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INJURY CONTROL RESEARCH LABORATORY

# THE INFLUENCE OF TRIGEMINAL STIMULATION ON CHILDREN'S JUDGMENTS OF ODOR



U. S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
Health Services and
Mental Health Administration

THE INJURY CONTROL RESEARCH LABORATORY PERforms experimental research on the human factors associated with the causation of accidents. Its principal studies are designed to determine the human characteristics and conditions of performance that affect a person's ability to anticipate danger and prevent injury. The Laboratory's program includes analysis of the influence on human efficiency of personal fitness, drugs, alcohol, and other agents. It employs, in general, simulation systems to analyze behavior under conditions of temporary or chronic impairment and to develop and evaluate remedies for inadequate performance.

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RESEARCH REPORT
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THIS RESEARCH REPORT PRESENTS DATA SHOWING that neither olfactory nor moderate trigeminal (pain) stimulation can be used as a natural and reliable method to prevent children from ingesting harmful substances.

THIS REPORT WILL BE OF INTEREST TO PUBLIC HEALTH officials, those concerned with product safety and accident prevention, and scientists engaged in research on the sense of smell.

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## ABSTRACT

Children's preference for odors, some of which presumably had marked trigeminal (noxious) effects, was assessed with the use of the method of pair comparison. Although the children, from 4 to 7 years old, were able to discriminate between the intensities of the odors, they were neither attracted nor repelled by them as much as the adults. In other words, the range of hedonic values associated with odors was found to be much smaller for children than for adults. This indicates that one must not depend on "bad" odors to keep children away from harmful substances. In particular, the finding that children are more tolerant of unpleasant odors than are adults suggests an even greater need for keeping potentially harmful substances out of the reach of children than would be necessary if children's preferences could be predicted on the basis of adult judgments.

## INTRODUCTION

Previous research on the feasibility of olfactory coding of noxious substances to ensure aversive responses in children (1) indicates that young children show a high degree of tolerance for unpleasant odors, and that differential responses to hedonic attributes associated with the sense of smell seem to be acquired rather than inborn. The possibility remains, however, that trigeminal stimulation could be used in coding noxious substances to elicit such inherent defense mechanisms.

The trigeminal system refers to the fifth cranial nerve, which mediates sensations of irritation and pain. It has long been considered possible that many odorants affect the trigeminal nerve as much as, if not more than the olfactory nerve. For example, ammonia elicits an odor, but the irritation experienced when inhaling the vapor of ammonia is probably the most noticeable experience and the most effective stimulation to action. Recent electrophysiological research on animal preparations (2) has shown that some compounds which were assumed to be "pure odorants", that is, noticeable only through the sense of smell, actually stimulate the trigeminal system as well as the olfactory.

Such results are not unexpected because trigeminal fibers do terminate in the nasal passages, and it is known that these fibers join others from other areas of the face and head in the fifth cranial nerve. Both the trigeminal and olfactory receptors make synaptic connections with the olfactory bulb and the brain, and the sensations associated with these different receptors cannot easily be separated introspectively by a human observer. What is of primary interest in the present case is that the trigerninal system might be utilized for the purpose of sensory coding in cases where pure odors are insufficient.

For this reason, it was decided to evaluate the usefulness of trigeminal stimulation in an olfactory experiment similar to the one mentioned above. In order to obtain information about the possible correlation between these two perceptual attributes, some subjects were asked to make both preference and intensity judgments of the same odorants.

## METHOD

### SUBJECTS

Four-year-old children were obtained from Kent Country Day School, a private nursery school in Warwick, Rhode Island; and 7-year-old children were obtained from Frenchtown School, a public school in East Greenwich, Rhode Island. These particular ages were selected to span those used in the original study (1), which showed that age was an important factor in reactions to odors. For comparison, a wide variety of adult friends and colleagues of the experimenter (L. M.) also were tested. Each subject was tested individually — the children in their school and the adults in their homes or in the home of the experimenter. Table 1 presents the mean, range, and standard deviation for the ages of the subjects and the number in each group. Although medical screening was not feasible, none of the subjects appeared to be suffering from colds or other conditions that might interfere with odor perception.

