10th SENSOMETRICS

Measuring Food or Consumers?
Latest Ideas and Methodological Issues in Difference Tests

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SENSORY DIFFERENCE TESTS

- Various paradigms of difference tests can be used for assessment of

(1) **Sensory differences between confusable food samples** in the analytical sensory evaluation of food

(2) **Consumers discriminability** between samples

Test protocol	Sample presentation & Instruction
A-Not A	Is this 'A' or not ?
2-AFC	Which one is 'A' ?
3-AFC	Which one is stronger?
Duo-trio	Which one is the reference? **Reference**
Triangle	Which is odd one?
Dual-pair	Which pair is the same pair?
Same-different	Is this pair same or different?

Sensory Difference Tests

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	ich pair is the same pair?
ame-different	is pair same or different?

Objective sensory specification, using equally sensitive panel

Methods have to be sensitive, having proper power, and reliable

The consumption context should be close to the normal situation.
What else?
How should the methodology differ then?

Understanding Variables of Sensory Difference Tests

"What are subjects or consumers actually doing during performing the difference test procedures?"

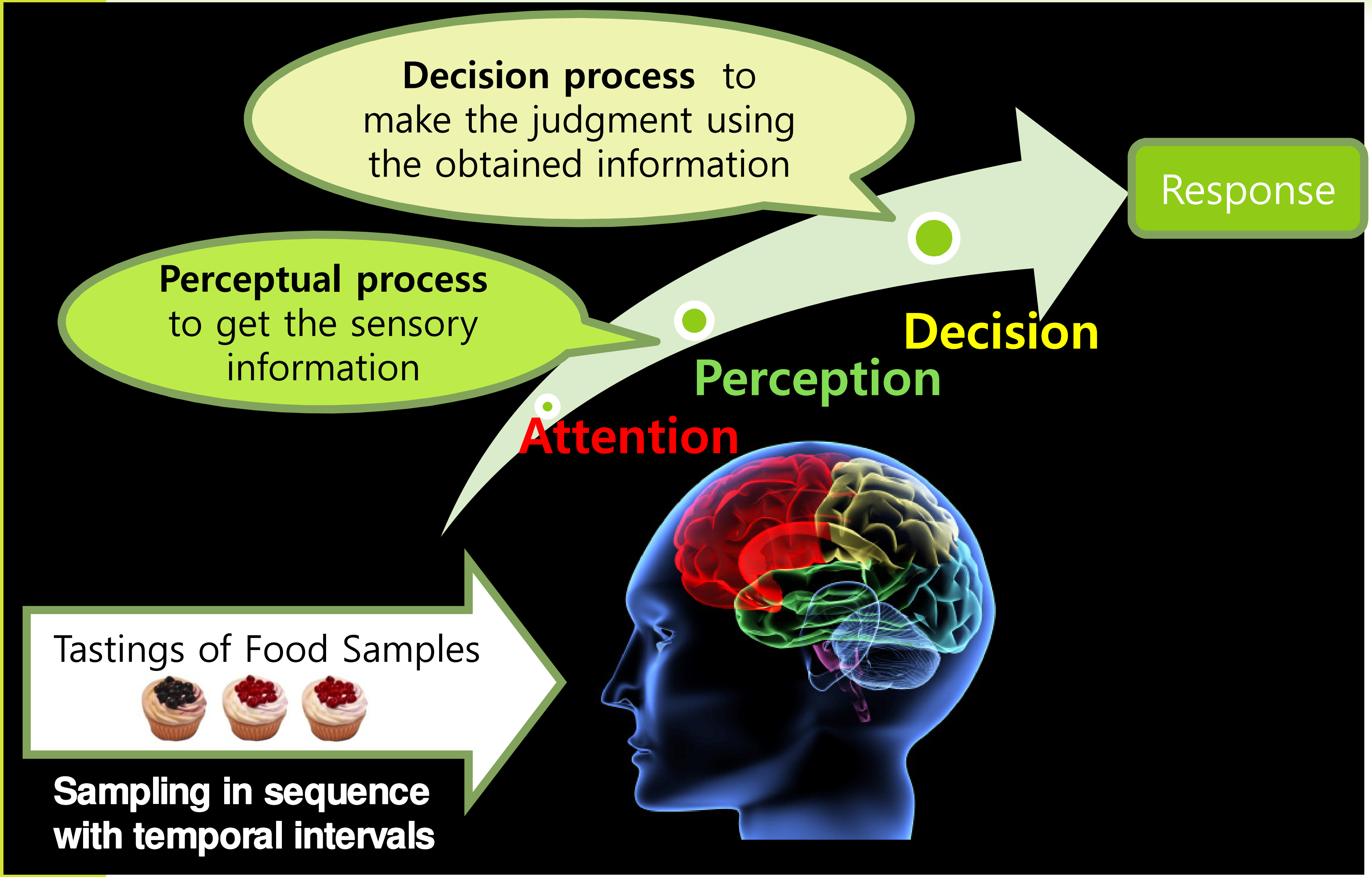
- Understanding this will help us…

(1) developing accurate modeling to various difference tests

(2) selecting and applying appropriate sensory difference tests according to the different purposes of experiments

Perception and Decision Process in Difference Tests

Perception and Judgment for Difference Tests



PERCEPTUAL PROCESS

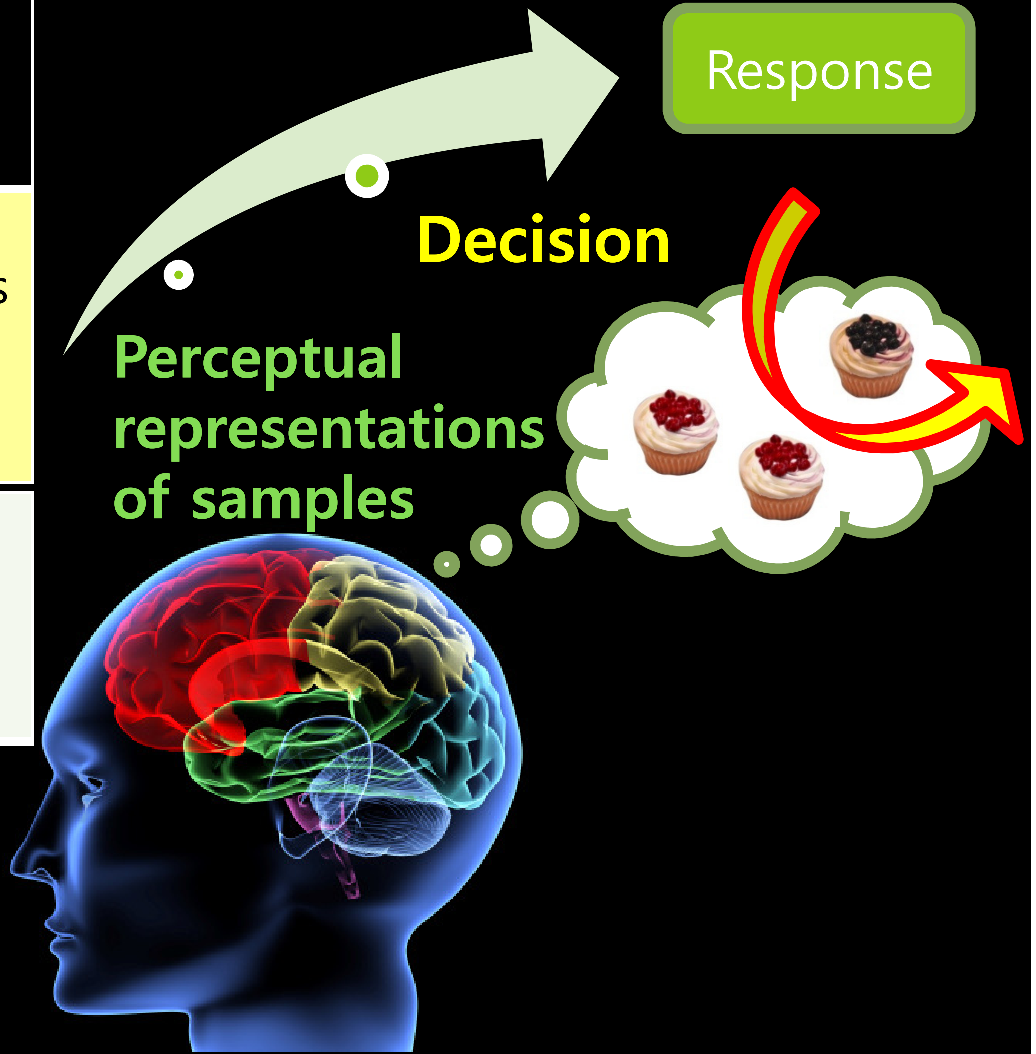
Factors influencing perception	
Cognitive perception strategy	**How and what dimension subjects attend to: Affecting the nature of information**
Function of Sensory System for Food	**Affecting the clarity of information getting into the brain**

Tastings of Food Samples

Perception

Decision Process

Factors affecting proportion of correct responses (P_c)	
Cognitive decision strategy	Subjects' way to compare samples to choose a response
Response bias	**Subjects favoring one response over the other**



FACTORS & MODELS EXPLAINING VARIABILITY IN DIFFERENCE TEST PERFORMANCES

1 Effects of involving hedonic state of mind on consumer discrimination

2 Effects of test designs & Thurstonian Modeling/ Signal Detection Theory

Factors influencing perception

- Cognitive perception strategy
- Function of Sensory System for Food

Factors affecting proportion of correct responses (P_c)

- Cognitive decision strategy
- Response bias

3 Effects of order of samples presentation on a test & Sequential Perception Analysis

EFFECTS OF PERCEPTION PROCESS ON CONSUMER DISCRIMINATION

PERCEPTION PROCESS

	Dimensions	Test Influences	References
Two distinctive perceptual strategies involved in food perception	***Analytic (selective)*** paying selective attention to specified attribute ***vs*** ***Synthetic (holistic)*** paying unitary, global attention to the overall food flavor	• Previous training • Nature of the instruction • Nature and degree of familiarization procedure	• Prescott, Johnstone & Francis, 2004 • Le Berre, et al., 2008 • Prescott & Murphy, 2009
	Analytic (not subjective) tests that do not consider the affective/hedonic states of the subjects ***vs*** ***Affective (unitary, holistic)*** Tests influenced by the mind set and subjective feelings of the individual	• Test design • Nature of the instruction • Nature and degree of familiarization procedure	• Chae, Lee & Lee, 2010 • Mojet & Köster, 1986 • Frandsen et al. 2003, 2007

TRAINED PANEL & CONSUMERS

- Regarding food perceptions, depending on how you give your attentions to, there could be two distinctive perception processes:

- **Analytical (and selective) approach**, which a trained sensory panel would normally apply when evaluating food.

- **Affective (and synthetic) approach**, which naive consumers would normally apply when consuming food.

- It was reported that affective/hedonic approach (different mode of attention, incompatible with analytical approach) promote synthetic perception (Prescott, Johnstone and Francis, 2004).

Is affective discrimination more discriminating than analytical tests?

- It has been reported that affective approach (i.e. authenticity test) is more sensitive than analytical approach to discriminate subtle differences in foods.
- These results suggest that for the products that consumers have high emotional involvements, the affective concept (foreign vs. national) help to apply the synthetic perception process and define the perceptual variable.

