- psychological flavor.

Simple and complex expressions

One particular problem in the early studies of emotion was the following: Is the result of two simultaneous elementary feelings a new mixed feeling or will the elementary feelings, even if simultaneous, remain elementary and be perceived as simultaneous feelings of different kinds. Woodworth (1938) seems to have reviewed more evidence for the hypothesis of elementary feelings than for the hypothesis of mixed feelings (see also Ruckmick, 1936).

Are there any problems analogous to this in the study of expressions of emotion? The purpose of the multidimensional scaling procedures is

[1] Kauranne (1960), applying a method described by Osgood & Suci (1952) to a selected collection of 30 Frois—Wittman pictures, obtained a three-dimensional system; anger, pleasure, and contempt being the dimensions. The correlations between these factors were all positive. Expressions of surprise did not form a factor of their own in this study.

to find out the dimensions that are needed to describe a set of stimuli and to locate the stimuli in the system of dimensions. The stimuli that are located on the axes (after a rotation, possibly) can be regarded as representative of basic qualities, and the stimuli that are not located on any of the axes can be regarded as combinations of these basic qualities. In the case of emotional expressions the stimuli that are located on the axes could be regarded as expressions of elementary emotions, while the stimuli not located on any of the axes could be regarded as simultaneously expressing several elementary emotions, i.e. they could be regarded as combinations of elementary expressions. We can now introduce problems analogous to that relating to mixed feelings. There are two of these. Both questions could be perfectly well introduced without any reference to the earlier dispute about mixed versus elementary feelings.

The first is the ever recurring question of the additivity of cues: can expressions that are interpreted as meaningful complex expressions be obtained by adding cues of several simple expressions? Or rather: are the cue compounds on the basis of which a complex interpretation is made, sums of the cues for simple expressions? The differential use of regions hypothesis is relevant here (see page 36). The second question relates to synonymy: is a complex expression perfectly synonymous with a suitably chosen conjunctive collection of elementary expressions? This is a question of how much specificity there is in the complex expressions. It is the additivity of meaning rather than of cues we are interested in here.

Let us then consider the experimental evidence. We shall first consider the latter problem. In Exp. II it was shown that two expressions can be combined at will. These combinations can be well explained in terms of elementary expressions. But it was also shown in Exp. III that arbitrary combinations of simple facial and verbal expressions cannot be so explained without residuals that are considerably greater than those of the simple expressions. The evidence may be inconclusive, but even so the present writer is inclined to draw the following conclusion: Simultaneous combinations of the expressions of pleasure, surprise, and anger are perfectly possible and meaningful (Exp. II). But the mechanical combination of elementary expressions of pleasure and anger is not meaningful (Exp. III), whereas the other two combinations may be. There may be several kinds of »pleasant anger», but at least those expressed in pictures 13 and 14 of Fig. 6 seem (I am interpreting them myself now, of course) to have a tone of cruelty;

the anger is directed toward some other person, and the person making faces in enjoying this. A mechanical combination cannot produce this.

