

PERCEPTUAL CHARACTERISTICS OF VOWELS

Kurt Johansson

My intention in this paper is to report some investigations concerning how adults and children perceive vowels, or rather how they describe their perception of vowels.

- a) when they have complete freedom for description
- and
- b) when the frame of description is limited in some way or other by the experimenter.

The investigations were carried out during two terms of seminar work with students at the Department of linguistics, Lund University. The tests were carried out by students of phonetics and presented in independent reports. This is a revision, based on the original data from these papers.

INTRODUCTION

While quite a lot has been said about the discrimination and identification of vowels, descriptions of perceptual characteristics seem to be rather scarce. Descriptions concerning similarity are given by Göte Hansson (e.g. 1967). Eli Fischer-Jørgensen (e.g. 1967) exemplifies another type of investigation, where the task had been to describe vowels by using certain previously fixed adjectives.

Generally speaking the perceptual dimension has been much less investigated than has the articulatory and the acoustic, in spite of the fact that its importance has often been stressed and that it has often been argued that the distinctive features should be given perceptual labels rather than labels pertaining to the other levels. Of course, the essential thing could hardly be to make a consistent choice of terminology from one level or another, but rather that available data on a (possible) psycholinguistic reality are reflected by the choice.

It is beyond the scope of this paper to give a detailed account of the extensive discussion that has taken place on the domain of distinctive features, particularly since the appearance of Jakobson-Fant-Halle's Preliminaries to Speech Analysis (1952). The purpose is instead to make a contribution to this discussion with the previously

mentioned seminar investigations as a starting-point.

SCOPE OF INVESTIGATIONS

The investigations concerned two main fields:

- A. Associations between vowels and adjectives
- B. Associations between vowels and colours.

The same material was used for tests I-V viz. the long Swedish vowels [i:, e:, ε :, a:, o:, u:, y:, ω :, ϕ :] plus the short [a]. The vowels were uttered as monophthongs by a male phonetician and recorded on tape. Formant frequencies of these vowels are given in Table 1.

| | F1 | F2 | F3 |
|---------------|--------|---------|---------|
| i | 200 Hz | 2300 Hz | 2900 Hz |
| e | 350 | 2200 | 2650 |
| ε | 500 | 2000 | 2300 |
| a | 800 | 1250 | - |
| α | 500 | 900 | - |
| o | 350 | 650 | - |
| u | 250 | 600 | - |
| y | 225 | 2200 | 2400 |
| ω | 250 | 1850 | 2400 |
| ϕ | 400 | 1600 | 2200 |

Table 1. Formant frequencies of the vowels used in tests I-V.

Field A comprised the following tests:

- I. Judgements using 6 given adjectives that are frequently used in phonetics for describing vowels perceptually.
- II. Free association between vowels and adjectives.
- III. Judgements using 7 given adjectives. This investigation was based on the free associations in test II.

Field B was composed of the following tests:

- IV. Free associations between vowels and colours.
- V. Judgements using given colours. This investigation was based on the free associations in test IV.
- VI. The same as IV and V but with French oral and nasal vowels and French listeners.

All tests started with some buffer stimuli. In each randomized test each stimulus appeared on three different occasions, each time presented three times in a succession with about one-second pauses.

FIELD A (ASSOCIATIONS BETWEEN VOWELS AND ADJECTIVES)

Test I

The starting-point for this investigation were 6 adjectives, often used for perceptual descriptions of vowels:

ljus - mörk ("light":"dark") for [i]:[u]

tunn - fyllig ("thin":"mellow") for [i/u]:[a/a]

klar - dov ("bright":"dull") for [i]:[y]

The material was first presented to 14 phonetically naive Swedish university students who were asked to give one or more adjectives for each vowel, with second choices in brackets. However, some of the listeners did not indicate their primary choice at all. But if these people had been excluded from the analysis, the results would still have been very much the same.

A second test that on the whole could be regarded as a repetition of the first one was undertaken some time later. Here, only one adjective was to be listed for each vowel. The 10 listeners had also participated in the first part.

Though the circumstances are not quite comparable, the scores are treated as if they had been achieved on the same occasion. (Table 2.)

| | i | e | ɛ | a | ɑ | o | u | y | ʉ | ø |
|--------|----|----|----|----|----|----|----|----|----|----|
| light | 32 | 28 | 7 | 18 | 5 | | | 5 | | |
| dark | 5 | 2 | 15 | 8 | 17 | 18 | 20 | 14 | 16 | 21 |
| thin | 25 | 18 | 9 | 26 | 7 | 3 | 3 | 15 | 12 | 5 |
| mellow | 5 | 3 | 20 | 10 | 14 | 11 | 14 | 20 | 13 | 19 |
| bright | 13 | 27 | 21 | 20 | 33 | 5 | 3 | 12 | 7 | 9 |
| dull | 3 | 3 | 9 | 1 | 6 | 43 | 43 | 13 | 31 | 28 |

Table 2. Scores for the six adjectives used in test I. The responses from two similar tests have been pooled.