Table 1. ANALYSIS OF AGES OF TEST SUBJECTS

| Age group | Number of subjects | Mean age (in years) | Range | Standard deviation |
|---|---|---|---|---|
| 4-year-olds | 16 | 4.73 | 10 months | .26 |
| 7-year-olds | 17 | 7.86 | 19 months | .49 |
| Adults | 35 | 31.55 | 39 years, 10 months | 11.73 |

### MATERIALS

The five odorants were undiluted safrole, neroli oil, 95 to 100 percent heptanal, 70 percent by volume unscented alcohol, and aromatic spirits of ammonia U. S. P. Although it can not be objectively demonstrated, it was expected on the basis of adult judgments that ammonia and to some extent, alcohol, would be judged differently than the other substances, because they produce a sensation of mild pain in the nose.

### DESIGN AND PROCEDURE

All 10 pairs of the five odorants (excluding identical pairs) were presented to each subject. Each odorant was paired with every other odorant in a balanced series. The two members of each pair were presented successively, and each of them was

presented first in two pairs and second in the other two pairs in which it was included. To eliminate color as a possible cue, all the odorants were dyed the same color with Sudan Yellow ($C_{17}H_{14}N_2O$).

There were four subgroups for each age (4, 7, and adult), and each subject was assigned to one of these subgroups at random. A random order of the 10 pairs was first drawn, but this order was modified so that the alcohol was presented first as a common standard of reference for all subjects. In addition, the order was arranged so that no odorant was repeated in two successive pairs. This odor was presented to subgroup 1. Subgroup 2 received the same order, but for them the order of presentation of the two members of each pair was reversed. For subgroups 3 and 4 the orders of presentation were the reverse of those used for subgroups 1 and 2, respectively. The first stimulus pair was repeated at the end of the series for all subgroups to estimate the reliability of the responses. Each member of a subgroup made a total of 11 comparisons.

The subject was seated across the table from the experimenter. The odorants were kept out of view. In order to make a judgment, the subject was asked to sniff cotton wrapped around a glass rod and saturated in the liquid odorant. When not in use, the glass rod and cotton were kept in a stoppered test tube. On each trial, a pair of odorants was presented by the experimenter, one after the other in succession. The presentation of the pair required about 4 to 5 seconds. The subject was instructed to take a good sniff of each member of the pair, as the experimenter held the cotton under his nose, and then to point to the one he "liked best" or "liked least". A different form of the question was used for different subjects, more or less at random, in order to eliminate semantic problems observed in earlier studies (1). Only two odorants were visible to the subject at any one time. Since the subjects were not given any information about the total number of odorants involved, they generally believed there were many more than five.

The group of adult subjects was divided into two halves to compare judgments of intensity versus preference. One-half judged preference first and intensity second, and for the other half this order was reversed. The same order of pairs was used for both tasks. For the reason mentioned above, the form of the question regarding intensity was also varied for different subjects; for example, "Which is stronger", "Which is more intense", "Which is weaker", or "Which is less strong?"

## RESULTS AND DISCUSSIONS

Measured by the proportion of the subjects who chose the same member of a pair when the first pair was repeated at the end of the test, the judgments obtained seemed relatively stable and worthy of further analysis. The basic data of the experiment are presented in Table 2.

The entries in this table are the proportions of the subjects in each group who chose one odorant over the other for each of the 10 pairs. Table 3 shows these proportions converted to *z*-scores based on the relationships between *z*-scores and proportions under the normal curve. This assumes, according to Thurstone's Law of Comparative Judgment, that preferences are normally distributed and, thus, that *z*-scores will reflect psychological distances between the preference values associated with each member of the pair (3). Note that a *z*-score of zero corresponds to a proportion of 0.50, and thus indicates that half of the children selected one member and the other half selected the other member of a particular pair. The larger the *z*-score, the more decisive was the vote for (+) or against (−) an odorant, and the larger the psychological distance between the members of a pair.

For each pair of odorants there is one direct and three indirect estimates of this distance; the latter estimates are obtained from the comparison made between each member of a particular pair and each of the three remaining odorants which are not members of that particular pair. The psychological value associated with each single odorant, as distinguished from the distance between pairs of odorants, is defined as the mean of these four estimates. These means are shown in the last row for each part (A, B, and C) of Table 3. These values are only relative and do not permit absolute quantitative comparisons. Basically, they provide information about the variability of the preference judgments, and that information is sufficient for the present purpose.

