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Consistency of Sweet Taste Perception for Phenylthiourea (P.T.C.)

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Introduction

Sweet taste perception for phenylthiourea (P. T. C.) appeared to be caused by a gene with an autosomal dominant mode of inheritance (Skude 1959). In a series of 67 South Swedish university students and probational nurses 2.99% described their threshold solution of P. T. C. as sweet, and 5.97% as sweet and bitter. The total frequency of sweet tasters might thus be 8.96% (Skude 1960).

A source of error in the above-mentioned investigations is the lack of repeated examinations. It is possible that sweet tasting for P. T. C. varies so that a given individual may sometimes be a sweet taster, sometimes not. Various types of inconsistencies might influence the result of investigations into the inheritance of the trait. The purpose of the present investigation [1] was to check the consistency of sweet taste perception for P. T. C.

Material and Method

The material consisted of eight of the thirty-seven sweet tasters, aged 16 to 20 years and found in an earlier investigation of school pupils (Skude 1959), who were retested with P. T. C. solutions. Four of the eight persons included in this material were males, they were the probands of the families B I, C IX, D I and D IV, the remaining four were women and probands of the families A I, A II, E II and E VI. These notations refer to the family numbers in the previous investigation. In this paper they refer to the probands of the respective families. They were chosen because of their willingness to cooperate. Test intervals varied from three times a day to once every second week. None of the eight persons partaking in the examinations had during the year passed between the preceding investigation and the present changed his manner of living. One woman, E II, however, had become a smoker.

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According to Harris and Kalmus (1949) dilutions (1 : 2, 1 : 4, 1 : 8 etc.) are prepared from a stock solution, containing 1300 mg P. T. C. per litre solution. The stock solution was numbered 1 and the dilutions 2 to 14. Four beakers containing distilled water and four beakers with a P. T. C. solution were given to the examinee, who was asked to assort them according to their taste quality. The number of the weakest solution correctly assorted is defined as the threshold solution. The dilutions, which were prepared with distilled water were kept at room temperature. The beakers used were made of paraffined paper.

Results and Discussion

Table 1 gives the results of the present examinations as well as the taste sensations for P. T. C. reported by the persons on the two occasions (the two upper rows) they were tested in the previous investigation. In that investigation, however, the examinees were not given four beakers containing a P. T. C. solution and four con-

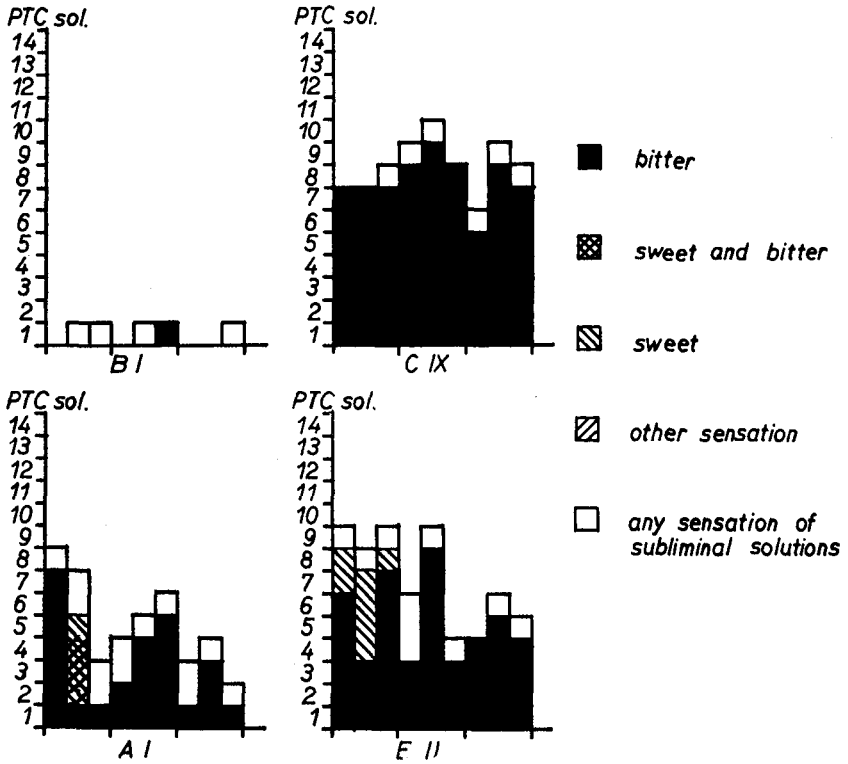

Fig. 1. Taste qualities and threshold values for the individuals tested three times a day on three consecutive days