References	Food Sample	Analytical test	Sensiti-vity	Affective test
Mojet & Köster 1986	Beer	-		Authenticity test
Kjearulff. 2002	Milk	Multiple A-not A test	〈	Authenticity test
Frandsen et al. 2003	Milk	Descriptive analysis	〈	Authenticity test
Frandsen et al. 2007	Milk	Same-different test	〈	Authenticity test

STUDY I

AFFECTIVE SAME-DIFFERENT DISCRIMINATION TESTS FOR ASSESSING CONSUMER DISCRIMINABILITY BETWEEN MILKS WITH SUBTLE DIFFERENCES

- Objective I: investigating the effects of the affective familiarization on the consumers' discriminability in comparison with the same discrimination test in an analytical mode

Chae, Lee, & Lee (2009) Food Quality & Preference 21, 427- 438

EXPERIMENTAL PROCEDURE

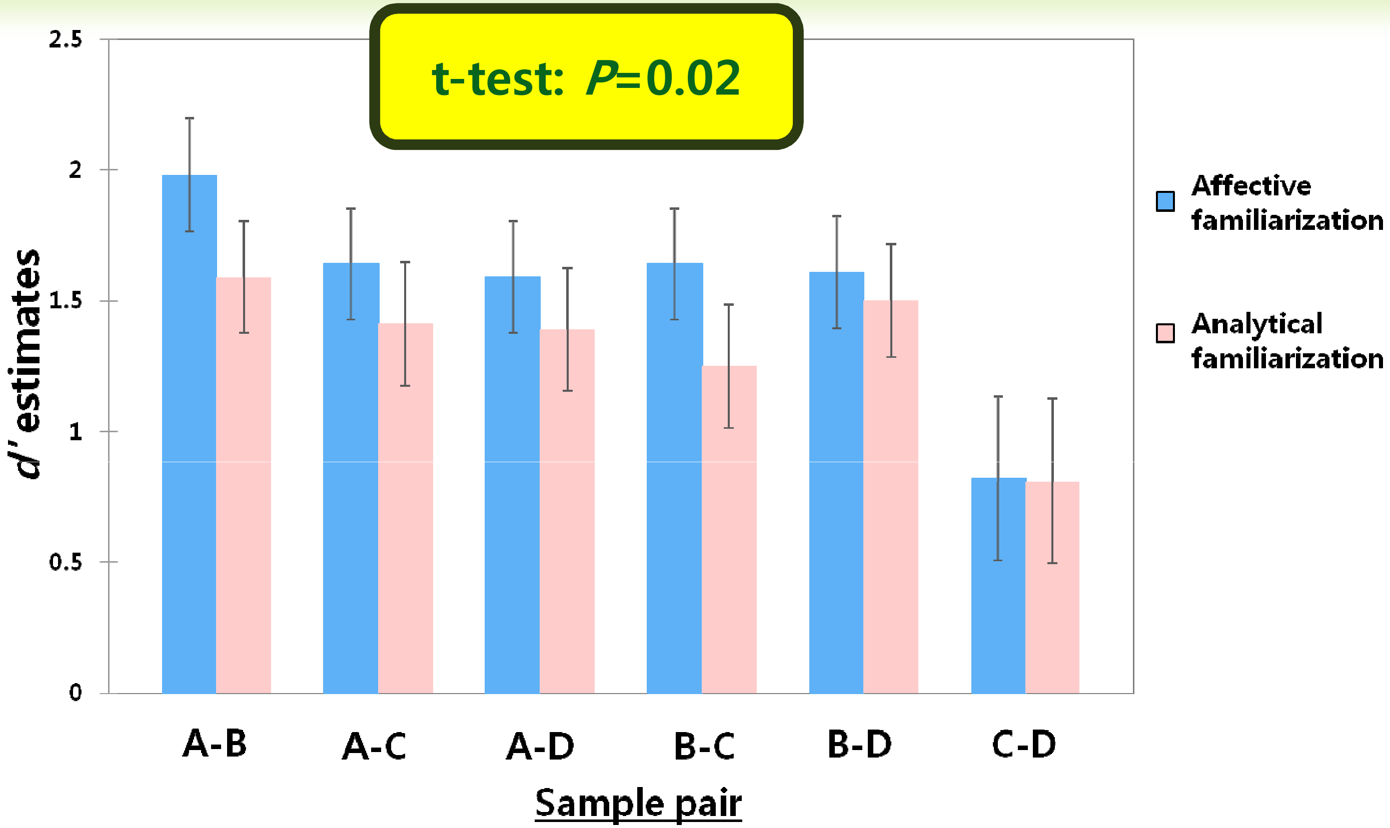
- Stimuli: four commercial confusable milk products (A~D)
- Subjects: 100 female milk consumers (age range 22±2 years)
- Consumer performed 4 sessions of same-different tests and each session was preceded by one of the two different familiarization procedures

Af.F: Affective familiarization procedure	**An.F**: Analytical familiarization procedure
Four sets of 10 point rank-ratings for 'liking' and three affective and integrated attributes ('freshness', 'well-being', and 'off-flavor')	Four sets of 10 point rank-ratings for similarity to each of the four milk products

Chae, Lee, & Lee (2009) Food Quality & Preference 21, 427- 438

RESULTS: SAME-DIFFERENT RATINGS

- **SD/Af.F resulted in higher discriminability than SD/An.F.**



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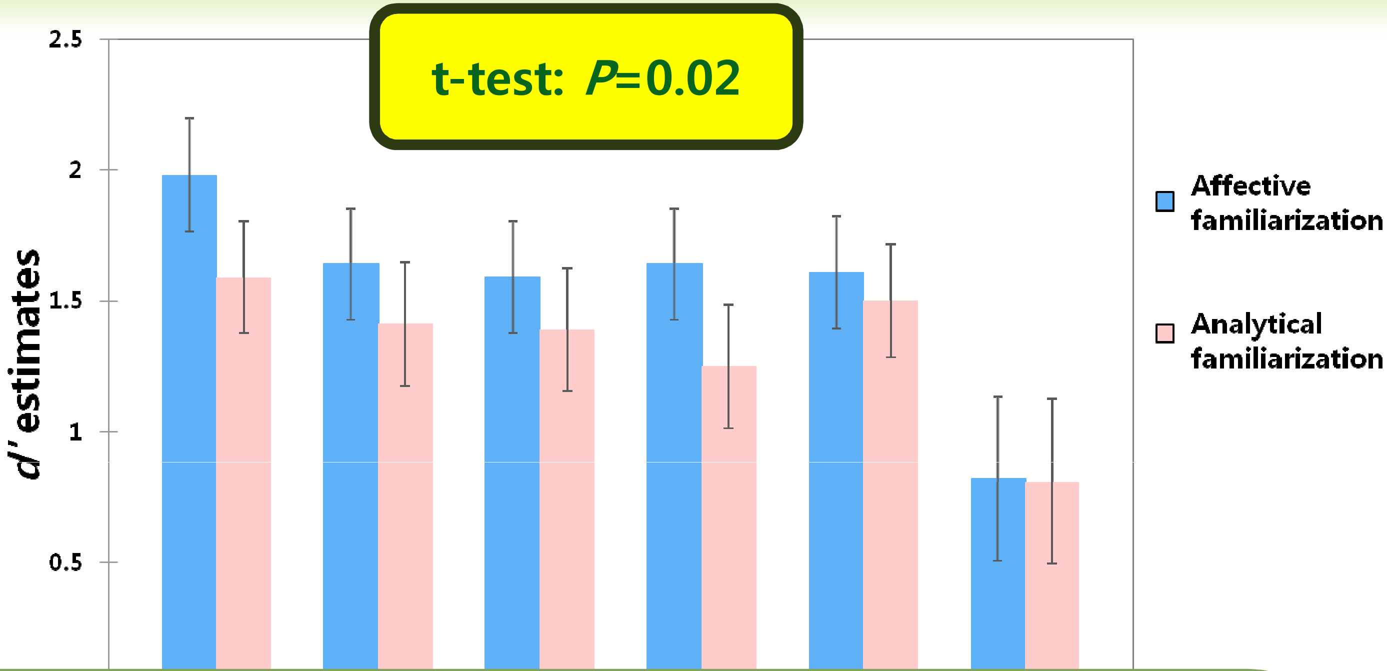


➢ Drawing consumers' attention in affective modes enhanced consumers` perceptual discriminability

➢ **For measuring more natural consumers' discriminability, it might be essential to trigger the affective mode of perception and allow the consumers' natural, synthetic perception process to occur.**

RESULTS: NOT HOMOGENEOUS RESPONSE DISTRIBUTIONS FOR SAME PRODUCTS

- $\chi 2$-tests for the same pairs revealed that consumers' familiarity to the tested products were not all the same. Consumers developed better familiarity (or memory) to 'A' and 'B' than 'C' and 'D'.
- **These suggest that there might be an interaction between the affective perception and familiarity (or memory) to the products.**

Sample pair	SD/Af.F							
	Same			Different				
	Sure	Not sure	Don't know But guess	Don't know but guess	Not sure	Sure	χ^2	p
AA	**46**	**18**	**8**	**4**	**11**	**13**		
BB	**39**	**36**	**6**	**4**	**9**	**6**	**31.25**	**0.01**
CC	**26**	**29**	**7**	**13**	**12**	**13**		
DD	**28**	**27**	**11**	**4**	**17**	**13**		
Mean	34.75	27.50	8.00	6.25	12.25	11.25		

Least liked,
Least fresh

Most liked,
Most fresh

RESULTS: CONSUMERS SEGMENTATION

To check the effects of inter-consumers' different familiarity and criteria in discriminability,

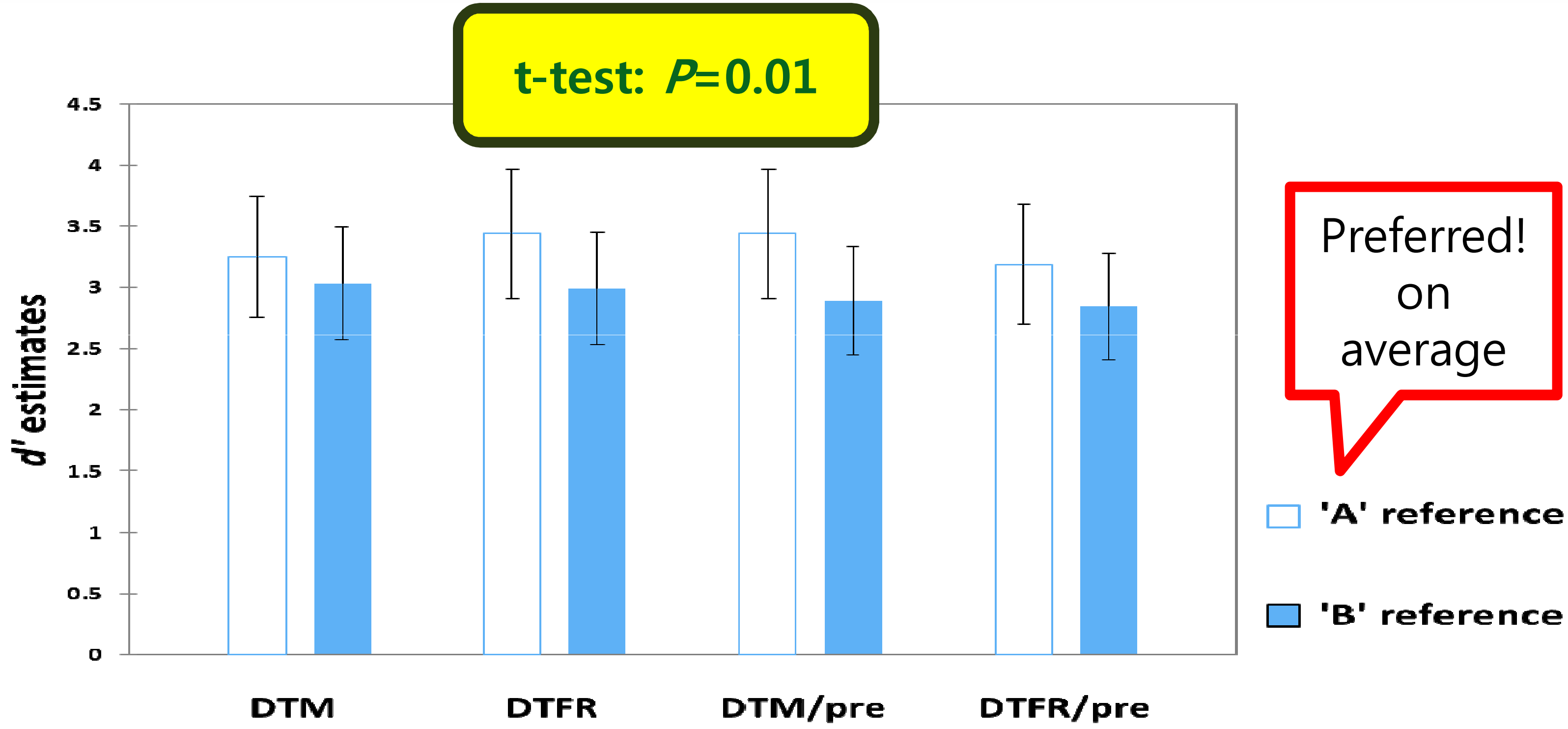
a hierarchical cluster analysis was performed on frequency distributions elicited by the six response categories for the same product pairs

Table 2. Results of ROC analyses on the pooled data across each class of subjects

Cluster	Sample pair	SD/Af.F	SD/An.F	χ^2	*p*
Class 1 54F (23 in Group1, 31 in Group2)	A-B	**2.27±0.10**	**1.81±0.11**	**9.28**	**0.01**
	A-C	1.80±0.11	1.79±0.11	0.01	0.91
	A-D	1.79±0.11	1.57±0.11	1.35	0.25
	B-C	1.77±0.10	1.66±0.11	0.48	0.49
	B-D	**2.06±0.10**	**1.71±0.11**	**5.87**	**0.02**
	C-D	1.08±0.13	1.10±0.13	0.02	0.88
	Mean	**1.80**	**1.61**		
Class 2 46F (27 in Group1, 19 in Group2)	A-B	1.39±0.12	1.44±0.12	0.08	0.77
	A-C	1.18±0.13	1.03±0.14	0.59	0.44
	A-D	1.25±0.13	1.32±0.12	0.15	0.70
	B-C	1.23±0.13	1.12±0.13	0.36	0.55
	B-D	1.14±0.13	1.35±0.12	1.39	0.24
	C-D	0.60±0.20	0.67±0.20	0.05	0.82
	Mean	**1.13**	**1.16**		
	t-test	***p*** **= <0.01**	***p*** **= <0.01**		

Study II: Balanced mode Duo-Trio
(Kim & Lee, in prep.)