Table 4 presents a summary of these psychological values associated with each single odorant taken from Table 3. It can be seen in Table 4 that, as in the original study (1), the variability of preferences is smaller for children than for adults. In other words, children do not discriminate between odors in terms of likes and dislikes to the same extent as do adults. While adults indicate a fairly wide range of values (e.g., -1.20 to +0.84 for the first preference judgments), all the values obtained for both groups of children are closer to zero (e.g., -0.21 to +0.21 for age 4).

**Table 2. PROPORTION OF CHOICES OF ODORANTS**

[Each entry is the proportion of subjects preferring the odorant specifics in that column to the corresponding odorant in the row of odorants. Each matrix gives the results for a different age group Note that the entries below the diagonal are complements of those above the diagonal.]

| Odorants | Isopropyl alcohol | Heptanal | Aromatic spirits of ammonia | Safrole | Neroli oil |
|---|---|---|---|---|---|
| | | A. 4-year-olds (N=16) | | | |
| Isopropyl alcohol | -- | .438 | .500 | .438 | .562 |
| Heptanal | .562 | -- | 250 | .375 | .500 |
| Aromatic spirits of ammonia | .500 | .750 | -- | .562 | .500 |
| Safrole | .562 | .625 | 438 | -- | .562 |
| Neroli oil | .438 | .500 | .500 | .438 | -- |
| | | B 7-year-olds (N=17) | | | |
| Isopropyl alcohol | -- | 353 | .471 | .412 | 235 |
| Heptanal | .647 | -- | .647 | .529 | .471 |
| Aromatic spirits of ammonia | .529 | .353 | – | .411 | .353 |
| Safrole | .588 | .471 | .588 | -- | .118 |
| Neroli oil | .765 | .529 | .647 | .882 | -- |
| | | C. Adults (N=35) | | | |
| 1a) Preference--1st | | | | | |
| Isopropyl alcohol | -- | .056 | 444 | .667 | 500 |
| Heptanal | .944 | -- | .778 | 944 | .833 |
| Aromatic spirits of ammonia | .556 | .222 | -- | .667 | 722 |
| Safrole | .333 | .056 | 333 | -- | .167 |
| Neroli oil | .500 | .167 | .278 | 833 | -- |

Table 2. --Continued

| Odorants | Isopropyl alcohol | Heptanal | Aromatic spirits of ammonia | Safrole | Neroli oil |
|---|---|---|---|---|---|
| | | C. Adults (N=35) | | | |
| 1b) Intensity--2nd | | | | | |
| Isopropyl alcohol | -- | .611 | .611 | .389 | .500 |
| Heptanal | .389 | -- | .444 | .167 | .389 |
| Aromatic spirits of ammonia | .389 | .556 | -- | .500 | .611 |
| Safrole | .611 | 833 | .500 | --- | 667 |
| Neroli oil | .500 | .611 | .389 | .333 | -- |
| 2a) Intensity--1st | | | | | |
| Isopropyl alcohol | -- | .353 | .470 | .176 | .235 |
| Heptanal | .647 | --- | .706 | .412 | .588 |
| Aromatic spirits of ammonia | .529 | .294 | -- | .294 | .353 |
| Safrole | .824 | .588 | .706 | --- | .706 |
| Neroli oil | .765 | .412 | .649 | .294 | -- |
| 2b) Preference--2nd | | | | | |
| Isopropyl alcohol | -- | .118 | .353 | .647 | .294 |
| Heptanal | .882 | -- | .765 | .941 | .765 |
| Aromatic spirits of ammonia | .647 | .235 | --- | .706 | .529 |
| Safrole | .353 | .059 | .294 | -- | .235 |
| Neroli oil | .706 | .235 | .470 | .765 | --- |