taining distilled water to assort by taste quality, but one beaker with distilled water and one with a P. T. C. solution and they were asked to describe the taste quality of the latter in comparison with water.

Figure 1 gives the data on the two persons of each sex (males B I and C IX; females A I and E II), who were tested with P. T. C. solutions three times a day on three consecutive days. They were tested before breakfast on an empty stomach, fust before or after lunch, and in the afternoon, as a rule before dinner (table 1).

Two of these persons (C IX and E II) as well as two males (D I and D IV) and

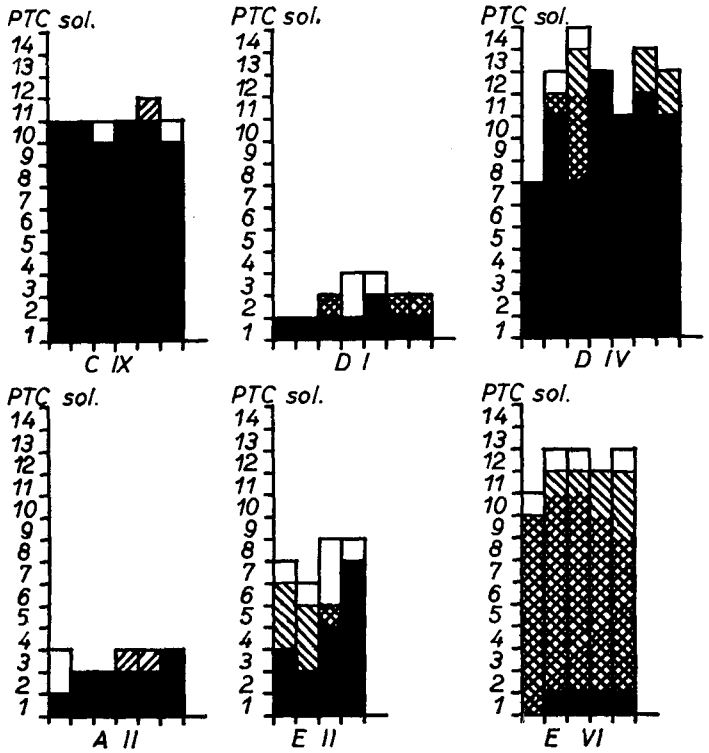

Fig. 2. Taste qualities and threshold values for the individuals tested four to seven times at intervals of four to sixteen days. Explanation see fig. 1

two females (A II and E VI) were examined four to seven times at intervals of four to sixteen days (table 1 and fig. 2).

Three (37.5%) of the eight persons tested with P. T. C. solutions did not state any concentration to taste sweet or sweet in combination with a bitter taste sensation (table 1 and the figures). The man B I in the previous investigation described

certain P. T. C. dilutions as sweet and bitter or sweet. On no occasion in the present examination, however, did he report sweet taste. He was found to have a very low threshold value, and only on one occasion could he distinguish correctly between distilled water and P. T. C. solution 1, on four occasions he reported that two or three of the four beakers containing the strongest concentration had a weak bitter taste. This is indicated by small letters in table 1 and the solution is said to be subliminal. On four occasions he described this very strong concentration as tasteless. He had, according to his statement, had a mild concussion about four months before the present series of examinations.

The man C IX described none of the solutions as sweet. On one occasion, however, he could distinguish the four beakers with P. T. C. solution from those with distilled water, which he found to taste stronger than the P. T. C. solution. On two occasions he found distilled water taste sweet.