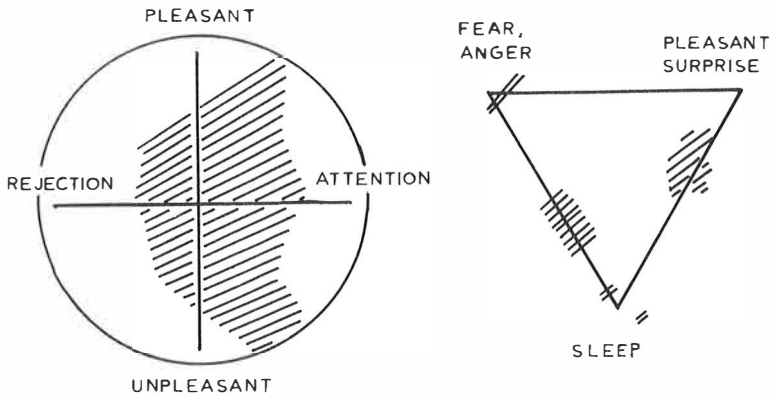
This in a natural way leads us to the question of the cues on the basis of which facial expressions are interpreted. In Exp. II (the two re-analyses) it was shown that simple expressions of pleasure, anger and surprise are identifiable from both the eye and the mouth regions of the face. This is in accordance with the material obtained experimentally and reviewed by Coleman (1949). In the combination of surprise with anger, surprise was obviously identified from the eye region, whereas anger was identified from the mouth region. This particular combination is thus obtained by simply adding the cues for surprise (eye region) to the cues for anger (mouth region). The differential use of regions hypothesis holds good for this particular combination. But for the combinations of pleasure with anger and pleasure with surprise it does not. In both these the mouth region and the eye region express two emotions simultaneously. In Exp. V an effort was made to locate the cues for surprise and pleasure and for anger and pleasure separately. Faces were divided into four parts instead of just two. But it appears that even this does not give us two different sets of cues, some for pleasure and some for the other emotions, except maybe in the case of the mouth region. But the eye region is remarkable in the sense that two expressions can be read in it simultaneously. Of seven cases of complex expressions two fail in this respect; one of these is precisely a combination of surprise with anger. As for the eye region, the present writer does not know how to divide it further to identify where the cues for pleasure, anger, and surprise are. And the conclusion, provisional of course, is as follows: the combinations of pleasure with anger, and pleasure with surprise, identified from the eye region are not divisible (at least not easily) into constituent parts. In the nose-mouth region the case may be different.

The shape of the expression surface

Abelson & Sermat (1962, p. 553) write: »A persistent concern in the facial expressions area has been the shape of the stimulus surface (the »emotion solid»). Schlosberg (1952) designated the shape as roughly oval in two dimensions and (Schlosberg, 1954) as a tilted cone with an oval cross-section in three dimensions. Triandis and Lambert (1958)

strove inconclusively to modify Schlosberg's formulation. One difficulty besetting these attempts has been the lack of calibration between dimensions. Shape is a direct outcome of the multidimensional scaling operation. A plot of Dimensions I and II of the present study yields a stimulus boundary or envelope which is nearly an equilateral triangle. The »sleep» expression, Stimulus 56, anchors one corner of the triangle at the negative pole of Dimension II. The other two corners lie at the other pole of Dimension II such that the side joining them is parallel to the I axis; Stimulus 15, very pleasant surprise, is close to one corner and Stimuli 29 and 51, anger and fear, close to the other. The boundary could of course bulge were more stimuli added, with a coat-of-arms or pear shaped contour as plausible possible alternatives. An oval or elliptical shape appears implausible, although one cannot have full confidence in this conclusion without a much more exhaustive sampling of stimuli.»

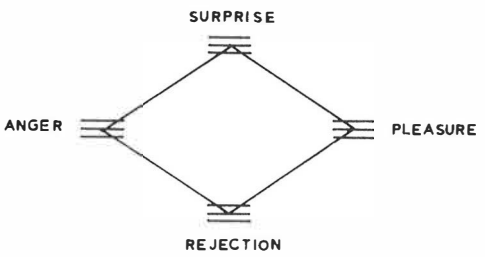
It may be useful to compare the different efforts with the help of Figures 16 and 17. Figure 16 shows Schlosberg's (1952) two-dimensional description and Abelson & Sermat's (1962) description. Figure 17 shows the description of Nummenmaa and Kauranne (1958); the re-analyzed data have been used. Figure 17 also shows the results of Nummenmaa (1962 b) from an experiment in which expressions of rejection were not involved. In all cases the areas on which the points were actually located have been approximately shown by shaded areas and lines.



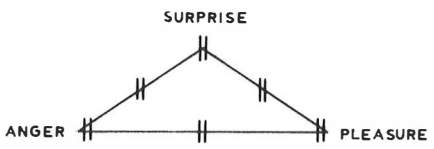
Schlosberg, 1952 *Abelson & Sermat, 1962*

Figure 16

Stimulus surfaces.



