Food Sci. Biotechnol. Vol. 17, No. 5, pp. 1052 ~ 1059 (2008)

Food Science and Biotechnology

A Predictive Model for Sensory Difference Tests Accounting for Sequence Effects

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Abstract Sequential Sensitivity Analysis (SSA) and conditional stimulus model have been developed to describe sequence effects in difference tests and proposed to generate prediction of differences in sensitivity between various test protocols and to assist the appropriate selection of difference test. Yet, such models did not furnish a complete explanation of the relative sensitivity in 4 different versions of 3-alternative forced choice (AFC) tests where various interstimulus rinses were introduced. In the present study, the vector of the contrasts between various conditional stimuli were measured using same-different and 2-AFC and a new 16-distribution conditional stimulus model was developed by refining Lee and O'Mahony's contrast model. This new model gave superior predictions than previous models.

Keywords: difference test, sequence effect, conditional stimulus model, taste contrast, Thurstonian modeling

Introduction

Sensory difference tests are a vital tool in the sensory evaluation of food. These measurements are important for quality control, determining shelf-life, and the effects of ingredient change, processing change, or packaging change. They are also used in product development process including product imitation (benchmarking). The discrimination performance of sensory difference tests which are commonly used in sensory evaluation of food, has been extensively studied and modeled based on Thurstonian/signal detection theory. These have been reviewed in elsewhere (1-9). The common features of these Thurstonian/signal detection style models are that they all involve two distributions. Each distribution represents the variability of the intensity of the perceptual sensory input elicited by each food being tasted.

The important factors affecting the variance of those perceptual distributions of food are physiological and cognitive variables such as adaptation and contrasts effects caused by sequence of tasting (5). Sequence effects have been explained by two models: sequential sensitivity analysis (SSA) (10-19) and 4-distribution conditional stimulus model (5,20,21).

SSA is an ordinal model representing the detectability of the sensation of each food stimulus that will be encountered during the sensory difference test. The detectability of a food stimulus depends on the properties of the stimulus preceding it. The 4-distribution conditional stimulus model was developed in Thurstonian context, based on the Tedja *et al.*'s (18) data. The idea here was that because of physical and physiological carry-over effects, the taste of a food stimulus will vary depending on the food stimulus that precedes it. The variation due to such sequence effects can be so great that it is best to consider what appeared to be single stimulus as 2 separate stimuli (e.g., 'A' tasted after 'A' and 'A' tasted after 'B'). These 'separate' stimuli are called conditional stimuli because their taste is conditional on the stimulus that preceded it. Thus, a 2-distribution model is developed to become a 4-distribution model (20,21).

Yet, such models did not furnish a complete explanation of the relative sensitivity in 4 different versions of 3-alternative forced choice (AFC) tests discriminating between low concentration of NaCl and water stimuli where various interstimulus rinses were introduced (5). Lee and O'Mahony (5,21) by adopting such interstimulus rinses, which are same as stimuli, in their experimental design, introduced the idea of the conditionality of a conditional stimulus. This is the notion that a NaCl stimulus will be judged as having a stronger supra-adapting taste if it follows and therefore contrasts with a water stimulus with a strong sub-adapting taste. From this line of reasoning, they hypothesized 8 conditional stimuli, each of which is conditional on the contrast between the conditional stimulus and its predecessor, which itself depends on how the interstimulus rinses enhance their supra- or sub-adapting tastes. Lee and O'Mahony (21) also hypothesized the magnitude of various contrasts that can be encountered during sensory difference tests with interstimulus rinses on a bipolar axis having the taste of NaCl and the taste of water at opposite ends (Fig. 1). In Thurstonian terms, these contrasts entail differences between perceptual sensory distributions. For example, the sS$\rightarrow$sS contrast is really a distribution of the differences between 2 s-S conditional stimuli. It will have a mean of zero and a variance equal to the sum of the 2 s-S conditional stimulus variances. These distributions of differences resemble those used in the computation of d' in a same-different test (9) and thus can be measured by applying the same-different test procedure.

The objectives of the present study were 1) to measure the relative magnitude of the contrasts between various

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Received March 2, 2008; Revised March 8, 2008;
Accepted March 22, 2008

conditional stimuli that can be encountered during sensory difference tests using same-different test and 2) to refine Lee and O'Mahony's 8-distribution conditional stimulus model to generate reliable prediction of differences in sensitivity between various test protocols and so assist to the appropriate selection of difference test.