Comparison of performance between different reference



➢ Affects/preference towards certain sample could induce more stable memory representations of those samples and may allow a more efficient form of information processing

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2-AFC	Which one is 'A' ?
3-AFC	
Duo-trio	W… Re…
…iangle	W…
…ame-different	Is…

Subjective affects may play a role. Segments can exist.

Methods should involve consumers' natural attention and perception.

Not just general processing strategy, but the consumers' affects towards the samples may also need to be understood.

FACTORS & MODELS EXPLAINING VARIABILITY IN DIFFERENCE TEST PERFORMANCES

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2 Effects of test designs & Thurstonian Modeling/ Signal Detection Theory

Factors influencing perception

Cognitive perception strategy

Function of Sensory System for Food

Factors affecting proportion of correct responses (P_c)

Cognitive decision strategy

Response bias

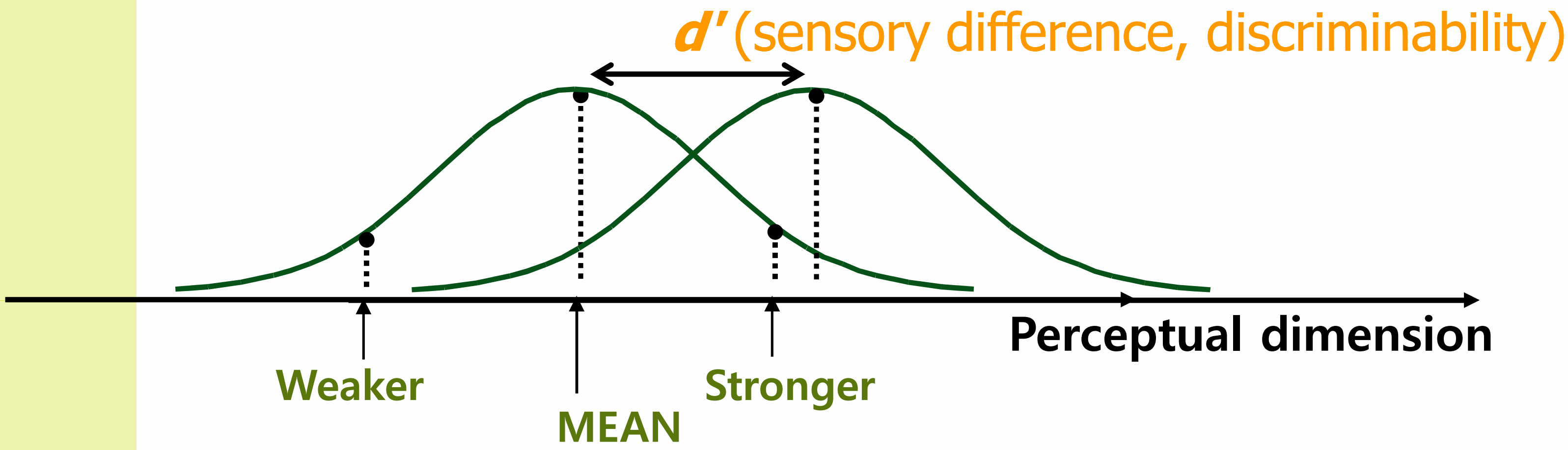
3 Effects of order of sample presentation in a test & Sequential Perception Analysis

THURSTONIAN MODELING & SIGNAL DETECTION THEORY

Currently the most advanced psychometric approach to modeling various sensory difference tests accounting for differences in decision process

THURSTONIAN MODELING & SIGNAL DETECTION THEORY

1. Assuming variation in sensory perception



- Each sample presentation yields a value of a perceptual decision variable.
- Repeated presentations do not always lead to the same results, but generate a distribution of perceptual values.
- For two confusable samples, the average difference of the perceptual value represents the index of absolute sensitivity difference or discriminability

THURSTONIAN MODELING (TM) & SIGNAL DETECTION THEORY (SDT)

2. **Accommodation of the decision strategy used in the process of judgment**

Triangle

Which is odd one?

3-AFC

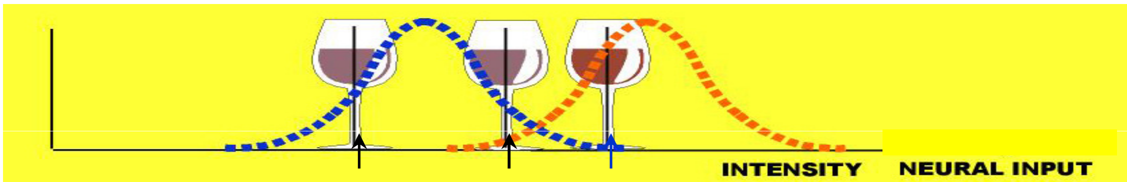
Which one is stronger?

- **Guessing probability is 0.333 for both.**
- **TM & SDT model predicts the probability of proportion of correct responses to be different accounting for their cognitive decision strategy:** **Triangle < 3-AFC**
- **Thus TM & SDT model computes the absolute distance measure, *d'*** (sensory difference, discriminability), **independent of test procedures used for the discriminations.**

TRIANGLE VS 3-AFC (FRIJTER, 1979; O'Mahony et al., 1994)

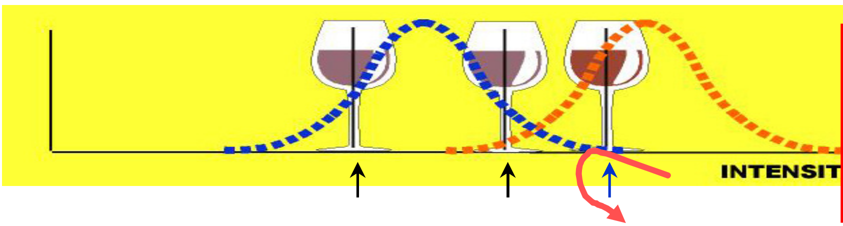
- Perceptual modeling based on one-dimensional perceptual space and possible cognitive decision strategy in theory

Triangle: 'Comparison of distances' (COD) strategy



Group together the two most similar

3-AFC: 'Skimming' strategy



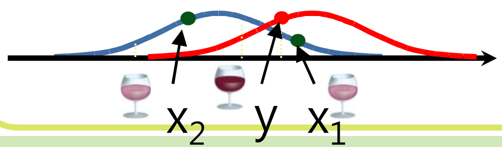
More efficient strategy, resulting in higher P(c) than triangle

"skim off" or choose the highest intensity

THURSTONIAN PROBABILISTIC MODELING BASED ON ONE-DIMENSIONAL PERCEPTUAL SPACE

Triangle

Perceptual presentation & Decision rule



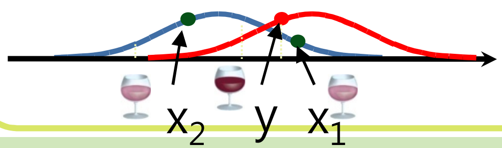
- $P(c) = P\,(|x_2 - x_1| < |y - x_1|$ and $|x_2 - x_1| < |y - x_2|)$

Psychometric function

$$P_C = 2\int_0^{\infty}\left[\Phi\left(-u\sqrt{3} + \delta\sqrt{\frac{2}{3}}\right) + \Phi\left(-u\sqrt{3} - \delta\sqrt{\frac{2}{3}}\right)\right]\exp\left(\frac{-u^2}{2}\right) / \sqrt{2\pi}\,du$$

3-AFC

Perceptual presentation & Decision rule



- $P(c) = P\,(\, y > x_1$ and $y > x_2\,)$

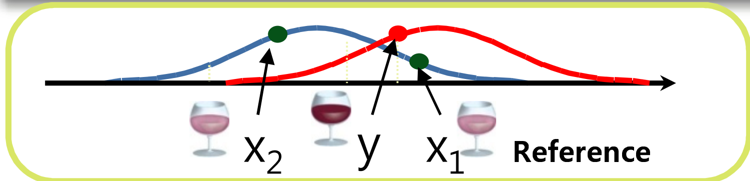
Psychometric function

$$P_C = \int_{-\infty}^{\infty} \Phi^2(u)\phi(u - \delta)\,du$$

THURSTONIAN PROBABILISTIC MODELING BASED ON ONE-DIMENSIONAL PERCEPTUAL SPACE

Duo-Trio

Perceptual presentation & Decision rule



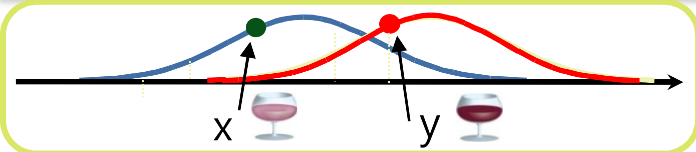
- $P(c) = P(|x_2 - x_1| < |y - x_1|)$

Psychometric function

$$P_C = 1 - \Phi\left(\frac{\delta}{\sqrt{2}}\right) - \Phi\left(\frac{\delta}{\sqrt{6}}\right) + 2\Phi\left(\frac{\delta}{\sqrt{2}}\right)\Phi\left(\frac{\delta}{\sqrt{6}}\right)$$

2-AFC

Perceptual presentation & Decision rule



- $P(c) = P(y > x)$

Psychometric function

$$P_C = \Phi(\delta / \sqrt{2})$$

COGNITIVE DECISION STRATEGY

<table>
<tr><th></th><th>Types</th><th>Terminology used in Psychology</th><th>References</th></tr>
<tr><td rowspan="2">Based on one-dimensional Thurstonian model</td><td>Skimming strategy</td><td></td><td rowspan="2">O'Manony & Rousseu 2002
O'Mahony et al., 1994</td></tr>
<tr><td>Comparison of distances (COD) strategy</td><td></td></tr>
<tr><td rowspan="2">Based on decision space (SDT)</td><td>β-decision strategy

Subject sets a β-criterion at some level of sensory information and makes judgment based on where the information from the samples in a test falls about this criterion</td><td>Independent observation rule
Optimal decision rule</td><td rowspan="2">Green & Swets 1966
Hautus, van Hout & Lee, 2009
Macmillan & Creelman 2005</td></tr>
<tr><td>τ-decision strategy