In the previous examination the male D I reported a wide variety of P. T. C. concentrations as sweet or sweet and bitter at the same time, (0.04% and 0.08% sodium chloride solutions were also described as sweet, while he found 0.80% sodium chloride solution to have a salt taste). In the present examination none of the solutions were even described simply as sweet, on three different occasions the solutions were described as sweet and bitter at the same time. Once a subliminal dilution was reported to have this double taste. None of these 3 persons found the taste to be perceived by any particular area of the tongue.

The fourth man, D IV, examined seven times in the present investigation, reported an exclusively bitter taste three times. On one occasion he had a severe cold, but on the remaining four occasions he found at least one concentration to taste both sweet and bitter. On one occasion solution 7 and stronger solutions tasted bitter, the four solutions 8 to 11 had a double taste quality of sweet and bitter, and the solutions 12 and 13 tasted only sweet, the subliminal solution 14 was sometimes described as sweet and sometimes as bitter. The solutions had a sweet taste quality different from that of sucrose. Sweet taste was perceived on the tip of the tongue, bitter taste further back.

The female A I, tested three times a day on three consecutive days, reported sweet or sweet and bitter taste sensations on the first day only. She was surprised when she afterwards learned that it was the same substance in the solutions on all three days. Sweet taste was perceived near the tip of the tongue; bitter taste in the pharynx. Bitter taste was, however, perceived on the tip of the tongue when the most concentrated solutions were used. She also stated that the sweet taste of the P. T. C. solutions was different from that of sucrose, and was more like that of artificial sweeteners.

In the previous investigation the second woman, A II, had described solutions 3 to 12, as well as 0.08% sodium chloride solution, as sweet. She found the weaker concentration of this substance to be tasteless and the more concentrated to be salty. In the present examination sweet taste was never reported, except on one occasion (subliminal solution). On another occasion, however, she was able to distinguish

Table 1. Taste sensation for P. T. C. solutions.