Nummenmaa & Kauranne, 1958
(re-analyzed data)



Nummenmaa, 1962 b

Figure 17
Stimulus surfaces.

One gathers from the results of Schlosberg (1952) and Nummenmaa & Kauranne (1958) that at least in the plane defined by pleasure-anger and surprise-rejection a triangle- shaped stimulus surface does not seem plausible, and much more probable is a diamond- shaped one. We recall from Exps II and III that this surface does not bulge very easily.

A triangle-shaped surface was obtained by Nummenmaa (1962 b) who then used only three basic expressions as stimuli. As to the results of Abelson & Sermat, it seems that the suspicion of these writers is entirely justified: the Lightfoot Series does not seem to exhaust the set of facial expressions nearly as well as the Frois-Wittman Series or the series used by Nummenmaa & Kauranne. In Abelson & Sermat's study, suspicions are aroused by the fact that expressions of pleasure and surprise are located in the same place, as are also, on the other hand, those of fear and anger. These are results contradictory to those of Schlosberg (1952) and Nummenmaa & Kauranne (1958). It is plausible that the Ss would not describe the expressions of the Lightfoot Series in the same way as the experimenters (Engen, Levy, & Schlosberg, 1957).

The conclusion is thus: in the plane defined by pleasure-anger and surprise-rejection a diamond-shaped stimulus surface seems probable. This could bulge somewhat, to make the surface roughly elliptical, pleasure-anger being the longer axis and surprise-rejection the shorter one. Whether, in a representative sample of facial expressions, the 'expressions' of sleep would be located in the point of intersection of the axes or somewhere else, pushed out of the plane, cannot be said.

If a third dimension, tension-sleep, is necessary, there still remains the question of what the three-dimensional description would look like.

There are two possibilities. The system would probably be bowl-like, like Schlosberg's tilted cone. But the bowl might either be full to the brim, of facial expressions, or it might not. It could in fact be quite empty, the bowl itself representing the possible positions. The latter possibility seems more probable.

The »meaning» of facial expression

We have observed that the language of the face has a basic vocabulary of at least four easily identifiable 'words'. The stimulus surface is probably some diamond-shaped area, pleasure-anger being the longer and surprise-rejection the shorter diagonal.

It remains to be seen whether this multidimensional model can be applied to anything. One possibility is in fact implied in Schlosberg's 1941 paper. If we consider these axes from the social-psychological point of view, we could conceive of the pleasure-anger axis as relating to the kind of information that is wanted, i.e. this could be the rewarding-punishing axis. And again, an expression of surprise begs for more additional non-redundant information, the content of which remains otherwise unspecified; rejection again indicates that no information whatever is wanted. If a combination of two expressions occurs, the total effect would be a joint function of the two dimensions. The only experimental evidence seems to be that concerning the pleasant expressions, and the smile in particular (see Krasner, 1958). These facts remain to be worked out.

VII
Summary

A series of experiments was carried out. The starting point was a paper by Nummenmaa & Kauranne (1958), in which these writers, using the method of similarity analysis, described four basic qualities of expression: pleasure, anger, surprise-fear, and rejection. The writers identified these as the different poles of Schlosberg's (1952) dimensions pleasant-unpleasant and attention-rejection. This identification was confirmed by a re-analysis, made by multidimensional scaling methods, of the data of Nummenmaa and Kauranne. This re-analysis gave two dimensions: pleasure-anger and surprise & fear-rejection. In a series of five experiments the following results were obtained.