There are some clear tendencies. They are perhaps still more apparent from table 3 below, where I have given the three most common adjectives for each vowel, with the one most preferred first.

| | 1 | 2 | 3 |
|---|---------------|--------|--------|
| i | light | thin | bright |
| e | light | bright | thin |
| ɛ | bright | mellow | dark |
| a | thin | bright | light |
| ɑ | <u>bright</u> | dark | mellow |
| o | <u>dull</u> | dark | mellow |
| u | <u>dull</u> | dark | mellow |
| y | mellow | thin | dark |
| ɯ | <u>dull</u> | dark | mellow |
| ø | dull | dark | mellow |

Table 3. The three most common adjectives for each vowel in test I (cf. table 2). When underlined an adjective dominates completely.

"Light/thin/bright" are the adjectives principally found for [i] and [e]. For [e] the order is "light/bright/thin".

If we compare [i] and [y] which are rather akin from an articulatory as well as from an acoustic angle, we find for the rounded vowel that the lowering of F2 and (particularly) F3 have caused a shift towards "mellow", "dark", and "dull".

For [ɯ], where there has been a further lowering of F2, the listeners prefer "dull", but also "dark" and "mellow" appear. As a matter of fact [ɯ] belongs to the same perceptual group as [u], [o], and [ø]. In all cases the same adjectives are chosen, and in the same order: "dull/dark/mellow", with "dull" as the dominating choice.

"Mellow" and "dark" also appear for [ɛ] and [ɑ], in different order, however, and in both cases "bright" is the most common adjective. Particularly for [ɑ] it dominates completely. "Bright" is also found for [a], but here together with "thin" and "light".

On the whole the results are satisfactory though the different vowels are not kept totally apart. We get two clearly separated groups, [i/e]

and [u/o/ʊ/ø], but also [ɛ] and [a] that seem to be connected somehow. [a] and [y] seem to constitute intermediate forms.

The main tendency would have been the same if the two tests had been treated separately. Some changes would have appeared, however: "dull" instead of "dark" for [ɛ] and [y] (in one test). For [y] "thin" in one test was exchanged for "bright" in the other. In connection with [ʊ] "thin" is chosen in one case instead of "dark", showing a certain and expected kinship with [y] and [i]. There would also have been some changes of the order between the adjectives, compared to the order in table 3.

These were the main results of this test. In order to proceed further along this line, a semantic normalization has to be made. Now, some of the adjectives seem to be synonymous. Particularly "dark", "dull", and "mellow" seem to interchange freely.

Test II

For this test the subjects were instructed to give one adjective only, that best described the vowel, with no restrictions on their choice. That the listeners were not restricted to a certain kind of adjective means for instance that also colour adjectives appear, albeit sparsely. Further, not only are "purely" perceptual terms to be expected, but also terms referring to the articulatory level. If the motor theory of speech perception is correct, one might expect quite a few adjectives of that kind, though certainly not so many for vowels as for consonants, where the tactile feedback is more obvious. In fact, terms of that type did appear, but they are very rare and whenever they occur they do not always have a connection with the actual articulatory features of the vowel in question. See however table 4.

Two groups of 10-12 listeners each took part in this investigation, group A consisting of students aged about 20 and group B of school children aged 10 to 11. Group A was tested once and group B twice.

Results

Under these circumstances it is quite obvious that the distribution of choices must be very great. In all about 70 different adjectives were offered by group A and about 60 by group B. In most cases an adjective

only appears occasionally, but as could be seen from table 4 there are some more frequent choices. In a few cases different adjectives have been gathered under the same heading. For instance some kantig ("angular") responses have been added to spetsig ("sharp"). This does not alter the facts, however.