Ind	Date	Time for test	Time for meal	P. T. C. solution 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Remarks
B I	25.10.58			s&b						s&b			O					Discriminating test not used
	12.11.58	19.00		b	s	s	s	s	s	O								Discriminating test not used
	12.10.59	8.20		O														
		12.35	12.10	b	O													
		17.30	15.00	b	O													
	13.10.59	8.20		O														
		12.35	12.10	b	O													
		17.30		B	O													
	14.10.59	8.20		O														
		12.35	12.10	O														
		17.30		b	O													
C IX	25.10.58									b			s					Discriminating test not used
	26.11.58	17.00					b	s&b	s&b	s&b	s	s	O					Discriminating test not used
	5.10.59	7.20								B	O							
		11.15	11.00							B	O							
		16.30								B	b	O						
	6.10.59	7.25									B	b	O					
		11.30	11.05									B	b	O				
		15.30									B	O						
	7.10.59	7.00						B	b	O								
		11.35	11.05								B	b	O					
		15.30								B	b	O						
	3.11.59	16.00	11.15									B	O					Distilled water sweet
	17.11.59	16.00	11.15									B	O					Distilled water sweet
	24.11.59	16.30	11.15								B	b	O					
	1.12.59	15.30	11.15									B	O					
	10.12.59	15.30	11.15									B	X	O				Sol. 10 tasting less than distilled water
	16.12.59	18.00	17.30								B	b	O					
D I	5.11.58			s						s			s					Discriminating test not used
	25.11.58	19.00			b	s&b	s&b	s&b	s	s	s	s	s	s	s	s		Discriminating test not used
	3.11.59	14.30	11.00	B	O													
	10.11.59	14.30	12.00	B	O													
	17.11.59	14.00	13.00	B	S&B	O												
	24.11.59	14.30	12.30	B	b	s	O											
	1.12.59	14.00	13.00		B	s&b	O											
	10.12.59	14.00	13.00	B	S&B	O												
	16.12.59	14.30	12.30	B	S&B	O												
D IV	7.11.58									b			s					Discriminating test not used
	27.11.58	20.00									b	s&b	s	s	s	s		Discriminating test not used
	3.11.59	18.30	17.00							B	O							
	12.11.59	18.30	18.00										B	S&B	x	O		Sol. 12 undecided
	20.11.59	19.00	18.00							B	S&B	S&B	S&B	S&B	S	S	x	Sol. 14 sometimes sweet sometimes bitter
	30.11.59	19.00	18.00												B	O		got hard cold
	4.12.59	19.00	16.30										B	O				
	10.12.59	19.30	16.30											B	S	S	O	
	16.12.59	16.00	11.30										B	S	S	O		
A I	25.10.58									b			s&b					Discriminating test not used
	11.11.58	18.00			b	s	s	s	s	s	s	s	s	s	s	O		Discriminating test not used
	7.10.59	7.25								B	b	O						
		11.05	7.45	B	B&S	S&B	S&B	S	s	s	O							
		15.40	11.30	B	b	s	O											
	8.10.59	7.25			B	b	b	O										
	8.10.59	11.05	7.45				B	b	O									
		15.00	11.30					B	b	O								
	9.10.59	7.25		B	b	b	O											
		11.05	7.45			B	b	O										
		15.00	11.30	B	b	O												
A II	3.11.58			b						s			s					Discriminating test not used
	14.11.58	16.00			b	s	s	s	s	s	s	s	s	s	s	O		Discriminating test not used
	3.11.59	19.45	19.00	B	b	s	O											
	11.11.59	19.45	15.30		B	O												
	16.11.59	20.00	16.00		B	O												
	25.11.59	19.30	16.00		B	X	O											Sol. 3 not bitter
	30.11.59	19.30	17.00		B	X	O											Sol. 3 tasting less than distilled water
	14.12.59	20.00	16.30			B	O											Sol. 3 bitter and "warmer" than distilled water
E II	25.10.58			b						s			O					Discriminating test not used
	1.12.58	20.00									b	s	O					Discriminating test not used
	12.10.59	7.30							B	S	S	s	O					
	11.00	7.45			B	S	S	S	S	s	O							
		20.00	19.00							B	S	s	O					
	13.10.59	7.30				B	b	x	x	O								Sol. 5, 6 sour
		11.00	7.45								B	x	O					Sol. 9 sour
		17.30	17.00			B	x	O										Sol. 4 sour or sweet
	14.10.59	7.30					B	O										Distilled water sour-sweet
		11.00	7.45					B	b	O								
		18.00	17.15				B	x	O									Sol. 5 sour or sweet
	13.11.59	20.00	16.00			B	S	S	S	s	O							
	27.11.59	20.00	17.30		B	S	S	S	s	O								
	11.12.59	20.00	17.00				B	S&B	s&b	s&b	s	O						
	15.12.59	20.00	15.30							B	s	O						
E VI	20.10.58									b			s					Discriminating test not used
	4.12.58	19.00						b	s&b	s&b	s&b	s&b	s	s	s	x		Discriminating test not used
	4.11.59	19.30	13.00	B&S	B&S	B&S	B&S	B&S	B&S	S&B	S&B	S&B	s&b	O				
	11.11.59	20.30	11.00	B	B&S	B&S	S&B	S&B	S&B	S&B	S&B	S&B	S&B	S	s	O		
	18.11.59	20.00	11.00	B	B&S	B&S	B&S	S&B	S&B	S&B	S&B	S&B	S&B	S	s	O		
	2.12.59	20.00	12.00	B	B&S	S&B	S&B	S&B	S&B	S&B	S&B	S&B	S	S	O			
	18.12.59	19.30	13.00	B	B&S	B&S	B&S	B&S	S&B	S&B	S&B	S	S	S	s	O		

B: Bitter taste.
B & S: Sweet and bitter taste, the bitter taste is the most predominant taste quality.
S & B: Sweet and bitter taste, the sweet taste is the most predominant taste quality.
S: Sweet taste.
X: Other taste quality, see remarks.
Capital letter indicates that the examinee was able to distinguish four beakers randomly ordered with the actual P. T. C. solution from four with distilled water.
Small letter indicates that the examinee was unable to distinguish all four beakers containing P. T. C. solution, but described a taste quality for two or three of them.
The columm " Time for meal " gives time of last meal.
The two first rows give the result of the preceding investigation, where no assortment technique was used.