Materials and Methods

Judges Four judges, female students (age range: 21-26 years) at Ewha Womans University in Seoul, Korea, participated in the experiment. Judges were required to fast, except for water, for at least 1 hr prior to testing. All were naive to the specific aim of the study although they had participated in taste psychophysical experiments beforehand.

Stimuli Four conditional stimuli were used: low concentration NaCl solutions (S) (1.0-5.0 mM) and water stimulus (W), each following NaCl solutions (s) of the same concentration as the stimulus or water rinse (w) (sS, wS, sW, and wW). All 16 possible pairs of these 4 conditional stimuli as seen in Fig. 1 were compared using same-different test. As the experiment proceeded, it was necessary gradually to reduce the NaCl concentration so as to counter stimulus learning and maintain confusability between the NaCl and water stimuli. Thus, out of 10 sessions of experiments, 5.0 mM NaCl solution was used for the first 5 sessions and 3.0 mM NaCl solution was used for the next 3 sessions and, 1.0 mM NaCl solution was used for the last 2 sessions. Preliminary testing indicated that 5.0 mM was about the threshold level for NaCl solutions for the judges participated in this experiment.

The NaCl solutions were prepared by dissolving reagent grade NaCl (Ducksan Pure Chemical Co., Ltd., Ansan, Gyeonggi, Korea) in deionized water. The deionized water was used as the water stimulus. The NaCl solutions and water stimuli were dispensed in 10 mL aliquots using Labmax Bottle-Top Dispensers (Witeg Scientific, Berlin, Germany), and served in 2-oz semitransparent plastic cups (Jesam Co., Seongnam, Korea). All stimuli were presented at room temperature at 20±2°C, on plastic trays, with 2 same-different or 2-AFC tests per tray.

Procedure Judges performed same-different tests for all 16 possible pairs of 4 conditional stimuli. Judges were required to give either 'same' or 'different' binary response for each pair of conditional stimuli and give the sureness for their responses using 3-point sureness rating: '1 - sure', '2 - not sure', and '3 - I don't know but I guess'.

Each judge performed a total of 320 same-different tests over 10 sessions (32 tests per session): 2 sub-sessions, both including all 16 pairs. Between the 2 sub-sessions within a session 5-10, 10 min breaks were taken to minimize the fatigue effects. This gave a total of 20 tests for each pair of conditional stimuli per judge. The order of presentation of the 16 pairs of conditional stimuli was counterbalanced within each judge. The experimental sessions were separated by at least 1 day and no more than 5 days. Each experimental session started with judges' rinsing their mouth at least 5 times with deionized water and a water mouthrinse was taken before each same-different test. Session length ranged 20-35 min.

After completion of 10 sessions of same-different tests, each judge performed 10 2-AFC tests for 3 pairs of conditional stimuli involving low concentrations of NaCl solutions (S) as target stimuli: sS vs. sS, sS vs. wS, and wS vs. sS. For these pairs, judges were required to respond which conditional stimulus is saltier. In these sequences,