| | i | e | ɛ | a | ɑ | o | u | y | ʷ | ∅ |
|-----------|----|----|----|----|----|----|----|----|---|----|
| sharp | 28 | 21 | | | 5 | | 2 | 13 | 9 | |
| light | 8 | 4 | | 7 | 12 | | | | 5 | 2 |
| bright | | | | 2 | 4 | | | | | |
| cold | | | | 4 | 4 | | | | | |
| hard | | 4 | | 7 | | 10 | 2 | 5 | | 2 |
| thin | 2 | | 2 | | 3 | | 3 | | 2 | |
| dark | | | | | | 6 | | | | 15 |
| gloomy | | 2 | 3 | 11 | 2 | | 5 | 9 | 4 | |
| dull | | | | 2 | | 11 | 17 | | 2 | 6 |
| coarse | | 2 | | 2 | | 3 | 2 | | | 2 |
| soft | | | | | 4 | | | | 3 | |
| round | | 2 | | | | | 3 | | 2 | |
| bleating | 3 | | 20 | | | | | | | |
| close | | | | | | | | 2 | 4 | |
| half-open | | | | | | 7 | 10 | | | |

Table 4. Scores for free association between vowels and consonants. Groups A and B are pooled. The Swedish adjectives were spetsig, ljus, klar, kall, hård, tunn, mörk, cyster, dov, grov, mjuk, rund, bråkig, sluten, halvöppen respectively.

In the investigation reported above [i] was "light/thin/bright". "Light" is the only adjective of these that to some extent maintains its place, but here "light" must give way to "sharp" which is the adjective preferred by most listeners. "Angular", "piercing" (skarp), "keen" (vass) are other adjectives of a similar meaning, which also occur occasionally for this vowel.

[y] and [ʷ] have their highest scores for "sharp", too, indicating a kinship with [i]. "Gloomy" for [y] in this test might correspond to "mellow/dark" in test I.

[u] and [o] are still "dull", [o] is "hard" as well, [u] "half-open" (!), however.

[ø], which was also labelled "dull/hard/mellow" in test I, gets the highest score for "dark". An influence from the vowel letter or the vowel sound in the matching adjective offered by the listener cannot be excluded, here or elsewhere.

[ɛ] is labelled "bleating", probably for the same reason.

[a] is primarily "light", while the dominating adjective in the earlier investigation was "bright". The earlier "thin/bright/light" for [a] has become "gloomy/light/hard".

No doubt some consistency could be found between tests I and II, also when groups A and B are treated separately. Considering the low scores in test II definite conclusions are impossible.

Test III

This investigation is a consequence of test II. The most frequent adjectives from that test have been made up into one set, i.e. "sharp", "light", "gloomy", and "hard". Further, the opposites of "light" and "hard" were included, i.e. "dark" and "soft". "Bright" was included as a potential opposite of "gloomy". No more opposites appear. Personally I miss "dull", which obviously belongs to the most frequent group, and which furthermore was the most frequent choice in test I. In order to correct, at least to some extent, a wrong choice of adjectives, there was also an open alternative, where the listeners might choose freely.

Three groups of listeners were tested:

Group I: a group of 11 students of phonetics aged 25 to 60

Group II: 17 school children aged 10 to 11

Group III: 5 phonetically naive adults aged 21 to 30,

Results

The variety of responses is large in all groups. There is slightly more consistency among the adults than among the children, but there are common tendencies within all groups. Below (table 5) the groups are treated as one group. As can be seen, all adjectives have more than 100 responses, none more than 185. In order to facilitate a comparison with the earlier tests the three most common adjectives for each vowel

and each test are given in table 6, with the most frequent adjective first.

| | i | e | ɛ | a | ɑ | o | u | y | ʊ | ø | total |
|-----------------|----|----|----|----|----|----|----|----|----|----|-------|
| sharp | 32 | 10 | 14 | 19 | 7 | 2 | 1 | 23 | 8 | 9 | 125 |
| light | 28 | 11 | 11 | 14 | 8 | 1 | 8 | 22 | 6 | 2 | 111 |
| bright | 6 | 14 | 4 | 21 | 24 | 8 | 2 | 6 | 6 | 9 | 100 |
| hard | 22 | 31 | 19 | 36 | 18 | 11 | 13 | 19 | 8 | 8 | 185 |
| dark | 1 | 10 | 11 | 2 | 21 | 22 | 33 | 5 | 19 | 29 | 153 |
| gloomy | 2 | 14 | 25 | 4 | 11 | 17 | 14 | 15 | 24 | 35 | 161 |
| soft | 6 | 8 | 10 | 2 | 6 | 30 | 23 | 8 | 26 | 3 | 122 |
| other choice | 2 | 1 | 5 | 1 | 3 | 8 | 5 | 1 | 2 | 4 | 32 |

Table 5. Choice between given adjectives. The scores for the three groups in test III are pooled. "Other choice" also includes blank responses.