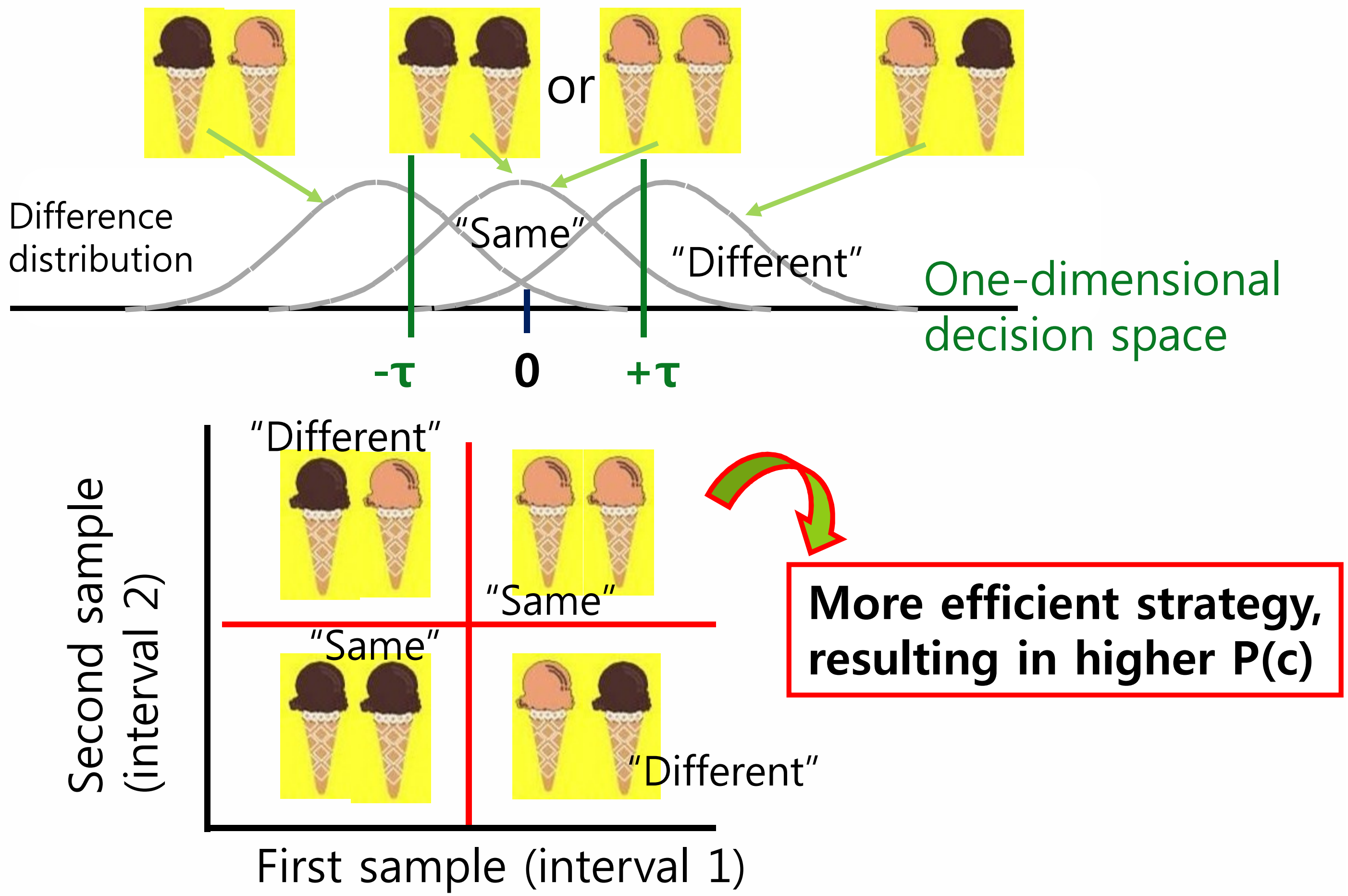
Subject sets a criterion difference (the τ-criterion) that is compared to the difference in sensory information that arises from two or more samples.</td><td>Differencing strategy
Sensory difference decision rule</td></tr>
</table>

SAME-DIFFERENT
(LEE. ET AL., 2007)

- Possible cognitive decision strategy in theory

τ-decision strategy

β-decision strategy



COGNITIVE DECISION STRATEGY (CONT.)

	Types	Relevant tests (in theory)	
Based on one dimensional Thurstonian model	*Skimming strategy*	• m-AFC (m>2)	
	Comparison of distances strategy	• Triangle • Duo-trio	
Based on decision space (SDT)	*β-decision strategy* Subject sets a β-criterion at some level of sensory information and makes judgment based on where the information from the samples in a test falls about this criterion	• A-Not A • 2-AFC	• Same-different • Dual-Pair • Triangle • Duo-trio
	τ-decision strategy Subject sets a criterion difference (the τ-criterion) that is compared to the difference in sensory information that arises from two or more samples.	• Same-different • Dual-Pair	• 2-AFC • Triangle • Duo-trio

STUDY I REVISITED

AFFECTIVE SAME-DIFFERENT DISCRIMINATION TESTS FOR ASSESSING CONSUMER DISCRIMINABILITY BETWEEN MILKS WITH SUBTLE DIFFERENCES

- Hypothesis:

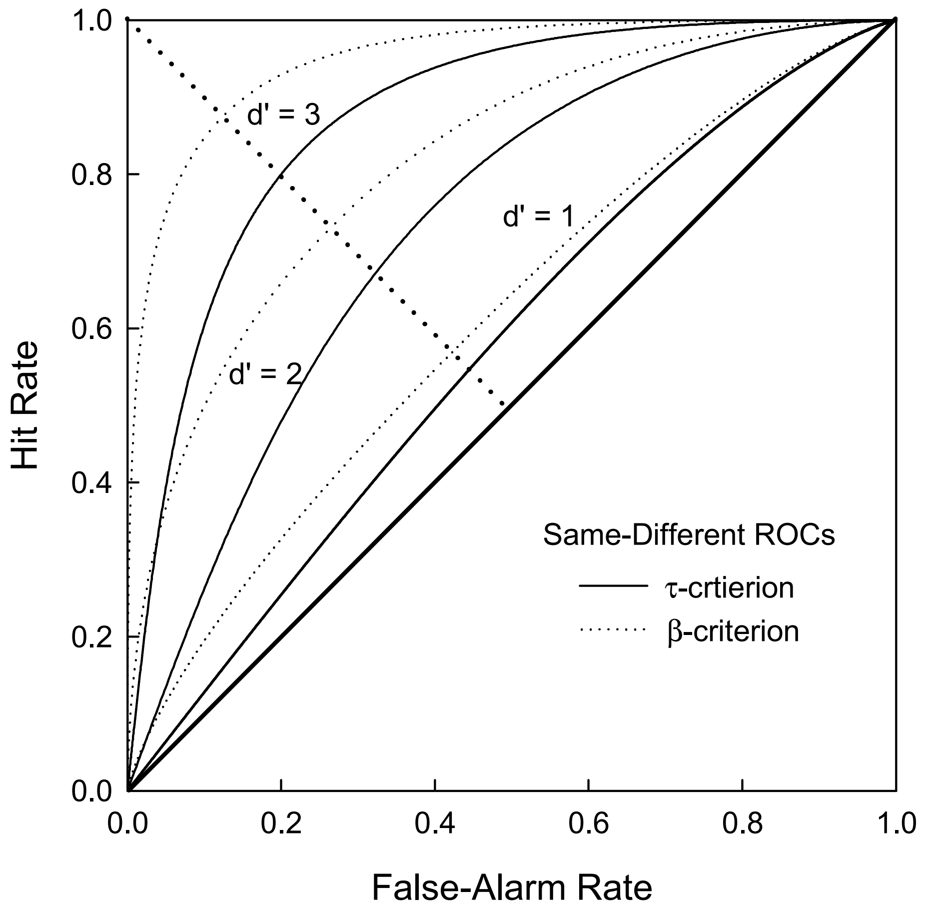
  When consumers have been exposed to the products and involved in making judgments about individual products, they might then just try to identify the products using a **β-criterion** rather than using the commonly assumed ***τ*-criterion.**

- Objective 2: exploring the effects of the previous task on the cognitive decision strategies used in the same-different tests.

Chae, Lee, & Lee (2009) Food Quality & Preference 18, 920- 928

Approach to Determine Cognitive Decision Strategy

- **Signal Detection Theory**
  - The shape of ROC analysis
  - Investigation of d′ estimates in comparison with the standard detection method such as A-Not A (yes-no) and 2-AFC.



Hautus, O'Mahony, & Lee (2008) Journal of Sensory Studies 23, 743–764

ROC ANALYSIS

- Based on the χ^2 -goodness of fit test, for all the data from each session, a model assuming β-strategy gave the better fitting.

Procedure	Sample pair	τ-Strategy			β-Strategy		
		d´	χ^2	*p*	*d´*	χ^2	*p*
SD/Af.F	A-B	2.46±0.07	14.84	0.01	1.98±0.11	8.05	0.10
	A-C	1.99±0.08	20.65	<0.01	1.64±0.11	11.90	0.02
	A-D	1.90±0.08	13.61	0.01	1.59±0.11	6.03	0.20
	B-C	1.99±0.08	14.90	0.01	1.64±0.11	4.43	0.35
	B-D	1.92±0.08	24.41	<0.01	1.61±0.11	9.88	0.04
	C-D	0.82±0.11	5.95	0.20	0.82±0.16	2.45	0.65
	Mean	**1.85**			**1.55**		
SD/An.F	A-B	1.89±0.08	24.47	<0.01	1.59±0.11	10.82	0.03
	A-C	1.69±0.08	4.91	0.30	1.41±0.12	1.93	0.75
	A-D	1.67±0.09	10.23	0.04	1.39±0.12	5.73	0.22
	B-C	1.43±0.08	15.00	0.01	1.25±0.12	6.76	0.15
	B-D	1.80±0.08	9.26	0.06	1.50±0.11	2.40	0.66
	C-D	0.87±0.10	5.53	0.24	0.81±0.16	3.29	0.51
	Mean	**1.56**			**1.32**		

Chae, Lee, & Lee (2009) Food Quality & Preference 21, 427- 438

ROC ANALYSIS

- Based on the χ^2 -goodness of fit test, for all the data from each session, a model assuming β-strategy gave the better fitting.

- This suggests that when complex food products are compared and the products are pre-viewed, consumers can use more efficient (optimal) decision strategy than the commonly assumed τ-strategy.
- The nature of the product category (milk) might have been an influence on the decision strategy used in the same-different test.
- Therefore, when analyzing the same-different tests, checking the model's validity and justifying the decision strategy is needed for accurate d′ computation.

β-Strategy		
d′	χ^2	p
±0.11	8.05	0.10
±0.11	11.90	0.02
±0.11	6.03	0.20
±0.11	4.43	0.35
±0.11	9.88	0.04
±0.16	2.45	0.65
55		
±0.11	10.82	0.03
±0.12	1.93	0.75
±0.12	5.73	0.22
±0.12	6.76	0.15
±0.11	2.40	0.66
±0.16	3.29	0.51
1.32		

Chae, Lee, & Lee (2009) Food Quality & Preference 21, 427- 438

The importance of knowing what the test design is

PROBLEM OF NOT STANDARDISED TEST DESIGN

- In food science literature, for many commonly used difference tests, there are no agreed standard format. As long as the general procedure is followed, the method is given its name.

➡ "Lack of agreement on terminology"

➡ "difficulty in deciding among competing models for the same test design"

➡ Without valid modeling, data like $P_{(c)}$ can be misinterpreted.

(Macmillan & Creelmann, 2005; Lee, van Hout & O'Mahony, 2007; Kim, Lee & Lee, 2010)

A-Not A

- There are many different versions of the A-Not A test

(Meilgaard, Civille & Carr, 1991; Lawless & Heymann, 1996; Lee, van Hout & O'Mahony, 2007)

Familiarization before the tests to describe the dimension

Only 'A' or Both 'A' & 'Not A'

Is this 'A' or not ?

Is this 'A' or not ?

Is this 'A' or not ?

Is this 'A' or not ?

Is this 'A' or not ?

Reminder during tests

Sometimes available, other times not

- The different methods have the potential to change the cognitive decision strategy being used.
- If there were changes in decision strategy, comparisons of the discrimination indices between methods would be problematical.

A-NOT A: SDT

A-Not A (yes-no)

Is this 'A' or not ?

β- strategy

A-Not A Reminder

Reminder 'A'

Is this 'A' or not ?