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correctly between the distilled water and the four beakers with P. T. C. solution 3, which was definitely not bitter, and on another occasion the P. T. C. solutions tasted less than water. On another occasion the same concentration was described as bitter and to be ,, warmer " than the distilled water.

The person E II, also a woman, was tested three times a day on three days as well as four times at intervals varying of four to fourteen days. In the preceding investigation she had found not only P. T. C. to be sweet but also 0.04% sodium chloride and 0.0015 N hydrochloric acid, 0.000586% allylthiourea solution tasted sour-sweet, stronger concentrations of these compounds tasted salt, sour and bitter respectively. In this investigation she found the P. T. C. solutions to be not only sweet, sweet and bitter, and bitter, on two occasions also sour; on two other occasions she was doubtful whether the taste was sour or sweet. Once she described distilled water as sour-sweet. Six times of the thirteen she was examined, different supraliminal P. T. C. dilutions were described as sweet or sweet and bitter. The sweetness was not like that of sucrose and was perceived on the tip of the tongue, bitter taste was perceived further back. Certain weak solutions of P. T. C. seemed ,, warmer " than distilled water.

On all five occasions the female E VI was tested she reported a sweet and bitter taste of at least seven different concentrations and in four cases one to three weaker solutions were described as sweet. Subliminal solutions were also described as sweet or sweet and bitter. The sweet taste was perceived on the tip of the tongue, bitter further back. She stated very definitely that the weakest solutions were sweet, stronger concentrations sweet and bitter (the bitterer the more concentrated dilution), the strongest solutions tasted bitter only. Similar experience was often noted for the other examinees.

Three of the persons (C IX, A II and E II) stated that the taste of a specific solution varied in intensity, so that some of the four beakers with P. T. C. solutions, given to compare with four containing distilled water, gave a stronger taste sensation than others of the same concentration. This very phenomenon can explain why some subliminal solutions give rise to a taste sensation while others do not. Harris and Kalmus found some subjects who stated a slight taste sensation in some of the tumblers with the concentration nearest below their threshold solution. They continue: " it seems therefore possible that the , true ' physiological threshold is somewhat lower than that one taken by us ". Harris and Kalmus also write: " Some individuals were found who, while they were able to discriminate between quite low P. T. C. concentrations and water like most , tasters ', did not find very strong concentrations particularly bitter or unpleasant ". A comparison can be made with sweet taste perception, some persons found only a few solutions sweet or sweet and bitter while others (for instance E VI) found several solutions as sweet or sweet and bitter. This peculiarity, however, seems to vary from time to time, as judged from the present examinations.

Table 2 shows the variations of the number of solutions tasting sweet or sweet and bitter. The row ,, Total number of sweet tasting dilutions " includes taste sen-

sations of subliminal solutions. It is clear from the table that D IV showed the widest variation. Sometimes six concentrations were sweet or sweet and bitter tasting, but on other occasions no solution had these taste sensations. The female E VI who perceived at least nine dilutions as sweet or sweet and bitter was more consistent. The greatest number of supraliminal solutions tasting sweet or sweet and bitter was ten.

If the persons B I, C IX and A II who did not perceive any supraliminal concentration as sweet are excluded and if only those tests are considered in which the taste

Table 2. Number of P.T.C. solutions described as sweet or sweet and bitter on different occasions

Individual	B I	C IX	D I	D IV	A I	A II	E II	E VI
Number of sweet tasting supraliminal dilutions	0	0	0-1	0-6	0-4	0	0-4	9-10
Total number of sweet tasting dilutions	0	0	0-1	0-7	0-6	0-1	0-5	10-11

was described as sweet the mean of the number of sweet or sweet and bitter tasting dilutions was 4.26. When the same persons were excluded but all examinations of the counted persons are included, the mean number was 1.98. These figures refer to supraliminal concentrations. If taste sensations of subliminal solutions are included, the figures will be 4.50 and 2.42 respectively.