"Sharp" and "light" evidently give a good characterization of [i].

For the back rounded vowels there is "dull", not included in test III, together with "dark", "mellow", "soft", and "gloomy". These are also found for [ʊ], and, with the exception of "soft", for [ø]. Obviously as a result of the energy shift towards higher frequencies in comparison with [u] and [o], such adjectives as "sharp", "light", and "bright" appear.

With such adjectives as "sharp" and "mellow/gloomy", [y] has features in common with [i] as well as with the rest of the rounded vowels.

[e] is "hard", "sharp", but also "light" and "bright".

[ɛ] is difficult to account for. The responses lack uniformity. There are "bright", "hard", and "sharp", but also "bleating", "gloomy", and "mellow".

[ɑ] is "bright" and "light", but also "dark".

"Bright" and "light" are found for [a], too, but also "hard", "thin", and "gloomy".

| | | 1 | 2 | 3 |
|---|-----|-----------------|-----------|---------------------|
| i | I | light | thin | bright |
| | II | <u>sharp</u> | light | - |
| | III | sharp | light | hard |
| e | I | light | bright | thin |
| | II | <u>sharp</u> | (light) | (hard) |
| | III | <u>hard</u> | bright | gloomy |
| ɛ | I | bright | mellow | dark |
| | II | <u>bleating</u> | (gloomy) | (thin) |
| | III | gloomy | hard | sharp |
| a | I | thin | bright | light |
| | II | gloomy | light | hard |
| | III | <u>hard</u> | bright | sharp |
| ɑ | I | <u>bright</u> | dark | mellow |
| | II | light | sharp | (bright/cold/soft) |
| | III | bright | dark | hard |
| o | I | <u>dull</u> | dark | mellow |
| | II | dull | hard | half-open |
| | III | soft | dark | gloomy |
| u | I | <u>dull</u> | dark | mellow |
| | II | dull | half-open | gloomy |
| | III | dark | soft | gloomy |
| y | I | mellow | thin | dark |
| | II | sharp | gloomy | hard |
| | III | sharp | light | hard |
| ɯ | I | <u>dull</u> | dark | mellow |
| | II | sharp | light | (gloomy/close) |
| | III | soft | gloomy | dark |
| ɸ | I | dull | dark | mellow |
| | II | <u>dark</u> | dull | (coarse/hard/light) |
| | III | gloomy | dark | bright/sharp |

Table 6. The most common adjectives for each vowel in tests I, II, and III, respectively. When underlined an adjective dominates completely. Only exceptionally (from test II) have adjectives with scores lower than 5 been included (in brackets).

Discussion

With this material as a starting-point it does not seem impossible to reach a satisfactory perceptual description of the vowels. In spite of the fact that the problem has been attacked from somewhat different angles in the three tests, and that listeners of different age and phonetic knowledge have been used, there is good agreement on certain points.

[i] receives similar judgements in the three tests, and so do the rounded vowels, particularly the back vowels. "Light": "dark", or in the language of the listeners of these tests "sharp": "dull", seems to be the dimension most easily agreed upon. Considering the predominance on one hand of high, and on the other hand of low frequencies, this is hardly unexpected.

[a] ("bright") seems to constitute another extreme, but it is hardly so well defined. "Mellow", which has often been used for description of low vowels, does not seem adequate.

The dimension "dull": "bright" primarily seems to concern [u/o]: [a/a], but "bright" appears in effect for all unrounded vowels.

There are intermediary forms, e.g. the front rounded vowels [y] and [ɥ], which have "sharp" in common with [i], and "dull", "mellow", and "gloomy" with [u] and [o].

The data seem to some extent to suggest that the extremes, particularly [i] and [u], i.e. the acoustic extremes, are used as reference vowels, in other words as more absolute units than the other vowels. This would mean that when an [i] is judged as "sharp", it is not so much in comparison with the other vowels but rather in the same way as a whistle (or perhaps an [s] among the obstruents) may be perceived as "strident", "sharp", or "piercing". Similarly [u] would be perceived generally as "dull" by virtue of the very low frequencies characterizing it.

My intention is not to squeeze the data too much. What was, however, quite clear from test II was that the vowels were not to any great extent perceived in terms of colour or production. Much further elucidation is needed. I hope to be able to return to this problem later (as well as to the perception of consonants with investigations along the same line).

The great problem in investigations of this kind is of a semantic nature. The orthography, too, constitutes a "disturbance". How will it ever be possible to understand what a person means by a certain term and to relate this to what other persons mean? One way will perhaps be comparisons in pairs, where one vowel comes first the first time, the other vowel the second time. If the listeners are to describe the second vowel relative to the first one, it would at least be possible to get at what the different listeners consider to be terminological counterparts.