Decisionally separable boundary

β- strategy

τ- strategy

Comparison to a fixed product difference as a criterion

Hautus, van Hout, & Lee (2009) Food Quality & Preference 20, 222- 229

A-NOT A: SDT

A-Not A (yes-no)

Is this 'A' or not ?

β- strategy

A-Not A Reminder

Reminder 'A'

Is this 'A' or not ?

Decisionally separable boundary

β- strategy

rategy

Comparison to a fixed product difference as a criterion

Sometimes, it was called as "**single-reference same-different test**" (Rousseu et al., 1999)

Hautus, van Hout, & Lee (2009) Food Quality & Preference 20, 222- 229

DUO-TRIO

- There are many different versions of the duo-trio test

(Meilgaard, Civille & Carr, 1991; Lawless & Heymann, 1996; Kim, Lee & Lee, 2010)

Balanced reference mode

Variable between 'A' & 'Not A'

or

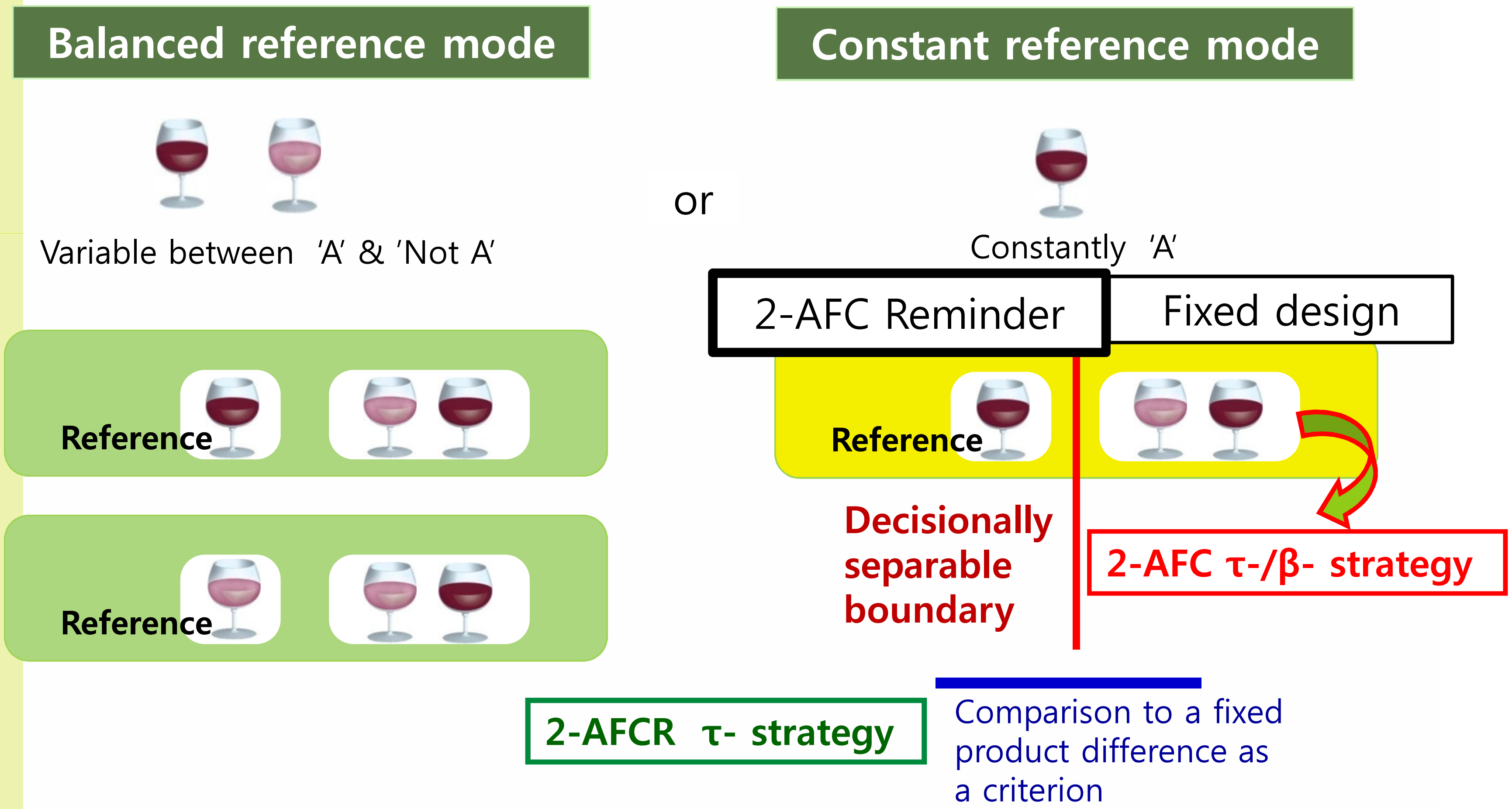
Constant reference mode

Constantly 'A'

DUO-TRIO

- There are many different versions of the duo-trio test

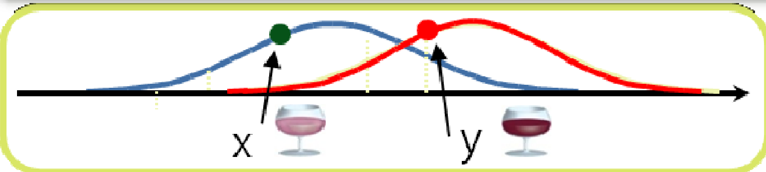
(Meilgaard, Civille & Carr, 1991; Lawless & Heymann, 1996; Kim, Lee & Lee, 2010)



PROBABILISTIC MODELING (SDT)

2-AFC

Perceptual presentation & Decision rule



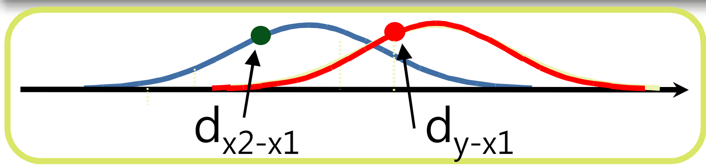
- P(c) = P (y > x)

Psychometric function

$$P_C = \Phi(\delta / \sqrt{2})$$

2-AFCR

Perceptual presentation & Decision rule



Difference distribution

- P(c) = P (y-x_1 > x_2-x_1)

Psychometric function

$$P_C = \Phi(\delta / \sqrt{2})$$

Hautus, van Hout, & Lee (2009) Food Quality & Preference 20, 222- 229

PROBABILISTIC MODELING (SDT)

2-AFC

Perceptual presentation & Decision rule

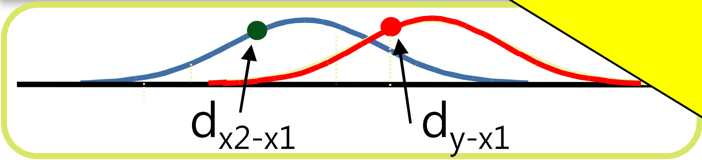
It is an empirical question.

More experiments are needed.

Is this model valid for food discriminations ?

2-AFCR

Perceptual pres... rule



$P(c) = P(y - x_1 > x_2 - x_1)$

Psychometric function

$$P_C = \Phi(\delta / \sqrt{2})$$

Hautus, van Hout, & Lee (2009) Food Quality … erence 20, 222- 229

CLASSICAL CLASSIFICATION: WHAT PROPERTY OF FOOD ARE WE COMPARING?

Test protocol	Sample presentation & Instruction
A-Not A	Is this 'A' or not ?
2-AFC	Which one is 'A' ?
3-AFC	Which one is stronger?
Duo-trio	Which one is the reference? Reference
Triangle	Which is odd one?
Dual-pair	Which pair is the same pair?
Same-different	Is this pair same or different?

Attribute or specified difference test

Overall difference test

(e.g. Meilgaard et al., 1999; Bi, 2006)

CLASSICAL CLASSIFICATION: WHAT PROPERTY OF FOOD ARE WE COMPARIN

Authenticity test:
Affective A-Not A

Is this 'Foreign' or not ?

Conceptual values describing the synthetic sensory perception can also be used to define the decision space for consumer discrimination tests

	presentation & Instru
A-Not A	
2-AFC	Which one is 'A' ?
3-AFC	Which one is stronger?
Duo-trio	Which one is the reference? Reference
Triangle	Which is odd one?
Dual-pair	Which pair is the same pair?
Same-different	Is this pair same or different?

test

Overall difference test

(e.g. Meilgaard et al., 1999; Bi, 2006)

CLASSICAL CLASSIFICATION:
WHAT PROPERTY OF FOOD ARE WE COMPARING?

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A-Not A	Is this 'A' or not ?
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3-AFC	Which one is stronger?
Duo-trio	Which one is the reference? Reference
Triangle	Which is odd one?
Dual-pair	Which pair is the same pair?
Same-different	Is this pair same or different?

With appropriate **familiarization** to induce a synthetic perception, **m-AFC** can also be used as identification test based on overall sensory perception just like A-Not A test.

O
difference test

(e.g. Meilgaard et al., 1999; Bi, 2006)

PROPOSED CLASSIFICATION:
DO WE HAVE 'A PERCEPTION' THAT CAN BE REFERENCED?

Test protocol	Sample presentation & Instruction	
A-Not A	Is this 'A' or not ?	**Identification test with a fixed reference (reminder)**
2-AFC	Which one is 'A' ?	
3-AFC	Which one is 'A'?	
Duo-trio	Which one is the reference? **Reference**	**Classification test with a variable reference**
Triangle	Which is odd one?	
Dual-pair	Which pair is the same pair?	
Same-different	Is this pair same or different?	

Proposed classification:

Do we have 'a perception' that can be referenced?

Test protocol	Sample presentation & Instruction
A-Not A	Is this 'A' or not ?
2-AFC	Which one is 'A' ?
3-AFC	Which one is 'A'?
Duo-trio	Which one is the reference?
Triangle	
Dual-pair	
Same-differe	

Identification test with a fixed reference (reminder)

test

le

When more familiar, or preferred sample is known, **applying a fixed reference discrimination design such as "2-AFC reminder"** identification rather than a variable reference design might be more suitable.

PROPOSED CLASSIFICATION:
DO WE HAVE 'A PERCEPTION' THAT CAN BE REFERENCED?

Test protocol	Sample presentation & Instruction
A-Not A	
2-AFC	
3-AFC	
Duo-trio	
Triangle	
Dual-pair	
Same-differe	

ication
a
r)
test
le

W... e is
know... rence
... mination de... ch as "2-AFC reminder"
i... fication rather than a variable reference
design might be more suitable.

More research on consumer discrimination test design are being conducted!

May be, I can tell you more coming years!!!

Factors & models explaining variability in difference test performances

1 Effects of involving hedonic state of mind on discrimination

2 Effects of test designs & Thurstonian Modeling/ Signal Detection Theory

Factors influencing perception

- Cognitive perception strategy
- Function of Sensory System for Food

Factors affecting proportion of correct responses (P_c)

- Cognitive decision strategy
- Response bias

3 Effects of order of sample presentation on a test & Sequential Perception Analysis

THE EFFECTS OF THE ORDER OF SAMPLES PRESENTED ON A TEST ON THE TEST PERFORMANCE

Achieving accuracy & efficiency in sensory data analysis

WAY WE NEED TO STUDY THE EFFECTS OF THE ORDER OF SAMPLES PRESENTED ON A TEST?

- **From a theoretical perspective**, we can learn more about the functioning of the sensory system and how it integrates information over time.
  - Learning particularly with regard to the 'complex' senses involved in flavor perception.
- **From a practical perspective**, we can learn how to optimize our sensory difference tests to best take advantage of 'favorable' orders of presentation.
  - Increasing the sensitivity of those tests to effectively measure perceptual differences.