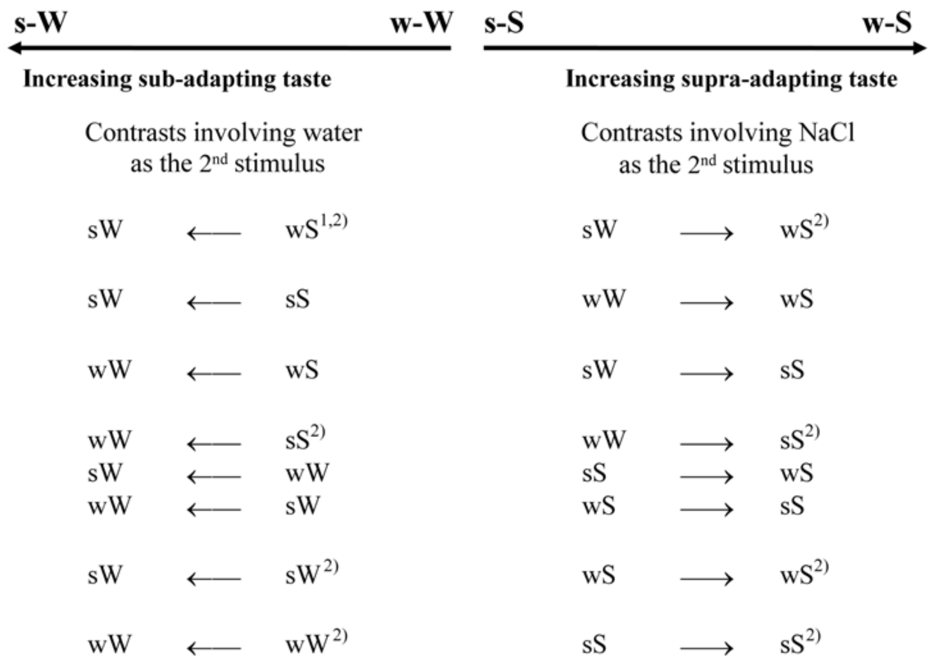

Fig. 1. Possible contrasts in the tasting of NaCl and water stimuli, including the effects of interstimulus rinsing. [from Lee and O'Mahony (21)]. [1)]'w', water rinse; 's', NaCl solution rinse; 'W', water stimulus; 'S', NaCl solution stimulus. [2)]These contrasts occur in Lee and O'Mahony's rinsing experiment (5), others do not.

again the target stimuli to be compared were both low concentrations of NaCl solutions. Yet, it was thought that these pairs might be perceived as different stimuli. Because of taste intensity suppressions and/or enhancements on the NaCl stimuli by adaptation and contrast effects, some conditional stimuli involving a low concentration of NaCl solution as a second stimulus, could be perceived as much weaker when the previous rinse and/or the conditional stimulus to be compared with were consisted of the same NaCl solutions. Thus, these 2-AFC discriminations were studied to investigate such adaptation and contrasts effects between these pairs.

All same-different and 2-AFC tests consisted of 4 samples (2 samples for each conditional stimulus: one interstimulus rinse and one target stimulus) to sip and expectorate. Judges were instructed to sip and expectorate all samples at the same pace, and to concentrate only on the taste of target stimuli. The target stimuli were presented with a marker. Judges were warned that the rinses may sometimes appear to have a taste because they were not always water, but that this should be ignored and that they should only attend to the taste of the target stimuli (the second sample in a pair). Subjective reports indicated no difficulty with this because the NaCl stimuli were at near threshold levels. It was required that judges sip the total amount of solution, and therefore, retasting was not possible. This was both to control the amount of stimulation and to keep stimulus sequences unchanged.

Data analysis The number of correct and incorrect responses was first noted for each of the 8 pairs of same-different tests involving NaCl as the second target stimulus and the other 8 pairs involving water as the second target stimulus, in order to find out the most similar pair to be used as a noise level for further computations of R-Indices and d' estimates. For these data, χ^2 analyses were also performed among the sequences involving the ‘same’ target stimuli as the first and second stimuli and the sequences involving the ‘different’ target stimuli as the first and second stimuli regardless the rinsing conditions. This approach was previously used in Rousseau *et al*. (22) to investigate the effects of adaptation and contrast between the conditional stimuli.

The R-Indices and d' estimates, which indicate the perceptual difference between the 2 conditional stimuli, were calculated for each sequence of same-different tests and used as a measure of the relative magnitude of difference between the 2 conditional stimuli. R-Indices were computed individually for each judge and mean R-Indices±standard deviations across judges were noted. Values of d' were computed from pooled data over 4 judges for each sequence of same-different tests and 2-AFC tests, using IFPrograms software - ‘degree of difference method analysis’ for data obtained from same-different test with rating procedure and ‘2-AFC’ for data obtained from 2-AFC (Institute for Perception, Richmond, VA, USA). d' Values for 2-AFC can also be computed from the proportion of correct responses using tables (2). Here both R-Indices and d' estimates were analyzed in order to compare their relative performance and sensitivity differentiating between pairs.