Eventually also the influence of different voice qualities (male, female, and child's voice) on the judgements of different types of listeners must be taken into consideration. The material must also be varied as to duration and certainly also as to consonantal context.

FIELD B (ASSOCIATIONS BETWEEN VOWELS AND COLOURS)

"... the structure of sound and colour systems shows marked agreements. Moreover, cases of pronounced coloured hearing, especially in children or retained from childhood, in which acoustic impressions and particularly speech sounds, "appear bound non-arbitrarily, regularly and consistently with the same colour experiences", show the close connection of the vowels o and u with the specifically dark colours, and of e and i, on the other hand, with the specifically light colours." (R. Jakobson, *Child Language, Aphasia, and Phonological Universals*, 1968, p. 82.)

Now and then statements of the above kind may be found in the literature. It is difficult to say how common a pronounced colour perception is, but the investigations reported above show that very few listeners, when facing the task to associate freely between adjectives and vowels, actually choose colour adjectives. Otherwise I can give an example that at least children may perceive vowels as colours. A six-year-old son of a friend of mine assigned colours with great confidence not only to isolated vowels but also to words containing two vowels. If the word contained one "yellow" and one "blue" vowel, it was reported as "green", and so on. Now, after a couple of years at school, at least his more spontaneous ability is said to have decreased.

Jakobson gives (op.cit., p. 83) examples of two systems of colour associations:

1.

| | | | |
|---------------------|--------------|---------------------|-----------------------|
| | <u>a</u> red | | <u>æ</u> rose |
| <u>o</u> blue | | <u>ø</u> light blue | <u>e</u> yellow |
| <u>u</u> dark brown | | <u>y</u> grey | <u>i</u> silver white |

2.

| | | |
|--------------------|--------------|------------------------|
| | <u>a</u> red | |
| <u>o</u> blue-red | | <u>e</u> light green |
| <u>u</u> dark blue | | <u>i</u> canary yellow |

One of the conclusions in connection with test II above was then that colour perception can hardly be the primary type of perception. From the tests below we may in other words only find out, if we nevertheless may have the ability to associate vowels and colours in a fairly consistent way. It might also be possible to relate the ability of children in this respect to that of adults.

Test IV

This test was carried out with the same listeners as in test II, both group A (adults) and group B (children). Each group, consisting of 10-12 listeners, judged the material once, and their task was to associate freely to colours.

Results

The total scores for both groups are reported in table 7. In table 8 the three most common colours for each vowel are given.

As can be seen the choice has primarily been between two colours for each vowel. It may be suspected that the orthography may have played an important role in some cases, though the listeners had been requested to try to neglect it. This is probably not true to any greater extent for [i], though it is characterized as "white" (cf. test VI). Other possible orthographical and vowel sound influences are that [ø] is "green" (grön), [o] is "blue" (blå), [u] is "yellow" (gul), and [a/a] are "black" (svart).

[e/ɛ/y] are primarily "green", [y] with a tinge of "white", revealing kinship with [i].

| | i | e | ɛ | a | ɑ | o | u | y | ʊ | ϕ |
|--------|----|----|----|----|----|----|----|----|----|----|
| white | 41 | 2 | 6 | 4 | 3 | 3 | 2 | 12 | 2 | 2 |
| yellow | 11 | 7 | 17 | 1 | 1 | 6 | 20 | 9 | 29 | 1 |
| green | 1 | 17 | 23 | | 2 | 2 | 8 | 14 | 4 | 41 |
| blue | 5 | 10 | 2 | 9 | 6 | 30 | 16 | 5 | 1 | 5 |
| black | | 2 | 3 | 21 | 26 | 2 | 3 | 2 | | |
| red | 3 | 12 | | 21 | 24 | 1 | 7 | 7 | 5 | 17 |
| lilac | 7 | 4 | | | | 1 | 1 | 8 | 2 | 2 |
| pink | | | 14 | | | 1 | 1 | | | |
| grey | 1 | 9 | 1 | 9 | | 18 | 4 | 2 | 7 | 1 |
| brown | | 6 | 3 | 4 | 7 | 5 | 7 | 10 | 18 | |

Table 7. Scores for free associations between vowels and colours.
Groups A and B are pooled.

| | 1 | 2 | 3 |
|---|------------------|------------|-------|
| i | <u>white</u> | yellow | - |
| e | green | red | blue |
| ɛ | green | yellow | pink |
| a | <u>red/black</u> | - | - |
| ɑ | <u>black</u> | <u>red</u> | - |
| o | <u>blue</u> | grey | - |
| u | yellow | blue | - |
| y | green | white | brown |
| ʊ | <u>yellow</u> | brown | - |
| ϕ | <u>green</u> | red | - |

Table 8. The three most common colours for each vowel (cf. table 7).
When underlined the colours dominate completely. Only colours
with scores higher than 10 are included.