FUNCTION OF SENSORY SYSTEM FOR FOOD

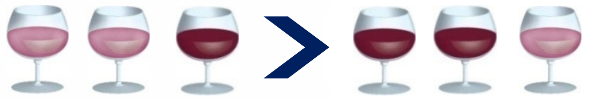
Factors Affecting the functioning of the sensory system for flavor perception	Relevant Factors	Test Influences	References
	Fatigue physical and mental disfunction	• Number of samples • Inter-stimulus interval and rinses	• Lee & O'Manony, 2007a,b
	Adaptation physiological desensitization	• Number of samples • Sequence of sample presentation	• Lee & O'Manony, 2007a,b • Lee, chae & Lee, 2009 • O'Manony, 1974, 1979
	Contrast Physiological and psychological sensitization	• Sequence of sample presentation	• Lee & O'Manony, 2007a,b • Lee, 2008 • Lee, chae & Lee, 2009

EFFECTS OF ORDER OF TASTING

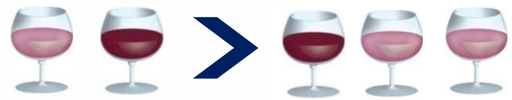

weaker (W)


stronger (S)

- **Adaptation effects**
  - **the more intense the more desensitizing**
    - O'Mahony & Odbert, 1987
    - O'Mahony and Goldstein, 1987



  - **The larger number of tasting the more desensitizing**
    - Lau, O'Mahony & Rousseu, 2004



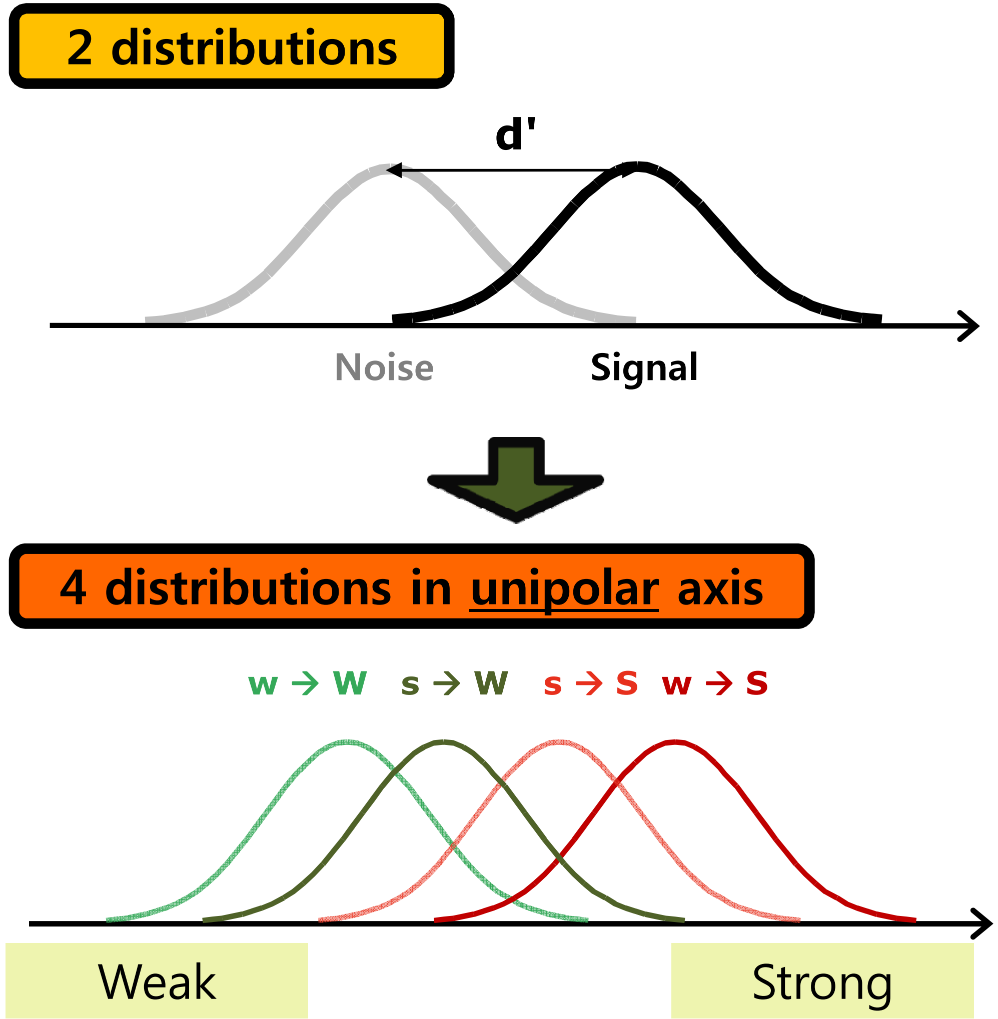
- **Contrast effects**
  - **the more contrasting the more recognizable**
    - Lee & O'Mahony, 2007
    - Lee, Chae & Lee, 2009

    - Dessirier, Siffermann & O'Mahony, 1999

CONDITIONAL STIMULUS MODEL (CSM)
(ENNIS & O'MAHONY, 1995)

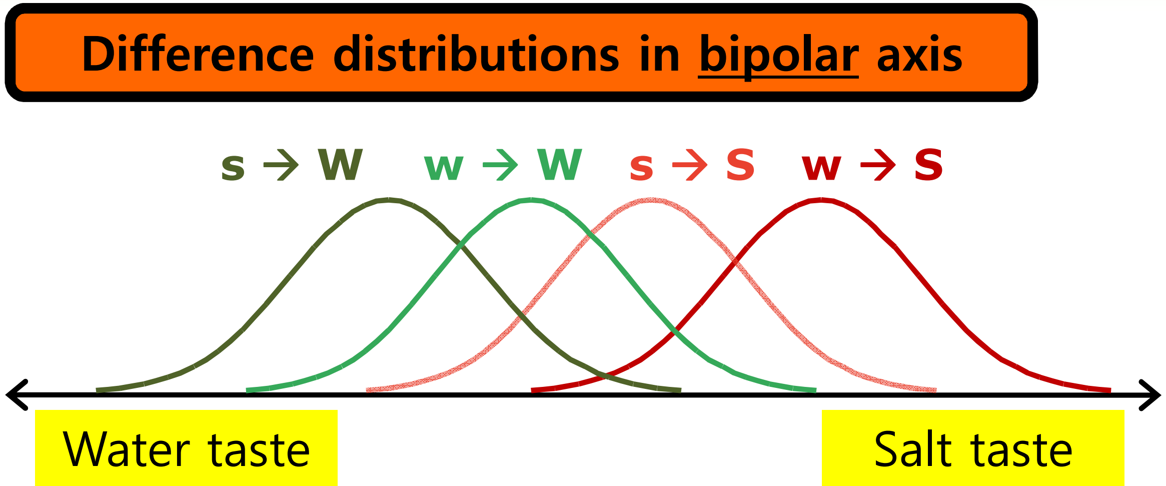
- A four distribution Thurstonian model accounting for order effects from one prior stimulus, based on Tedja et al. (1994)' s data

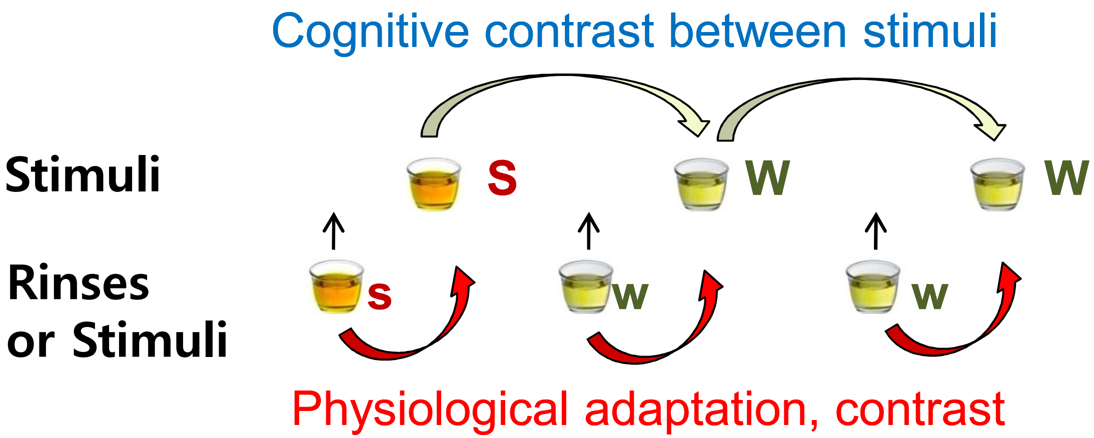
- The test sensitivity was compared by considering the confusability between perceptual distributions.



CONTRAST MODEL IN BIPOLAR DIMENSION (LEE & O'MAHONY, 2007)

- The perceptual model was further modified based on **bipolar synthetic perceptual dimension.**
- This model accounted for not only physiological adaptation affected by the one previous sample but also cognitive contrasts between comparison samples that are tasted in sequence.





Sources of Response Bias

Response bias

Factors lowering proportion of correct responses	Relevant Factors	Relevant Test Design	References
	Criterion variation	• A-Not A • Same-different	• Rousseu & O'Manony, 2002 • Lee and O'Mahony, 2004
	Position of presentation	• Tests having multiple sample presentations	• Lee & O'Manony, 2007a,b • Nisbett & Wilson, 1977
	Time order error (memory decay)	• Temporal test (When samples are separated by time rather than space) • 2-AFC • 3-AFC • Same-different	• Lee, chae & Lee, 2009 • Wilson and Tanner 1961 • Berliner and Durlach 1973 • Cubero et al.,1995 • Avancini de Almeida et al., 1999

IMPERFECT MEMORY (TIME-ORDER ERROR)

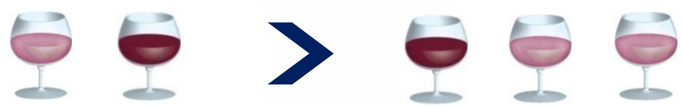

weaker (W)


stronger (S)

- **The greater the inter-stimulus interval the greater the bias**
  - Cubero et al., 1995
  - Avancini de Almeida et al., 1999
    - same-different test

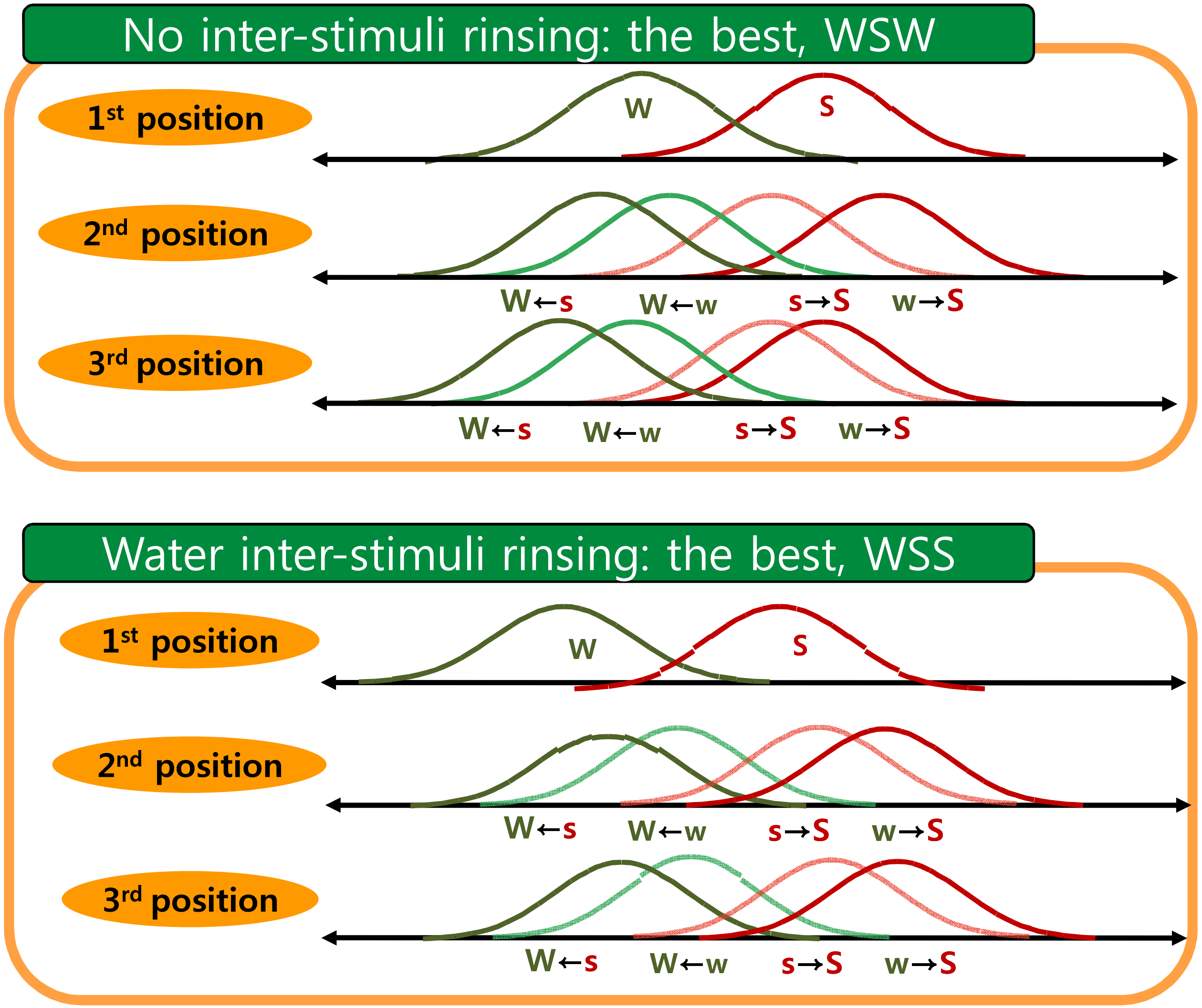
- **The more recently tasting the more intense**
  - Lee O'Mahony, 2007
  - With inter-stimulus rinsing
  - Lee, Chae & Lee, 2009
  - With water-inter-stimulus rinsing