In table 3 the individual number of tests is given in which the taste was described

Table 3. Number of tests in which the taste was described as sweet

Individual	Total number of tests	Sweet or sweet and bitter tasting supraliminal sol.		Total number of sweet or sweet and bitter tasting solutions	
		Number	Frequency	Number	Frequency
B I	9	0	0	0	0
C IX	15	0	0	0	0
D I	7	3	0.43	4	0.57
D IV	7	4	0.57	4	0.57
A I	9	1	0.11	3	0.33
A II	6	0	0	1	0.17
E II	13	6	0.46	7	0.54
E VI	5	5	1.00	5	1.00

as sweet or sweet and bitter. The intraindividual frequency of sweet tasting varies from O in three of the eight persons to 1.00 in one woman. The remaining four described the taste as sweet on about 50 per cent of the test occasions.

The consistency varied not only from person to person but also in one and the same taste. The female E VI was the most consistent, she tasted a wide range of P. T. C. solutions as sweet or sweet and bitter on every occasion tested and she showed little variation of the concentrations tasting sweet. The other examinees were more inconsistent both as regards the concentrations and the number of the solutions that tasted sweet or sweet and bitter. The woman A I at 7.25 a. m. on an empty stomach tasted the supraliminal solution 7 as bitter and about three and a half hours later she perceived this dilution and the more concentrated solution 6 as subliminal sweet tasting solutions, the supraliminal solution 5 tasted sweet, solutions 4, 3 and 2 sweet and bitter, only the stock solution tasted bitter. This solution was 64 times stronger than the concentration reported as bitter in the morning. The persons D IV and E II also showed great variations.

Soltan and Bracken (1958) studied the consistency in taste reactions for P. T. C. by using filter papers. The filter paper was impregnated with a saturated solution of the substance in ethanol and then allowed to dry. They observed that of 100 persons 48 gave consistent reports, 24 made one deviation, 16 made two and 12 persons made three deviations from the predominant taste quality once stated. These subjects were tested six times. None of the consistent tasters was a sweet taster. Hoover (1956), also using filter paper, found that 15 out of 20 persons reported consistent taste reactions when tested three times, four reported two and one person reported three different taste qualities. None reported a sweet taste. Inconsistency of taste quality might thus be fairly common. Salmon and Blakeslee (1935) using solutions given by the straw method noted variations in the threshold values. The most variable persons they found once needed a solution 256 times stronger than a solution recognized on three other occasions. Another person's threshold solution increased eightfold in 15 minutes. The greatest variation in the threshold solution in the present examination was shown by three persons, ranged over seven solutions, i. e. 64 times the lowest threshold concentration. On one occasion 3 persons could be regarded as a ,, taster " and on another as a ,, non-taster "; division of ,, tasters " and ,, non-tasters " lying at a threshold solution of 6. Harris and Kalmus (1949) noted minor variations in the threshold values, over three concentrations, when retesting persons with P. T. C. solutions by their method.

No systematic change in the taste quality or sensitivity could be detected in the small material used in the present examination.

The observation of intraindividual variations in sweet taste perception for P. T. C. do not exclude an inheritable cause of this deviation from well-studied taste variations. The occurrence of inconsistencies in taste thresholds for the bitter taste of P. T. C. even amounting to occasional discordance between monochorionic twins (Dencker, Hauge and Kaij 1959) does not impair the conclusion that the taster property is inheritable. However, the present observations admit the conclusion that the mode of inheritance of sweet tasting for P. T. C. cannot be analyzed without a further study of the range of intraindividual variation and its causes.

Summary

Eight sweet tasters for P. T. C. found in a preceding investigation were retested with P. T. C. solutions by using a discriminating test method. Variations in the course of a single day and during longer periods were studied. It was observed that the consistency of sweet tasting for this compound varied intraindividually as well as interindividually. One of the females showed a high consistency of taste sensations for different concentrations. Three persons never reported a sweet taste sensation of a supraliminal concentration, although one year earlier they had described different P. T. C. solutions as sweet or sweet and bitter at the same time. The remaining four persons showed a varying consistency of the number of solutions stated as sweet tasting and the concentrations of these sweet tasting solutions. The reasons for the variations of the consistency are unknown. Such inconsistencies influence the result of investigations into inheritance of the trait.