1. Similarity analysis was applied to the modal verbal descriptions given by the Ss of the stimuli used by Nummenmaa & Kauranne. The results of similarity analysis as well as those of the re-analysis by multidimensional scaling methods gave the following conclusion: two sets of messages, one of them sent by means of facial expressions and the other by means of verbal expressions, have, on the condition that the messages are pairwise »translatable», isomorphic structures, as revealed by multidimensional scaling methods.
2. Some facial expressions we consider simple and some we consider complex. In a multidimensional model the expressions falling, possibly after a rotation to simple structure, on any of the axes could be considered as simple or elementary expressions, and the expressions not falling on any of the axes as complex or combined expressions. According to the results the combinations of at least pleasure, surprise and anger, taken two at a time, are possible and identifiable.
3. The model gains predictive power if we can say of a given stimulus where it will be located in the multidimensional system. This is of course what the experimenter can do on the basis of his earlier knowledge and experience. But there is at least one particular case where

there is another possibility. This possibility relates to the complex expressions. Assume we combine some simple expressions and thus form a complex expression. Then we should know how this expression is related in reference to the simple expressions, i.e., the basic dimensions. According to the results, it seems that if we know the content of some simple expressions, both verbal and facial, and if we know whether the Ss will judge the combinations of these expressions, taken two at a time, as meaningful or meaningless, we can make some predictions. It would seem that the »possible» combinations are located on straight lines connecting the simple expressions in question; they are located somewhere near the midpoints of these segments of lines. The »impossible» combinations are pushed away from the space defined by the meaningful stimuli.

4. The starting point for Exp. IV was the following. It was assumed that the element of pleasure in the combined expression was predominantly expressed by the mouth region, and the element of surprise predominantly by the eye region. And consequently anger, when combined with pleasure, would be expressed by the eye region, and when with surprise, by the mouth region. This notion was called the differential-use-of-regions hypothesis. It was shown that this hypothesis is verified in the case of the combination of anger with surprise, but not in the other two cases. When pleasure is combined with surprise or with anger, both qualities involved can be read from both the eye region and the mouth region.

5. To get some more detailed information about the cues utilized by the subjects when interpreting facial expressions, the stimuli used in Exp. II were cut into four parts, these being the areas of the eyebrows, eyes, nose, and mouth. The subjects tried to identify facial expressions from these stimuli. The conclusion from this experiment seems to be this: certain simple expressions, especially perhaps anger but to some extent also pleasure and surprise, can be identified from the areas of eyebrows, eyes, nose, and mouth. But complex expressions can only be read in the eyes, thus making them the principal center of attention.

The correspondence between emotional states and expressions of emotion, the basic dimensions of facial expression, the nature of simple and complex expressions, the shape of the stimulus surface, and the »meaning» of facial expressions were discussed.

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Appendix: some tables

Table 24

The Experiment of Nummenmaa and Kauranne (1958). Similarity Matrix.