Table 3. Z-SCORES FOR PAIRS OF ODORANTS BASED ON THE PROPORTIONS IN A, B, AND C OF TABLE 2

| Odorants | Isopropyl alcohol | Heptanal | Aromatic spirits of ammonia | Safrole | Neroli oil |
|---|---|---|---|---|---|
| **A 4 year olds (N 16)** | | | | | |
| Isopropyl alcohol | -- | -0 15 | 0 00 | -0 15 | 0 15 |
| Heptanal | 0 15 | -- | -0 67 | -0 32 | 0 00 |
| Aromatic spirits of ammonia | 0 00 | 0 67 | -- | 0 15 | 0 00 |
| Safrole | 0 15 | 0 32 | -0 15 | -- | 0 15 |
| Neroli oil | -0 15 | 0 00 | 0 00 | -0 15 | -- |
| Σ | 0 15 | 0 84 | -0 84 | -0 48 | 0 30 |
| Mean | 0 04 | 0 21 | -0 21 | -0 12 | 0 08 |
| **B 7 year olds (N=17)** | | | | | |
| Isopropyl alcohol | -- | -0 39 | -0 08 | -0 23 | -0 71 |
| Heptanal | 0 39 | -- | 0 39 | 0 08 | -0 08 |
| Aromatic spirits of ammonia | 0 08 | -0 39 | -- | -0 23 | -0 39 |
| Safrole | 0 23 | -0 08 | 0 23 | -- | -1 18 |
| Neroli oil | 0 71 | 0 08 | 0 39 | 1 18 | -- |
| Σ | 1 41 | -0 78 | 0 93 | 0 80 | -2 36 |
| Mean | 0 35 | -0 20 | 0 23 | 0 20 | -0 59 |
| **C Adults (N=35)** | | | | | |
| 1a) Preference -- 1st | | | | | |
| Isopropyl alcohol | -- | -1 55 | -0 ·5 | 0 44 | 0 00 |
| Heptanal | 1 55 | -- | 0 77 | 1 55 | 0 95 |
| Aromatic spirits of ammonia | 0 15 | -0 77 | -- | 0 44 | 0 58 |
| Safrole | -0 44 | -1 55 | -0.44 | -- | -0 95 |
| Neroli oil | 0 00 | -0 95 | -0 58 | 0 95 | -- |
| Σ | 1 26 | -4 82 | -0 40 | 3 38 | 0 58 |
| Mean | 0 32 | -1 20 | -0 10 | 0 84 | 0 14 |

Table 3. --Continued

| Odorants | Isopropyl alcohol | Heptanal | Aromatic spirits of ammonia | Safrole | Neroli oil |
|---|---|---|---|---|---|
| | | C. Adults (N=35) | | | |
| 1b) Intensity--2nd | | | | | |
| Isopropyl alcohol | -- | 0 28 | 0.28 | -0 28 | 0 00 |
| Heptanal | -0 28 | -- | -0 15 | -0 95 | -0 28 |
| Aromatic spirits of ammonia | -0 28 | 0 15 | -- | 0 00 | 0 28 |
| Safrole | 0 28 | 0 95 | 0 00 | -- | 0 44 |
| Neroli oil | 0 00 | 0 28 | -0 28 | -0.44 | --- |
| Σ | -0 28 | 1 66 | -0 15 | -1 67 | 0 44 |
| Mean | -0 07 | 0 42 | -0 04 | -0 42 | 0 11 |
| 2a) Intensity--1st | | | | | |
| Isopropyl alcohol | -- | -C 39 | -0 08 | -0 92 | -0 71 |
| Heptanal | 0 39 | -- | 0 55 | -0 23 | 0 23 |
| Aromatic spirits of ammonia | 0 08 | -0 55 | -- | -0 55 | -0 39 |
| Safrole | 0 92 | 0 23 | 0 55 | -- | 0 55 |
| Neroli oil | 0 71 | -0 23 | 0,39 | -0 55 | --- |
| Σ | 2 10 | -0 94 | 1 41 | -2 25 | -0 32 |
| Mean | 0 52 | -0 24 | 0 35 | -0 56 | -0 08 |
| 2b) Preference--2nd | | | | | |
| Isopropyl alcohol | -- | -1 18 | -0 39 | 0 39 | -0 55 |
| Heptanal | 1 18 | -- | 0 71 | 1 55 | 0 71 |
| Aromatic spirits of ammonia | 0 39 | -0 71 | -- | 0 55 | 0 08 |
| Safrole | -0 39 | -1 55 | -0 55 | -- | -0 71 |
| Neroli oil | 0 55 | -0 71 | -0 08 | 0 71 | --- |
| Σ | 1 73 | -4.15 | -0 31 | 3 20 | -0 47 |
| Mean | 0 43 | -1 04 | -0 08 | 0 80 | -0 1? |