Results and Discussion

Same-different responses The number of correct and incorrect responses was first noted for each of the 8 pairs of same-different tests involving NaCl as the second target stimulus and the other 8 pairs of same-different tests involving water as the second target stimulus in Table 1 and 2, respectively. When the pair consisted of NaCl as the second target stimulus, there was a significant sequence effects resulting in different response patterns for both same and different pairs (Table 1). For the same pairs involving NaCl as the first target stimulus as well the second target stimulus, when water was used as interstimulus rinse, the pair was perceived as most similar and thus this sequence (wS vs. wS) was chosen as a noise sequence for further computations of R-Indices and d' estimates.

When the pair consisted of water as the second target stimulus, there was a significant sequence effects only for different pairs involving NaCl as the first target stimulus (Table 2). Unlike the NaCl same pairs, there was no significant effects for same pairs involving water as the first target stimulus as well as the second target stimulus regardless the interstimulus rinsing condition. This indicates that adaptation of salt taste has a significant effect on same-different test performance in the present experiment. For the water same pairs when water was used as interstimulus rinse, the pair was perceived as most similar and thus this sequence (wW vs. wW) was chosen as a noise sequence for further computations of R-Indices and d' estimates.

Table 1. Frequency of responses for the 8 pairs (sequences) of conditional stimuli involving NaCl as the 2nd stimulus presented in the same-different test (in hold, responses which can be scored as ‘correct’)[1)]

	Pair[2)]				Number of answers (/80)[3)]	
	1st Conditional stimulus		2nd Conditional stimulus		‘Correct’	‘Incorrect’
	Rinse	Stimulus	Rinse	Stimulus		
Different	w	W	w	S	74	6
	s	W	w	S	72	8
	w	W	s	S	33	47
	s	W	s	S	28	52
Same	w	S	s	S	19	61
	s	S	w	S	34	46
	s	S	s	S	51	29
	w	S	w	S	61	19

[1)]The pattern of responses was highly significant for both comparisons of ‘different’ pairs and ‘same’ pairs (2-way χ^2 analysis, $p<0.001$). The categories ‘Same-sure’, ‘Same-not sure’ and ‘Same-I don’t know but guess’ on one hand, and ‘Different-sure’, ‘Different-not sure’ and “Different-I don’t know but guess” on the other have been combined to permit easier comparison.

[2)]‘w’, water rinse; ‘s’, NaCl solution rinse; ‘W’, water stimulus; ‘S’, NaCl solution stimulus

[3)]For the different pairs involving water as the 1st stimulus, a response ‘different’ will be considered correct, while for the same pairs involving NaCl as the 1st stimulus, a response ‘same’ will be considered correct.

Table 2. Frequency of responses for the 8 pairs (sequences) of conditional stimuli involving water as the 2nd stimulus presented in the same-different test (in hold, responses which can be scored as 'correct')[1)]

	Pair[2)]				Number of answers (/80)[3)]	
	1st Conditional stimulus		2nd Conditional stimulus		'Correct'	'Incorrect'
	Rinse	Stimulus	Rinse	Stimulus		
Different	w	S	w	W	72	8
	w	S	s	W	65	15
	s	S	s	W	39	41
	s	S	w	W	36	44
Same	s	W	w	W	56	24
	w	W	s	W	58	22
	s	W	s	W	62	18
	w	W	w	W	63	17

[1)]The pattern of responses was significant for comparison of 'different' pairs (2-way χ^2 analysis, $p<0.001$) and not significant for comparison of 'same' pairs (2-way χ^2 analysis, $p=0.5$). The categories 'Same-sure', 'Same-not sure' and 'Same-I don't know but guess' on one hand, and 'Different-sure', 'Different-not sure' and 'Different-I don't know but guess' on the other have been combined to permit easier comparison.
[2)]'w', water rinse; 's', NaCl solution rinse; 'W', water stimulus; 'S', NaCl solution stimulus
[3)]For the different pairs involving NaCl as the 1st stimulus, a response 'different' will be considered correct, while for the same pairs involving water as the 1st stimulus, a response 'same' will be considered correct.

Differences between conditional stimuli Mean percent R-Index values and d' estimates indicating the relative magnitude of the differences between the 2 conditional stimuli in 8 pairs involving NaCl as the second stimulus and those in other 8 pairs involving water as the second stimulus were given in Table 3 and 4, respectively. Comparing two different indices, R-Indices and d' estimates, it was found that the results were well corresponding, although d' estimates differentiated between conditional pairs a bit better. It is worth noting that the obtained data showed quite high variance. The sources for such variation could have included variation in judges' adaptation to salty taste and salivation rates, and variation in rinsing and sip-and-spitting efficiency in this experiment.