Stimulus	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1																											
2	.32																										
3	.42	.57																									
4	.66	.40	.57																								
5	59	.31	.56	.91																							
6	.14	.33	.21	.06	.15																						
7	.36	.19	.25	.50	.59	.07																					
8	.56	.42	.69	.56	.64	.27	.53																				
9	.64	.63	.74	.41	.46	.50	.30	.83																			
10	.54	.35	.42	.67	.83	.14	.83	.71	.47																		
11	.56	.56	.64	.61	.70	.36	.53	.87	.72	.70																	
12	.30	.45	.39	.24	.26	.67	.21	.38	.57	.32	.44																
13	.28	.33	.40	.18	.17	.76	.13	.26	.45	.24	.32	.94															
14	.32	.18	.19	.42	.49	.04	.91	.47	.16	.78	.48	.09	.08														
15	.31	.60	.46	.28	.25	.43	.23	.29	.49	.30	.38	.56	.59	.17													
16	.16	.29	.22	.14	.14	.20	.24	.23	.25	.28	.26	.24	.18	.26	.32												
17	.15	.35	.18	.08	.08	.32	.12	.08	.19	.14	.14	.19	.21	.17	.33	.76											
18	.42	.72	.60	.34	.32	.41	.29	.44	.56	.37	.48	.50	.48	.22	.53	.63	.48										
19	.45	.56	.75	.38	.37	.38	.29	.60	.67	.34	.53	.48	.50	.25	.46	.28	.53	.45									
20	.55	.35	.37	.74	.83	.13	.81	.64	.20	.93	.61	.24	.21	.77	.26	.30	.12	.26	.27								
21	.38	.51	.39	.46	.52	.34	.42	.49	.43	.46	.57	.38	.34	.41	.35	.81	.56	.59	.30	.43							
22	.32	.44	.28	.34	.35	.35	.29	.34	.40	.35	.39	.41	.33	.24	.33	.80	.77	.62	.25	.20	.92						
23	.56	.30	.37	.77	.86	.13	.84	.68	.33	.87	.61	.21	.15	.74	.29	.30	.13	.20	.29	.98	.39	.25					
24	.38	.66	.56	.34	.28	.55	.24	.38	.53	.27	.39	.42	.46	.25	.70	.29	.39	.53	.55	.24	.32	.37	.27				
25	.50	.83	.69	.35	.33	.49	.23	.50	.64	.32	.47	.49	.53	.22	.66	.28	.38	.58	.71	.27	.34	.44	.46	.87			
26	.29	.47	.55	.25	.20	.88	.10	.44	.63	.22	.35	.68	.68	.12	.59	.19	.31	.49	.53	.13	.26	.37	.14	.62	.54		
27	.41	.81	.55	.25	.25	.56	.18	.47	.56	.21	.38	.56	.53	.20	.77	.25	.35	.51	.75	.18	.24	.34	.26	.67	.76	.46	

Table 25

Exp. I. Similarity Matrix.

Stimulus	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1																											
2	.50																										
3	.15	.55																									
4	.33	.11	.31																								
5	.26	.29	.32	.57																							
6	.19	.41	.34	.03	.07																						
7	.28	.06	.23	.85	.87	.07																					
8	.38	.77	.54	.23	.32	.51	.20																				
9	.15	.35	.69	.43	.35	.23	.30	.22																			
10	.24	.15	.23	.91	.63	.03	.87	.11	.34																		
11	.08	.29	.71	.35	.34	.14	.42	.31	.80	.34																	
12	.32	.45	.51	.11	.16	.38	.11	.46	.66	.12	.50																
13	.29	.42	.43	.11	.05	.95	.00	.51	.21	.04	.19	.39															
14	.22	.13	.22	.65	.79	.04	.94	.20	.29	.90	.25	.14	.06														
15	.45	.55	.36	.08	.10	.55	.02	.45	.52	.08	.26	.55	.65	.03													
16	.24	.23	.26	.35	.37	.37	.48	.30	.40	.30	.32	.33	.30	.31	.24												
17	.20	.32	.26	.06	.10	.59	.09	.25	.12	.06	.22	.34	.57	.07	.32	.64											
18	.37	.30	.24	.13	.08	.35	.03	.27	.47	.05	.19	.33	.42	.02	.71	.26	.39										
19	.67	.78	.55	.28	.36	.36	.18	.73	.26	.20	.30	.39	.37	.29	.44	.29	.28	.21									
20	.36	.18	.37	.93	.73	.10	.79	.27	.49	.79	.41	.20	.10	.69	.13	.32	.07	.16	.28								
21	.22	.19	.32	.39	.53	.41	.59	.25	.30	.63	.30	.29	.30	.51	.16	.76	.57	.28	.29	.38							
22	.14	.24	.20	.11	.19	.47	.14	.23	.21	.12	.30	.42	.32	.15	.28	.67	.82	.34	.21	.10	.62						
23	.44	.20	.33	.88	.69	.08	.75	.22	.52	.75	.40	.18	.04	.60	.09	.29	.09	.21	.16	.94	.31	.11					
24	.48	.79	.47	.11	.14	.51	.14	.68	.27	.12	.22	.42	.58	.08	.53	.27	.52	.30	.68	.13	.22	.36	.15				
25	.57	.92	.58	.17	.25	.33	.16	.73	.33	.16	.16	.43	.43	.17	.48	.28	.32	.30	.94	.18	.27	.20	.22	.74			
26	.18	.47	.42	.09	.08	.97	.05	.46	.23	.05	.29	.33	.94	.10	.59	.34	.62	.39	.42	.11	.36	.34	.06	.56	.39		
27	.68	.56	.37	.07	.11	.47	.14	.41	.33	.15	.16	.35	.51	.12	.70	.23	.33	.57	.50	.12	.20	.20	.19	.63	.57	.63	

Table 26

Exp. II. Similarity Matrix.