Some differences could be seen between the groups. The children are somewhat less consistent and sometimes prefer other colours.

As for [i/e/ɛ] there are no real differences. Nor are there for [a/a], though group A favours "red" and group B "black". [y/ʉ] are "brown" for group A, [y] "green/white" and [ʉ] "yellow" for group B. Group A chose "yellow" for [u] and "blue" for [o], while group B preferred "blue" and "grey/blue", respectively.

It is obvious that somehow the orthographic influence must be mastered. In tests V and VI we have tried to solve this problem by using colour plates in such a way that the listeners would not have to write down the names of the colours.

Test V

Here the listeners were given 6 colours to choose among, "white/yellow/green/blue/red/black" plus an open choice providing the possibility to choose other colours, if necessary. The above colours were, together with "brown" and "grey", the most frequent in test IV.

The material was presented to two groups, group A consisting of 19 adults aged 20 to 57, group B of 21 children aged about 11.

In order to avoid the orthographic influence a plate had been made containing the six colours mentioned above. Each colour was provided with a number to be written on the response sheet instead of the name of the colour.

Results

In table 9 below the responses for groups A and B are pooled.

The three most common colours for each vowel are more easily seen in table 10.

There are some differences, but also some similarities, in comparison with test I.

Here, too, [i] is associated with "white". "Red" reappears for [a], but not for [a], and "black" is not particularly common for either of these vowels. [u] has changed from "yellow/blue" to "black/green". [o] and [ɛ] are still "blue" and "green", respectively, while [e] has changed from "green/red" to "blue/red". Also for the rounded front vowels there are some changes: for [y] from "green/white" to "yellow/red",

| | i | e | ɛ | a | ɑ | o | u | y | ʊ | ϕ |
|-----------------|----|----|----|----|----|----|----|----|----|----|
| white | 50 | 14 | 16 | 25 | 20 | 3 | 12 | 13 | 5 | 5 |
| yellow | 33 | 19 | 7 | 26 | 21 | 11 | 15 | 33 | 19 | 12 |
| green | 1 | 18 | 28 | 8 | 16 | 22 | 22 | 14 | 21 | 31 |
| blue | 12 | 28 | 20 | 19 | 15 | 49 | 11 | 15 | 14 | 17 |
| black | 4 | 8 | 12 | 15 | 14 | 14 | 24 | 9 | 23 | 37 |
| red | 11 | 21 | 18 | 18 | 23 | 11 | 14 | 20 | 15 | 7 |
| other choice | 9 | 12 | 19 | 9 | 11 | 10 | 22 | 16 | 23 | 11 |

Table 9. Scores for associations between vowels and 6 given colours.
Groups A and B are pooled.

| | 1 | 2 | 3 |
|---|--------------|--------|-------|
| i | <u>white</u> | yellow | - |
| e | blue | red | - |
| ɛ | green | blue | - |
| a | yellow | white | - |
| ɑ | red | yellow | white |
| o | <u>blue</u> | green | - |
| u | black | green | - |
| y | yellow | red | - |
| ʊ | black | green | - |
| ϕ | black | green | - |

Table 10. The three most common colours assigned to each vowel in test V (cf. table 9). When underlined the colour dominates completely. Only colours with scores higher than 20 are included.

for [u] from "yellow/brown" and for [ɸ] from "green/red" to "black/green".

Also in this test the adults are more consistent than the children.

As the material is the same in the two tests reported above I have taken the liberty to treat the adult groups as a single group and the children's groups as another, in order to get, if possible, the differences that may occur between groups of different age. See tables 11-13.

| | i | e | ɛ | a | ɑ | o | u | y | u | ɸ |
|--------------|----|----|----|----|----|----|----|----|----|----|
| white | 44 | 6 | 6 | 19 | 17 | 4 | 6 | 13 | 1 | 3 |
| yellow | 22 | 12 | 15 | 10 | 8 | 12 | 22 | 24 | 15 | 6 |
| green | | 15 | 22 | 2 | 6 | 12 | 16 | 7 | 17 | 41 |
| blue | 7 | 24 | 9 | 19 | 16 | 40 | 10 | 9 | 9 | 11 |
| black | 1 | 2 | 6 | 14 | 15 | 4 | 5 | 4 | 7 | 13 |
| red | 10 | 15 | 10 | 17 | 20 | 5 | 9 | 10 | 11 | 9 |
| other choice | 7 | 16 | 22 | 9 | 8 | 13 | 22 | 23 | 30 | 7 |