- **The more difficult the task to deal with the more error**
  - Rousseu & O'Mahony, 1997
  - Dessirier & O'Mahony 1999
  - Lau, O'Mahony & Rousseu, 2004



SEQUENTIAL PERCEPTION ANALYSIS (SPA)
(LEE, CHAE & LEE, 2009)

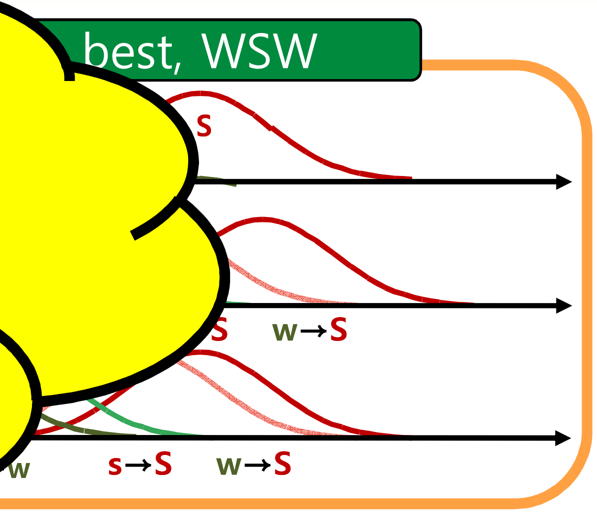
- A new model incorporating memory bias as well as adaptation and cognitive contrasts
- This predicted the position effects caused by the order of sample presentation in a 3-AFC using a skimming strategy

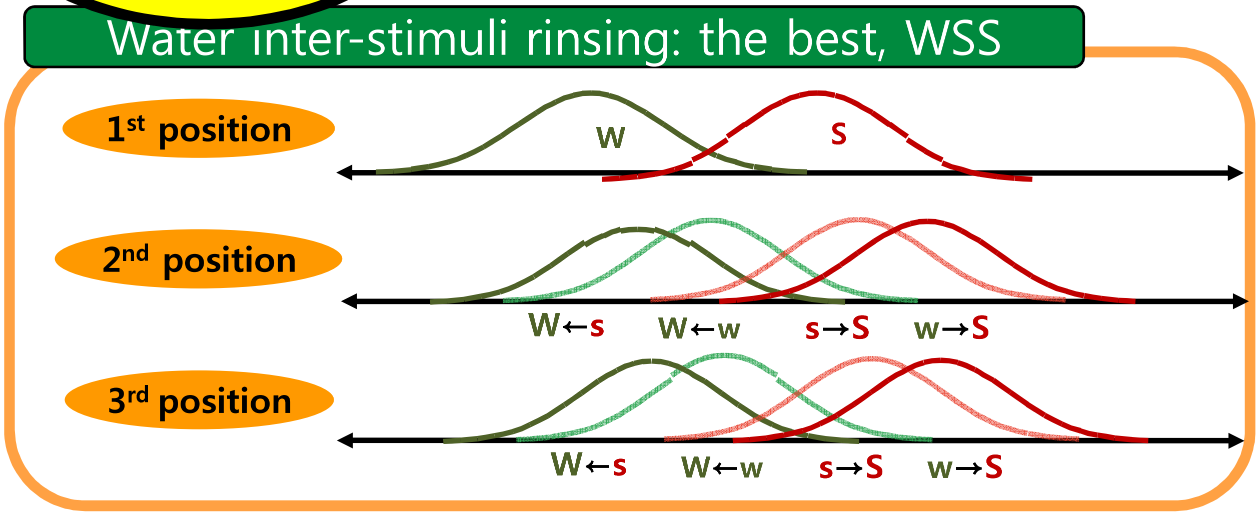


Sequential Perception Analysis (SPA)
(Lee, Chae & Lee, 2009)

- A new model incorporatin... mem... well...
- p... caused by... order of sample presentation ... 3-AFC using a skimming ...ategy

How this SPA model would apply to Duo-trio?





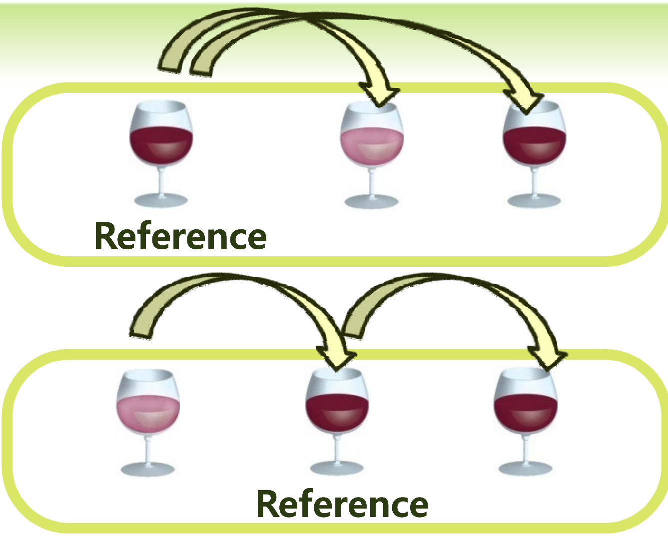
HOW DISCRIMINATION METHODS BECOME MORE DISCRIMINATING

Variable Duo-Trio Procedures

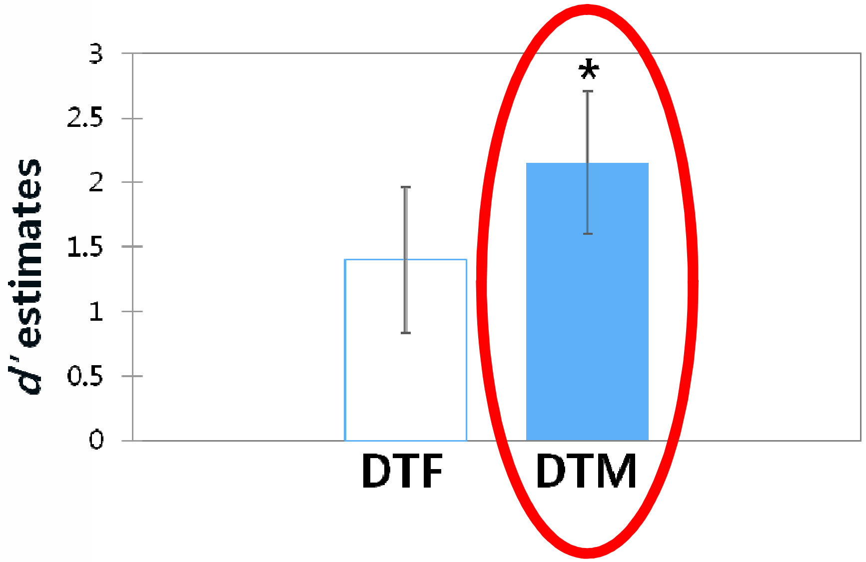
DUO-TRIO & DTM
(ROUSSEAU & O'MAHONY, 2002)

1. The traditional Duo-Trio

2. The Duo-Trio with the reference tasted in the Middle, between the two test samples (DTM)



- Orange-flavored beverage
- Fixed design
- Water inter-stimulus rinsing
- Tested sequences: SSW, WWS



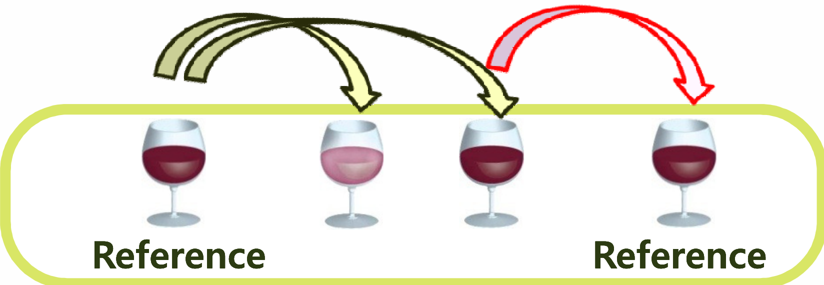
DUO-TRIO, DTM & DTFR
(LEE & KIM, 2008)

1. The traditional Duo-Trio with the reference tasted First (DTF)

2. The Duo-Trio with the reference tasted in the Middle, between the two test samples (DTM)

3. The Duo-Trio with the reference tasted twice, First and last as a Reminder (DTFR)

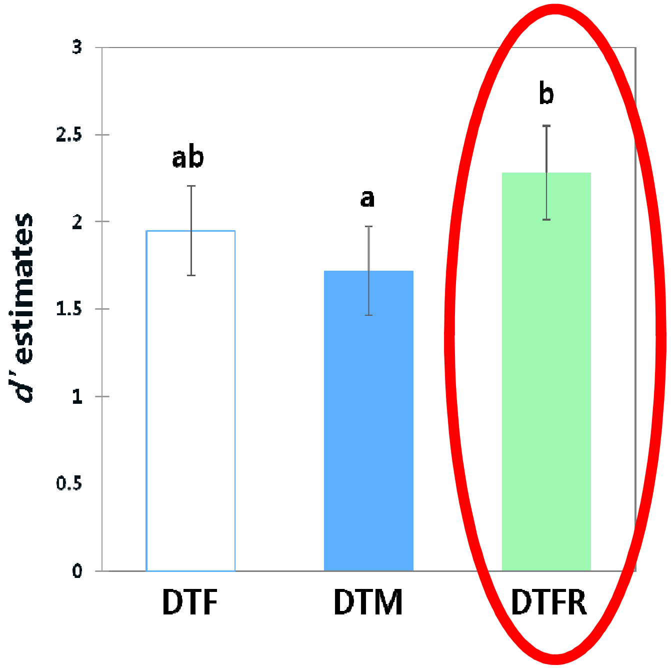
Reference is also directly compared to the comparison sample



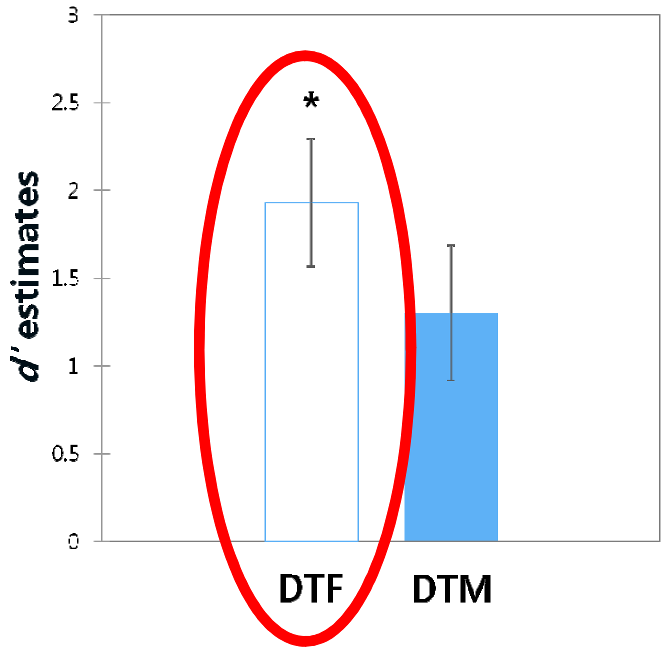
Duo-Trio, DTM & DTFR
(Lee & Kim, 2008)