Among the pairs of conditional stimuli listed in Fig. 1 (right column), Lee and O'Mahony (21) hypothesized that the contrast sW→wS would be the strongest because it passes from the conditional stimulus with the strongest sub-adapting taste to the conditional stimulus with the strongest supra-adapting taste. Likewise, it was hypothesized that wW→wS would be a less strong contrast because it passes from borderline sub-adapting state to strong supra-adapting state and probably sW→sS less strong or equal to wW→wS. The differences in magnitude between the contrasts wW→sS, sS→wS, and wS→sS were hypothesized to be tied because no information was available for distances between those conditional stimuli at that time. Lastly, it was hypothesized that there should logically be no contrast between wS→wS and sS→sS, yet the wS→wS contrast would be more favorable for judging the stimuli to be the same than the sS→sS contrast because of the enhancing effects from the water rinsing in the wS→wS contrast.

The measured magnitude of differences given in Table 3 indicated that both sW→wS and wW→wS contrasts were the bigger than others and the size of the wS→wS contrast was the smallest as predicted in Fig. 1. However, unlike the Lee and O'Mahony's (21) prediction, the differences in magnitude between the contrasts wW→sS, wS→sS, and sS→sS were not significantly different from that of the wS→wS contrast indicating significant adaptation effects in sS conditional stimuli with NaCl solution rinsing. Because of the same adaptation effects in sS conditional stimuli, the contrast wS→sS and sS→wS showed significantly bigger difference than that of the wS→wS contrast. The effects of adaptation in sS conditional stimuli are also seen in Table 4. The contrast sS→sW and sS→wW involving sS conditional stimuli showed significantly smaller difference than those of the wS→wW and wS→sW contrasts which were the biggest. The same pairs of conditional stimuli involving the water as the first target stimulus as well as the second target stimulus (sW→wW, wW→sW, and sW→sW) showed little differencing contrasts, not different from that of the wW→wW contrast.

Table 3. Mean percent R-Index values and estimates of d' indicating the degree of contrast (difference) between the 2 conditional stimuli, involving NaCl as the 2nd stimulus

1st Conditional stimulus		2nd Conditional stimulus		Mean R-Index[1)] (%)	d' Estimate[2)]
Rinse	Stimulus	Rinse	Stimulus		
w	W	w	S	89.68±4.00[a]	3.49±0.29[a]
s	W	w	S	89.50±5.69[a]	3.42±0.29[a]
w	S	s	S	83.63±7.41[ab]	2.73±0.27[b]
s	S	w	S	74.84±7.26[abc]	1.87±0.28[c]
s	S	s	S	64.00±9.20[bcd]	0.71±0.54[cd]
w	W	s	S	63.18±13.82[bcd]	0.76±0.53[cd]
s	W	s	S	62.28±12.21[cd]	0.48±0.80[cd]
w	S	w	S	50.0[d] by definition	0.00 [d] by definition

[1)]Each mean±SD represents R-Indices from the 4 judges; values with the same letters are not significantly different (Bonferroni comparisons, $p<0.05$).
[2)]Each estimate±SD represents an average d' estimate over the 4 judges; values with the same letters are not significantly different (Bonferroni comparisons, $p<0.05$).

Table 4. Mean percent R-Index values and estimates of d' indicating the degree of contrast (difference) between the 2 conditional stimuli, involving water as the 2nd stimulus

1st Conditional stimulus		2nd Conditional stimulus		Mean R-Index[1)] (%)	d′ Estimate[2)]
Rinse	Stimulus	Rinse	Stimulus		
w	S	w	W	90.47±7.38[a]	3.40±0.22[a]
w	S	s	W	86.22±2.27[a]	3.14±0.21[a]
s	S	s	W	67.53±4.07[b]	1.40±0.23[b]
s	S	w	W	66.69±13.44[b]	1.36±0.25[b]
s	W	w	W	56.72±3.51[bc]	0.32±0.74[c]
w	W	s	W	56.59±3.79[bc]	0.36±0.65[c]
s	W	s	W	56.47±3.38[bc]	0.00±0.48[c]
w	W	w	W	50.0[c] by definition	0.00[c] by definition

[1)]Each mean±SD represents R-Indices from the 4 judges, values with the same letters are not significantly different (Bonferroni comparisons, $p<0.05$).
[2)]Each estimate±SD represents an average d' estimate over the 4 judges, values with the same letters are not significantly different (Bonferroni comparisons, $p<0.05$).