Table 11. Total score for the adult groups in tests IV and V concerning vowels in relation to colours.

| | i | e | ɛ | a | ɑ | o | u | y | u | ɸ |
|--------------|----|----|----|----|----|----|----|----|----|----|
| white | 42 | 8 | 10 | 10 | 9 | 3 | 6 | 8 | 4 | 2 |
| yellow | 25 | 13 | 18 | 16 | 13 | 3 | 15 | 23 | 14 | 6 |
| green | 1 | 19 | 32 | 6 | 10 | 14 | 20 | 11 | 12 | 30 |
| blue | 11 | 20 | 13 | 12 | 9 | 43 | 11 | 12 | 7 | 14 |
| black | 3 | 6 | 6 | 13 | 19 | 12 | 19 | 7 | 16 | 24 |
| red | 7 | 16 | 8 | 25 | 31 | 6 | 11 | 10 | 10 | 16 |
| other choice | 7 | 14 | 9 | 14 | 5 | 15 | 14 | 25 | 33 | 4 |

Table 12. Total score for the children's groups in tests IV and V concerning vowels in relation to colours.

| | | 1 | 2 | 3 |
|---|---|--------------|-------------|----------|
| i | A | <u>white</u> | yellow | - |
| | B | <u>white</u> | yellow | - |
| e | A | blue | (red/green) | - |
| | B | blue | (green) | (red) |
| ɛ | A | green | (yellow) | - |
| | B | <u>green</u> | (yellow) | - |
| a | A | (blue/white) | (red) | - |
| | B | red | (yellow) | - |
| ɑ | A | red | (white) | (blue) |
| | B | <u>red</u> | (black) | - |
| o | A | <u>blue</u> | - | - |
| | B | <u>blue</u> | - | - |
| u | A | yellow | (green) | - |
| | B | green | (black) | (yellow) |
| y | A | yellow | - | - |
| | B | yellow | - | - |
| ʊ | A | (green) | (yellow) | - |
| | B | (black) | - | - |
| ∅ | A | <u>green</u> | - | - |
| | B | green | black | (red) |

Table 13. The three most common colours for each vowel. The two adult groups from tests IV and V are pooled (A), and so are the children's groups (B). When underlined a colour dominates completely. Colours with scores lower than 15 are not included. Colours in brackets have scores lower than 20.

As can be seen from table 13, there are certainly very great similarities between the two groups. Only on three points do there seem to be more apparent differences, viz. for [a], [u], and [ʊ]. For [a] "red" appears, however, for adults as well as for children, and it is the dominating colour for [a]. "Yellow" and "green" are associ-

ated with [u] by both groups. [u] looks more irregular, but if e.g. most of the "brown" responses of test IV had been replaced by "yellow", if the conditions had been quite the same as in test V, which does not seem too unlikely, "yellow" would have dominated for the adults as well as for the children. The differences are indeed very small between the two groups.

An arrangement of the same kind as the Jakobsonian might have the following appearance:

| | | | | | |
|----------|----------|----------|--------|----------|--------------|
| <u>i</u> | white | <u>y</u> | yellow | <u>u</u> | yellow/green |
| <u>e</u> | blue | <u>ɥ</u> | yellow | <u>o</u> | blue |
| <u>ɛ</u> | green | <u>ø</u> | green | | |
| | <u>a</u> | red | | <u>ɑ</u> | red |

In spite of the supposition that the listeners may have had difficulties in disregarding the orthography, the results are so unanimous that one does not hesitate to state that the listeners really possess the ability to associate fairly consistently between vowels and colours. This goes for both groups.

In a tentative arrangement like the one above there are several overlappings, which do not seem to be entirely unsystematic. No doubt the arrangement could serve as a starting-point for continued investigations.

To couple the results from the test concerning colours to those concerning adjectives in general does not appear particularly meaningful at this stage, but in both cases the data indicate that it is possible to reach a perceptual description that is not founded on the linguist's intuition alone.

Test VI

The following French vowels were included in this test [i, e, ɛ, a, ɑ, o, u, y, ø, œ, ɛ̃, œ̃, ɑ̃, ɔ̃].