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RIASSUNTO

Otto persone, che in un esame precedente provarono una sensazione di dolce assaggiando la feniltiourea (P.T.C.) furono sottoposte a nuovi esperimenti con soluzioni P.T.C. servendosi d'un metodo di prova discriminante. Si studiarono le variazioni nel corso d'un singolo giorno e durante periodi più lunghi e si osservò che la costanza nel provare una sensazione dolce era variabile sia nello stesso soggetto che in soggetti diversi (sia intraindividuale che interindividuale). Uno dei soggetti femminili mostrò di provare sensazioni di gusto fortemente costanti anche per concentrazioni diverse. Tre persone non provarono mai una sensazione di dolce per una concentrazione superliminare, benchè un anno prim avessero descritto il gusto delle differenti soluzioni P.T.C. come dolce o come dolce e amaro allo stesso tempo. Le altre quattro persone mostrarono una costanza variabile di fronte al numero di soluzioni considerate di gusto dolce come pure di fronte alle diverse concentrazioni di dette soluzioni. Le ragioni di queste variazioni non sono conosciute. Tali variazioni influenzano il risultato delle ricerche sulla ereditarietà di que sto carattere.

RÉSUMÉ

Huit personnes qui, lors d'une investigation précédente, avaient été qualifiées comme percepteurs de goût doux pour la phénylthiourée (P.T.C.), ont été réexaminées au moyen de solutions de P.T.C. suivant une méthode d'épreuves discriminatoires. Des variations au cours d'un même jour, ainsi que pendant des périodes plus longues ont été étudiées. Il a été observé que la constance de la perception douce de ce composé était variable, soit chez le même sujet que chez les différents sujets entre eux (soit intra-individuellement qu'interindividuellement). Un des sujets féminins présentait une haute constance de perception de goût pour des concentrations diverses. Trois personnes ne manifestèrent jamais de perception de goût doux pour une concentration superliminaire, bien qu'elles eussent décrit, un an auparavant, différentes solutions de P.T.C. comme ayant un goût, soit doux, soit « doux et amer ». Les quatre sujets restants présentaient une constance variable vis-à-vis du nombre de solutions considérées comme ayant un goût doux, ainsi que des concentrations de dites solutions. Les causes de ces variations sont inconnues. Ces inconstances influencent les résultats des recherches sur l'hérédité de ce caracter.

ZUSAMMENFASSUNG

Acht Süss-Schmecker für Phenylthiourea (P.T.C.), die durch eine vorhergehende Untersuchung ermittelt worden waren, wurden erneut mit P.T.C. Lösungen unter Anwendung einer Unterscheidungstestmethode geprüft. Unterscheide während eines einzelnen Tages und während längerer Perioden wurden studiert. Es wurde beobachtet, dass die Beständigkeit des Süsschmeckens für diese Verbindung interindividuell sowohl wie intraindividuell wechselte. Eine der weiblichen Versuchspersonen zeigte eine hochgradige Beständigkeit der Geschmacksempfindungen für verschiedene Konzentrationen. Drei Personen meldeten nie eine süsse Geschmacksempfindung bei einer über der Grenze liegenden (supraliminalen) Konzentration, obgleich sie ein Jahr zuvor andere P.T.C. Lösungen als süss oder als gleichzeitig süss und bitter beschrieben hatten. Die übrigen vier Personen zeigten eine wechselnde Beständigkeit in bezug auf die Anzahl der Lösungen, die als süsschmeckend bezeichnet wurden und bezüglich der Angabe der Konzentration dieser süsschmeckenden Lösungen. Die Ursachen dieser Unterschiede sind unbekannt. Solche Schwankungen beeinflussen das Ergebnis der Forschungen über die Erblichkeit der Anlage.