Table 5. Results obtained from the 2-AFC tests (N=80)

1st Conditional stimulus		2nd Conditional stimulus		Response frequency for saltier stimulus (/80)		*p*-value[1)]
Rinse	Stimulus	Rinse	Stimulus	1st Stimulus	2nd Stimulus	
w	S	s	S	70	10	<0.01
s	S	w	S	14	66	<0.01
s	S	s	S	58	22	<0.01

[1)]Binomial statistics for tests with probability = 1/2, 2-tailed.

2-AFC responses The 2-AFC tests were performed for the 3 same pairs of NaCl conditional stimuli involving sS (wS vs. sS, sS vs. wS and sS vs. sS) in order to study the cause of the differences in these pairs and the results were given in Table 5. All 3 pairs showed the significant difference in salt taste between the 2 conditional stimuli. The first stimulus was saltier for the pairs wS vs. sS and sS vs. sS, and the second stimulus was saltier for the pair sS vs. wS, confirming adaptation effects in sS conditional stimuli.

Modeling and testing the contrasts effects between conditional stimuli Accounting for these 2-AFC results, a set of cognitive and physiological contrasts (difference) of various magnitudes was hypothesized on the bipolar intensity axis (Fig 2). Figure 2A shows a possible representation of the 8 difference distribution involving NaCl as the second target stimulus with the wS→sS and sS→sS contrasts having a negative magnitude and Fig. 2B shows the 8 difference distribution involving water as the second target stimulus. In Fig. 2C, the supra-adapting taste of NaCl and the sub-adapting taste of distilled water are represented at opposite directions on the axis by rotating the dimension of (B) by 180°. In these diagrams, the origin means no difference.

For the problem at hand, only 8 of the contrasts (differences) are required for modeling the results of the rinsing experiment by Lee and O'Mahony (5). They are marked by asterisks in Fig. 1. The top of Fig. 3 gives the various contrasts or difference distributions relevant to the results of Lee and O'Mahony's (5) experiment. The relative distances between the distributions were approximated. To the left, the 4 blocks of sequences for the 3-AFCs with interstimulus rinses are given with the resulted d' values. The numbers in the table below each contrast sequence indicate how often each contrast appears for each triadic sequence. For example, consider the first sequence: sWsWwS. The first contrast or difference distribution to appear is sW→sW and the second to appear is sW→wS. Therefore a score of '1' is placed in each appropriate column. That takes care of the contrasts within the triad. However, the first stimulus in the triad was also part of a contrast. It may be hypothesized that it was tasted after the final stimulus in the preceding triad. The final stimulus in these triads with its pre-rinse is wS 1/3 of the time and sW 2/3 of the time. Therefore, it may be hypothesized that for the first rinse-stimulus combination in the triad (sW), the contrast wS→sW occurs 1/3 of the time and sW→sW occurs 2/3 of the time. Scores of 1/3 and 2/3 are therefore added to the wS→sW and sW→sW columns, respectively. Again, it should be remembered that these contrasts are really distributions of differences between the appropriate sensory distributions of conditional stimuli.

The same exercise is then performed for each triad and the total numbers of times each contrast occurs for each set of 3-AFC triads can be calculated. For example, in the triad block (A), the contrast wS→sW occurs 2 2/3 times, sW→sW, 3 1/3 times; wS→wS, 1/3 time; sW→wS, 2 2/3. The frequencies of occurring wS→wS and sW→wS contrasts were highlighted in gray because these are the odd stimuli that the judges required to pick out as saltier stimuli for the correct response. In this way the triad blocks contrast frequencies can be computed in a diagram showing the relative distances between the distributions and the odd stimulus to be chosen for the correct response.