Stimulus	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1															
2	.38														
3	.14	.35													
4	.26	.33	.93												
4	.64	.36	.56	.85											
6	.59	.19	.28	.55	.80										
7	.73	.38	.15	.28	.58	.76									
8	.13	.15	.83	.76	.45	.39	.10								
9	.16	.46	.25	.24	.28	.45	.16	.43							
10	.16	.63	.24	.25	.20	.26	.14	.40	.96						
11	.13	.61	.04	.06	.03	.05	.18	.13	.65	.81					
12	.83	.21	.20	.34	.59	.78	.86	.13	.26	.16	.04				
13	.44	.56	.28	.35	.33	.39	.53	.24	.34	.46	.51	.64			
14	.33	.66	.24	.23	.19	.26	.28	.21	.45	.58	.63	.43	.89		
15	.23	.91	.39	.31	.25	.18	.21	.25	.41	.56	.68	.11	.54	.75	

Table 27

Exp. III. Similarity Matrix.

Stimulus	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	.24											
3	.50	.55										
4	.38	.07	.34									
5	.30	1.00	.80	.14								
6	.02	.17	.02	.32	.21							
7	.09	.65	.38	.28	.51	.51						
8	.72	.74	.66	.27	.71	.13	.35					
9	.03	.15	.07	.68	.19	1.00	.59	.04				
10	1.00	.39	.80	.67	.39	.02	.11	.59	.04			
11	.43	.13	.35	.49	.11	.58	.23	.17	.45	.34		
12	.08	.52	.27	.32	.63	.73	.52	.35	.55	.05	.43	

Table 28

Exp. III. Multidimensional Scaling Results: Scalar Products.

Stimulus	1	2	3	4	5	6	7	8	9	10	11	12
1	4.55											
2	0.76	1.20										
3	2.59	1.04	1.94									
4	0.78	−1.79	0.63	3.40								
5	0.01	1.16	0.82	−1.63	1.12							
6	−4.33	−1.29	−3.13	0.90	−0.74	4.69						
7	−2.33	0.08	−1.24	0.58	0.71	2.05	2.09					
8	1.88	0.84	0.84	−0.59	0.81	−2.50	−0.44	1.48				
9	−4.47	−1.40	−2.94	0.07	−0.90	4.60	2.05	−2.57	5.43			
10	3.84	0.66	2.13	0.42	0.35	−3.38	−2.73	1.86	−4.25	3.54		
11	−0.33	−1.65	−1.72	−1.33	−1.49	1.12	−1.23	0.02	1.47	0.11	3.80	
12	−2.97	0.38	−1.01	−1.48	−0.22	1.96	0.39	−1.65	2.87	−2.58	1.21	3.06

Table 29

Exp. IV. Similarity Matrix.

Stimulus	3	4	5	6	7	9	10	11	12	13	14	15
3												
4	.54											
5	.16	.59										
6	.06	.47	.47									
7	.10	.22	.58	.59								
9	.58	.59	.18	.57	.12							
10	.17	.24	.13	.26	.11	.56						
11	.25	.22	.28	.16	.31	.23	.53					
12	.12	.22	.41	.41	.66	.17	.24	.15				
13	.16	.29	.26	.36	.45	.29	.42	.46	.59			
14	.25	.29	.59	.29	.61	.20	.40	.37	.62	.45		
15	.29	.31	.13	.12	.11	.44	.61	.60	.14	.38	.34	