- Using salt model systems, in a roving design to use comparison of distances (COD) decision strategy
- No rinsing between samples
- Tested all sequences

All sequences



Only WWS, SSW



STUDY III

COMPARISON OF *d´* ESTIMATES PRODUCED BY THREE VERSIONS OF A DUO-TRIO TEST FOR DISCRIMINATING TOMATO JUICES WITH VARYING SALT CONCENTRATIONS: THE EFFECTS OF THE NUMBER AND POSITION OF THE REFERENCE STIMULUS

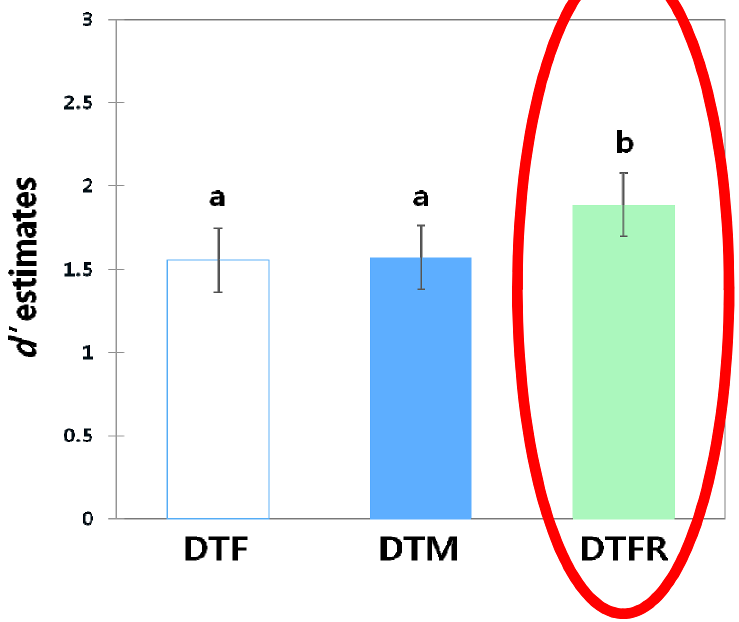
- Objectives:
  - To investigate the relative performance of the **DTF**, **DTM** and **DTFR**, focusing on the comparison of distances (COD) strategy
  - To examine the sensitivity predictions from the new SPA model for the same sequences of DTF and DTM

Kim, Lee & Lee (2010) Food Quality & Preference 21, 504–511

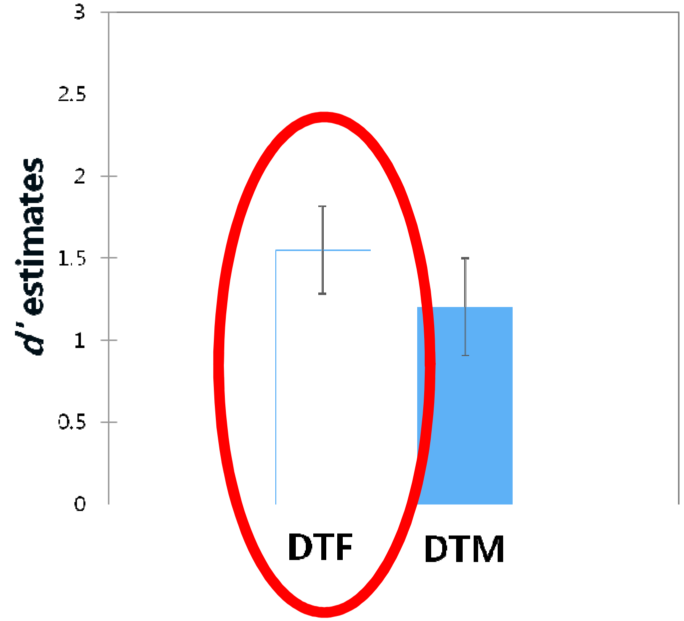
DUO-TRIO, DTM & DTFR
(KIM, LEE & LEE, 2010)

- Tomato juice
- Roving design to use comparison of distances (COD) decision strategy
- Tested all sequences

All sequences



Only WWS, SSW



SPA PREDICTION FOR WWS, SSW

Applying comparison of distances (COD) decision strategy

No inter-stimuli rinsing

SPA 8-distribution prediction

Sequence	Protocol	Triadic sequences for each protocol	Position of stimuli	Perception of stimuli accounting for contrast appearing in duo-trio test: W (Weaker ↔ Stronger)				S (Weaker ↔ Stronger)				Sensitivity rank based on COD strategy
			1st			W				S		
			2nd		W←S		W←W		S←S		W→S	
			3rd	W←S		W←W		S←S		S←W		
<WWS>	DTF	W_R				W_R						1st
		W					W					
		S								S		
	DTM	W				W						2nd
		W_R					W_R					
		S								S		
<SSW>	DTF	S_R								S_R		1st
		S						S				
		W		W								
	DTM	S								S		2nd
		S_R						S_R				
		W		W								

SPA PREDICTION FOR WWS, SSW

Applying comparison of distances (COD) decision strategy

Water inter-stimuli rinsing

Sequence	Protocol	Triadic sequences for each protocol	SPA 8-distribution prediction: Position of stimuli	Perception of stimuli accounting for contrast appearing in duo-trio test: W (Weaker ↔ Stronger)	S (Weaker ↔ Stronger)	Sensitivity rank based on COD strategy
			1st	W	S	
			2nd	W←S W←W	S←S W→S	
			3rd	W←S W←W	S←S S←W	
<WWS>	DTF	W_R		**W_R**		1st
		W		W		
		S			S	
	DTM	W		W		2nd
		W_R		**W_R**		
		S			S	
<SSW>	DTF	S_R			**S_R**	2nd
		S			**S**	
		W		W		
	DTM	S			S	1st
		S_R			**S_R**	
		W		W		

SPA PREDICTION FOR WWS, SSW

Applying comparison of distances (COD) decision strategy

Water inter-stimuli rinsing

- The difference between DTM and DTF was successfully explained by the SPA model. The differential results found between Kim et al.(2010) and Rousseau & O'Mahony (2002) could be due to **the differential inter-stimuli rinsing scheme.**

- But it is still possible that there might be a difference in the cognitive decision strategy used for the experiment.
  - Kim et al (2010): a roving design
  - Rousseau & O'Mahony (2002): a fixed design

Sensitivity rank based on COD strategy

1st

2nd

2nd

1st

DTM

W

W

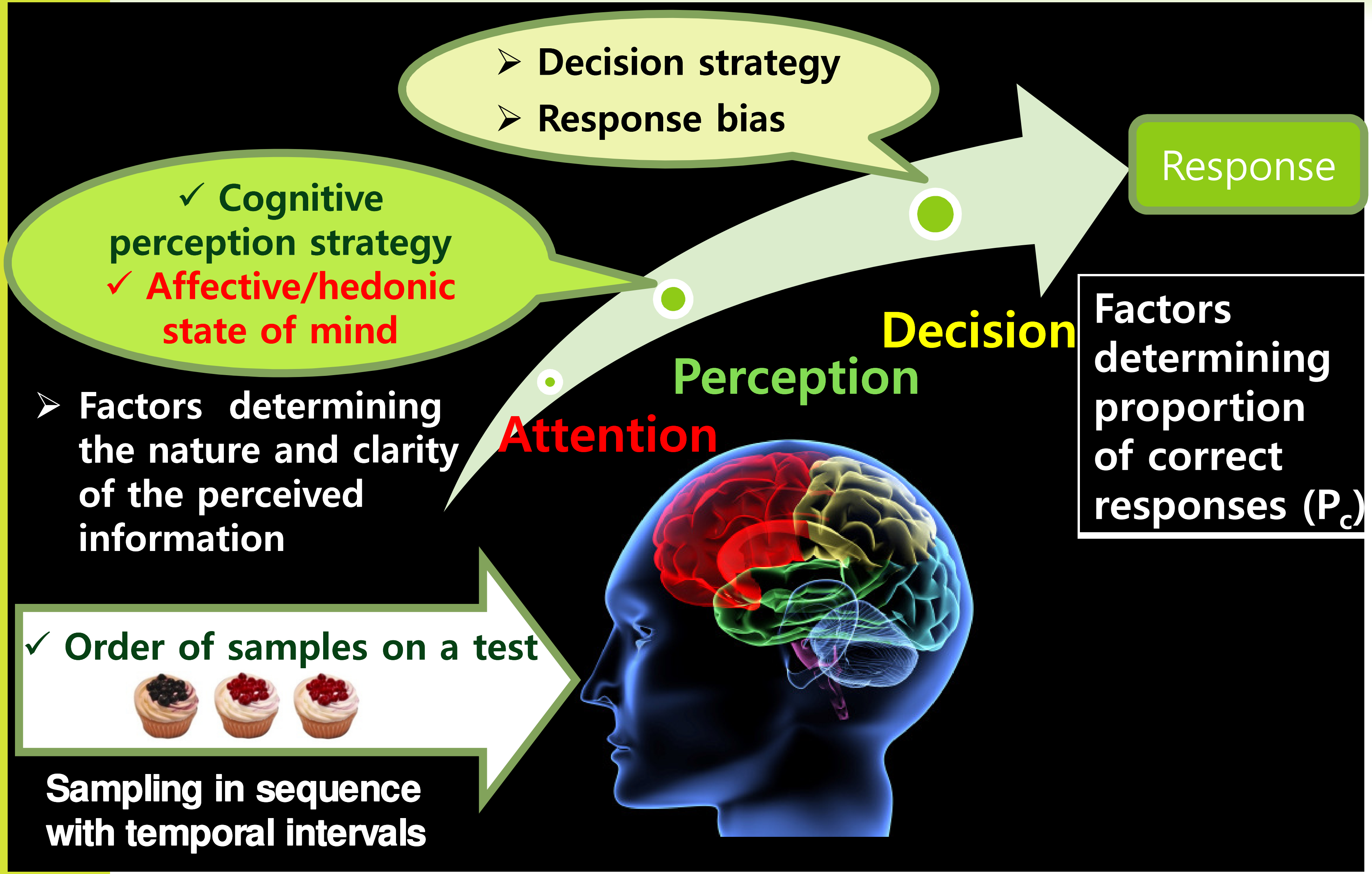
DTFR VS AB-X
(Kim, Lee & Lee, 2010)

- ✓ **Why would the Duo-Trio with the reference tasted twice, First and last as a Reminder (DTFR) perform better?**

  Is this test same as the "AB-X (matching to the sample)" ?

- ◎ It is possible that the first reference was tasted as a mere primer in the DTFR and the task was performed as the ABX design.
- ◎ It can also be hypothesized that when the DTFR is used as the ABX, subjects may be able to use a β-decision strategy.
- ◎ This is a topic for future research.

Factors Influencing Performances of Difference Tests



SUMMARY

- ✓ In order to predict accurate sensory difference or discriminability in flavor discrimination as an index comparable across different experiments, **no matter whether you use P(c) or Signal Detection measures such as d',**

  the test procedure and experimental context should be carefully standardized in a way that….

  1) **Appropriate attention can be driven to the food sample.**
  2) **A decision rule could be applied in a consistent manner.**
  3) **physiological and cognitive interference can be minimized.**

- ✓ The TM/SDT models are currently the most advanced model accommodating decision strategy used for the test method.
- ✓ Extended TM/SDT model should also be explored to take account for the physiological and cognitive complication in the temporal flavor discrimination.

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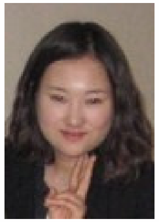
  - Yoon-Jung Choi



Collaborators

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Dr. Michael J. Hautus


Ewha Womans University
Food Design/Ergonomics Lab.
Thank you