From Fig. 3, it can be seen that the pattern of contrasts are obviously stronger (more distant from the opposite taste) for triad block (A) and (D) than for (C) and (B). The contrast patterns (A) and (D) are merely mirror images, so that no differences would be expected between them. Comparing the contrast patterns between triad block (C) and (B), in both triads the distributions of the odd stimulus

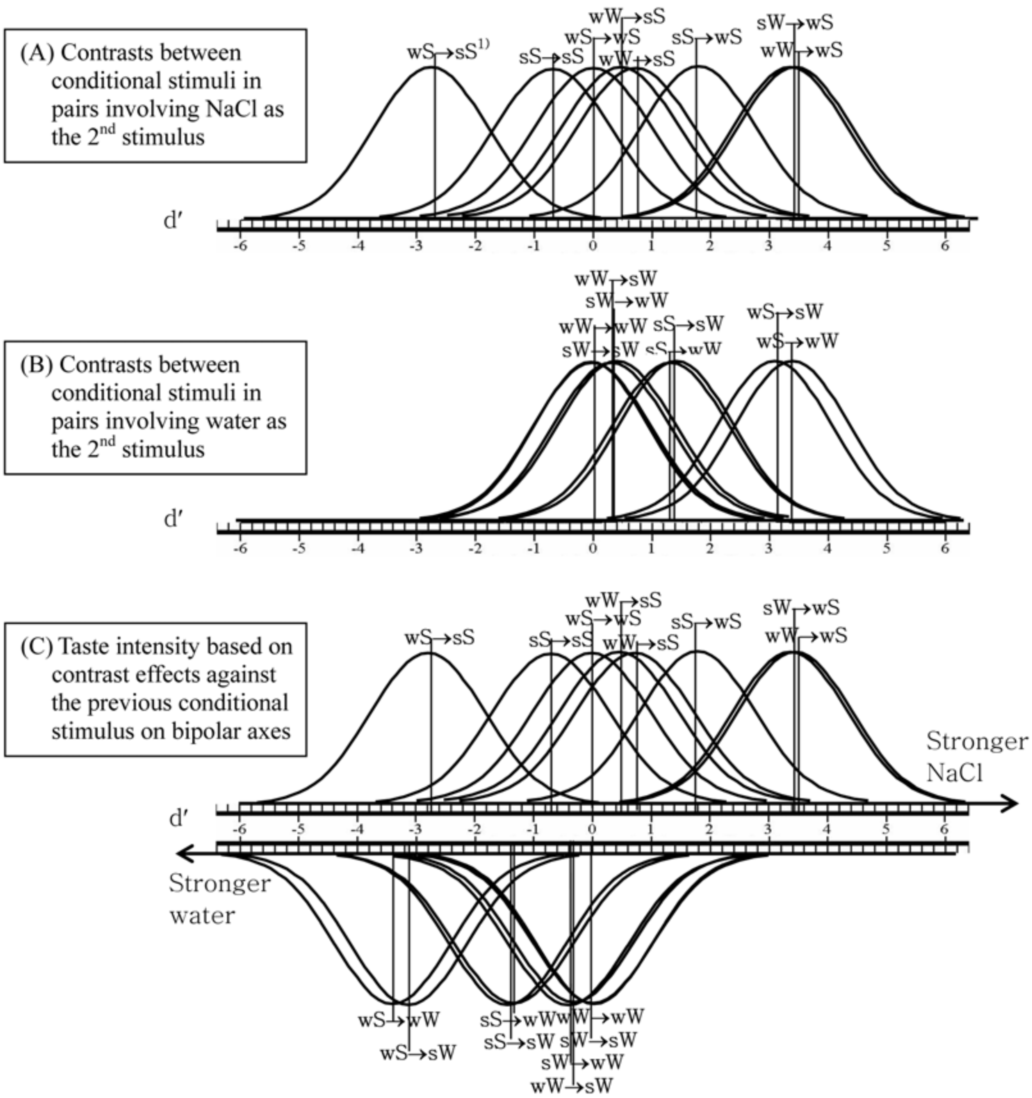

Fig. 2. Contrasts effects between the 2 conditional stimuli on unipolar (A and B) and bipolar axes (C). 'w', water rinse; 's', NaCl solution rinse; 'W', water stimulus; 'S', NaCl solution stimulus.

are considerably overlapped with distributions of other stimuli, yet for (B), it has a larger number of sS→sS contrast which could also elicit water-like taste and the distributions of the odd stimulus were more close to the distribution of the sS→sS contrast, resulting in non-discriminable condition. Thus, the postulated model would appear to predict the results of Lee and O'Mahony's (5) interstimulus rinsing experiment correctly.