For practical reasons the French student carrying out the test was not able to use prerecorded material, but had to pronounce the vowels himself at each test situation. The listeners were tested one at a time.

18 Frenchmen took part in this test, and their first task was to associate freely between vowels and colours. Three of the listeners did not consider it possible to associate with colours and are not included

in the tables below.

14 of the remaining listeners also took part in a second experiment. This differed from the first in that the listeners gave their responses by pointing to coloured squares - "white", "yellow", "red", "blue", "green", "brown", and "black". Each colour except "white" was divided into shades from lighter to darker.

Each listener was asked to give only one colour per vowel and experiment.

Results

In table 14 the responses to both experiments are reported together.

| | i | e | ɛ | a | ɑ | o | u | y | ø | œ | ẽ | œ̃ | ã | õ |
|--------------|----|---|----|----|----|----|----|----|---|---|---|----|---|---|
| white | 12 | 1 | | | | | | | | | | | | |
| yellow | 12 | 6 | | 1 | | 4 | 3 | 6 | 8 | 9 | 5 | 1 | 1 | 2 |
| brown | | 2 | 7 | | 1 | | 3 | 4 | 8 | 8 | 4 | 11 | 4 | 9 |
| green | 2 | 6 | 15 | 1 | | | | 1 | 2 | | 7 | 4 | 3 | 3 |
| blue | 2 | 5 | 2 | 5 | 4 | 7 | 11 | 10 | 4 | 4 | 2 | 5 | 6 | 2 |
| black | | 1 | 1 | 7 | 10 | 3 | 3 | 1 | 3 | 3 | 4 | 4 | 2 | 2 |
| red | | 2 | 3 | 13 | 14 | 13 | 5 | 4 | 4 | 4 | 2 | 4 | 9 | 5 |
| other choice | 1 | 5 | 1 | 2 | | 2 | 4 | 2 | | 1 | 5 | | 5 | 6 |

Table 14. Scores for associations between French vowels and colours. Two tests pooled.

Of course the responses are too few to permit any far-reaching conclusions, but certain similarities to the Swedish material seem to exist.

Here, too, [i] is "white" and "yellow", which is an indication that it is really possible to free oneself from the orthography (French blanc, jaune). [ɛ] is "green", [ɑ/a] "red" in both cases. Rounded vowels show a certain tendency towards "yellow/brown".

The nasal vowels have as a rule caused considerable difficulty. One of the listeners remarked, after having taken part in the test, that the nasals were no real sounds. Another listener called them "semi-sounds".

Where a comparison with the corresponding oral vowels is possible,

the judgements seem to be of a similar nature, with somewhat lower scores for the nasals.

Summing up it could be said that the colour experiments suggest that a coupling of vowels to colour perception is possible. Evidently there is reason to expect results of a more universal bearing in this connection. The orthographical difficulties will certainly not be easy to handle, but the method used in test VI, with a colour plate containing squares with a number of variants of the same colour would seem to be a useful method for solving some of these problems. Presenting several shades of the same colour will certainly make it easier for listeners who may not be willing to accept a "pure" colour, and it facilitates a mapping of the direction to which the colour perception within a certain square points.

Bibliography

- Chomsky, N., Halle, M., The Sound Pattern of English, 1968
- Fant, G., The Nature of Distinctive Features, 1967, To Honor Roman Jakobson, pp. 634-642
- Fant, G., Lindblom, B., Studies of Minimal Speech Sound Units, STL - QPSR - 2/1961, pp. 1-11
- Fischer-Jørgensen, E., Perceptual Dimensions of Vowels, 1967, To Honor Roman Jakobson, pp. 667-671
- Hansson, G., Dimensions in Speech Sound Perception, 1967
- Jakobson, R., Child Language, Aphasia, and Phonological Universals, 1968
- Jakobson, R., Fant G., Halle, M., Preliminaries to Speech Analysis, 1952
- Jakobson, R., Halle, M., Fundamentals of Language, 1956
- Ladefoged, P., Preliminaries to Linguistic Phonetics, 1971
- Lieberman, A.M., Cooper, F.S., Harris, K.S., MacNeilage, P.F., A Motor Theory of Speech Perception, Proceedings of the Speech Communication Seminar, Vol. 2, Stockholm: Royal Institute of Technology, 1962

Malmberg, B., Distinctive Features of Swedish Vowels: Some Instrumental and Structural Data, 1956, For Roman Jakobson, pp. 316-321

Malmberg, B., Réflexions sur les traits distinctifs et le classement des phonèmes, 1967, To Honor Roman Jakobson, pp. 1247-1251