Table 4. PSYCHOLOGICAL SCALE VALUES FOR FIVE ODORANTS FROM THREE DIFFERENT AGE GROUPS

| Age group | Judgment | Alcohol | Heptanal | Aromatic spirits of ammonia | Safrole | Neroli oil |
|---|---|---|---|---|---|---|
| 4-year-olds | Preference | 0.04 | 0.21 | –0.21 | –0.12 | 0.08 |
| 7-years-old | Preference | 0.35 | –0.20 | 0.23 | 0.20 | –0.59 |
| Adults | Preference, 1st | 0.32 | –1.20 | –0.10 | 0.84 | 0.14 |
| Adults | Intensity, 2nd | –0.07 | 0.42 | –0.04 | –0.42 | 0.11 |
| Adults | Intensity, 1st | 0.52 | –0.24 | 0.35 | –0.56 | –0.08 |
| Adults | Preference, 2nd | 0.43 | –1.04 | –0.08 | 0.80 | –0.12 |

Table 4 also indicates that whether adults judged preference before or after intensity made little, if any, difference. However, the order of judgments did seem to have an effect on intensity. This may be the result of adaptation, or it may indicate that the quality of the odorant is the most salient perceptual attribute and, therefore, elicits the most reliable judgments (4). Whatever the reason for this interesting problem, it is not of primary concern in this context.

The main purpose of this study was to assess the extent to which a noxious and, presumably, a trigeminal stimulus, such as ammonia or alcohol, would be judged by children. No outstanding effects were observed. The judgments of these substances were as variable as the others and did not deviate systematically from them. Of course, one could increase the concentration of ammonia enough to make it aversive, but probably not without crossing the limits of what would be safe and practically useful for the present purpose. The data obtained up to this point, therefore, seemed to indicate that children are either very tolerant of odor, or that they have a relatively undeveloped and dull sense of smell and may be unable to discriminate between odors on any perceptual dimension.

In order to decide between these two alternative interpretations of the results, another group of 32 children were tested in a supplementary experiment at the Dr. Martin Luther King School in Providence, Rhode Island. These children were asked to judge both the intensity and the pleasantness of odorants which were varied both in concentration and in quality. The results show clearly that the children did perceive differences in the intensity of the odorants; for example, 100%, 20%, and 10% neroli oil. There was also evidence of a negative correlation between perceived intensity and preference similar to that observed with the adult subjects.

However, of greatest interest was the finding that, although these children were shown to be sensitive to intensity (concentration) differences in the odorants, the range of their preferences again was limited, as has been the case with all the groups of children we have observed — now a total of 175 children. The range of values obtained from the preference judgment (-0.40 to +0.37 in $z$-scores as in Table 4) is less than half the range of values obtained for intensity (-0.86 to +0.98) for the present group. In fact, the range for intensity is larger than any of those obtained earlier for preferences of children. In other words, the evidence shows that children are able to judge differences between odorants, but the fact that they can discriminate between odorants does not mean that they also like some of them and dislike others.

## CONCLUSIONS AND RECOMMENDATIONS

The present research has reinforced the conclusion that children are neither attracted not repelled by odors as much as are adults. This tolerance is apparently not the result of insensitivity to differences between odorants but lack of experience. The younger the child the less likely he is to respond as might be expected from an adult's perceptual evaluation of an olfactory situation. To adults the presence of odor is often taken as a warning signal for further investigation of something potentially distasteful or harmful, but to children odor is less likely to have any special meaning. While a child tends to respond like a "yes man" in an opinion poll about odors, an adult tends to be negativistic, especially in the case of unfamiliar odors (5).

Contrary to expectation, even trigeminal stimulation, at least of a moderate intensity, is not sufficient to ensure avoidance behavior in children. Consideration of this fact makes it more understandable that children may eat or drink substances which seem unpalatable to adults. Although an individual child may express strong displeasure with a certain odor, it apparently is not possible to find something that smells bad to all children and to use it in connection with a product or environmental condition in such a way that they will avoid it. In fact, the need to prevent children access to harmful household goods or harmful atmospheric conditions seems even more critical than it did at the outset of this research. Children not only may be more careless and less knowledgeable about dangers, but they apparently are less likely to be repulsed by them than are adults.

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