With the 4-distribution model, the judged contrast between successively tasted stimuli depended, as did the supra- or sub-adapting taste strength of those stimuli, solely on the sequence of tasting those stimuli. Yet with interstimulus rinses, this concordance breaks down. The perceived contrast depends not only on the sequence of tasting (physiological enhancement or adaptation caused by the interstimulus rinses) but also on the cognitive contrasts between the attended target stimuli. It could be argued that the 2-distribution Thurstonian model used in vision and audition, where carry-over is minimal, is a special case of the 4-distribution model. It could also be argued that the 4-distribution model is a special case of the 16-distribution conditional stimulus model developed in the present study. Further experiments would be required to quantify the distances between the distributions of differences more precisely and to show how well this model fit the various sensory testing data.

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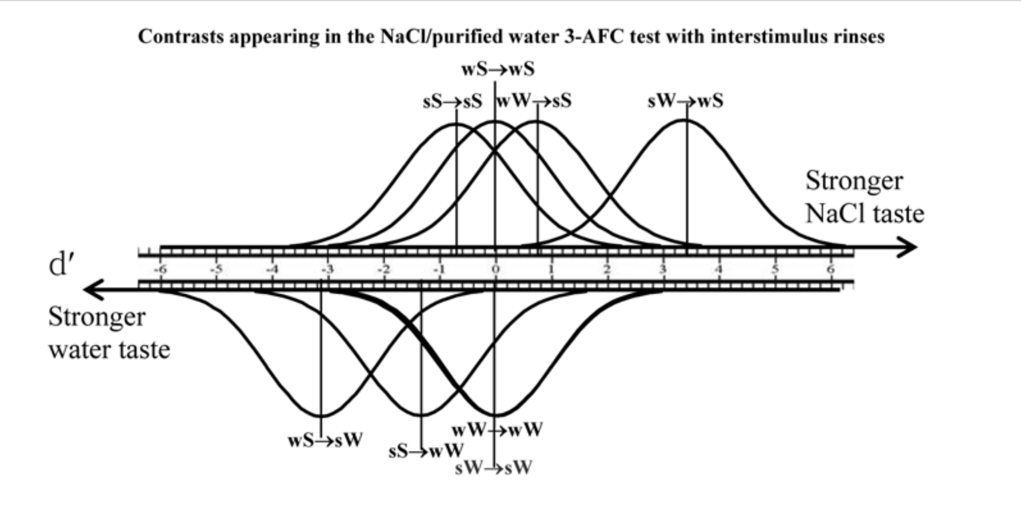

Sequence of tasting for S and W stimuli preceded by s and w rinses[1)]	wS→sW	sS→wW	sS→sS	wW→wW sW→sW	wS→wS	wW→sS	sW→wS
Magnitude of Contrasts							
(A)							
sW sW wS	⅓[2)]			1⅔			1
sW wS sW	1⅓			⅔			1
wS sW sW	1			1	⅓		⅔
Totals	**2⅔**			**3⅓**	**⅓**		**2⅔**
(B)							
wS wS sW	1				1⅔		⅓
wS sW wS	1				⅔		1⅓
sW wS wS	⅔			⅓	1		1
Totals	**2⅔**			**⅓**	**3⅓**		**2⅔**
(C)							
wW wW sS		⅓		1⅔		1	
wW sS wW		1⅓		⅔		1	
sS wW wW		1	⅓	1		⅔	
Totals		**2⅔**	**⅓**	**3⅓**		**2⅔**	
(D)							
sS sS wW		1	1⅔			⅓	
sS wW sS		1	⅔			1⅓	
wW sS sS		⅔	1	⅓		1	
Totals		**2⅔**	**3⅓**	**⅓**		**2⅔**	

Fig. 3. Contrasts from Fig. 2 that appear in the blocks of 3-AFC tests with various interstimulus rinsing protocols. [1)]'w', water rinse; 's', NaCl solution rinse; 'W', water stimulus; 'S', NaCl solution stimulus. [2)]Number indicates how often each contrast occurs.

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