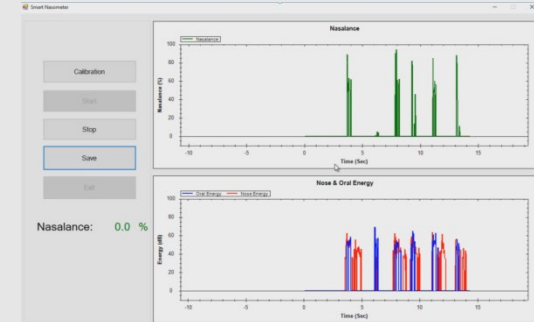


Development of an Ergonomic Nasometer with a Touchless Separator for Speech Assessment and Therapy



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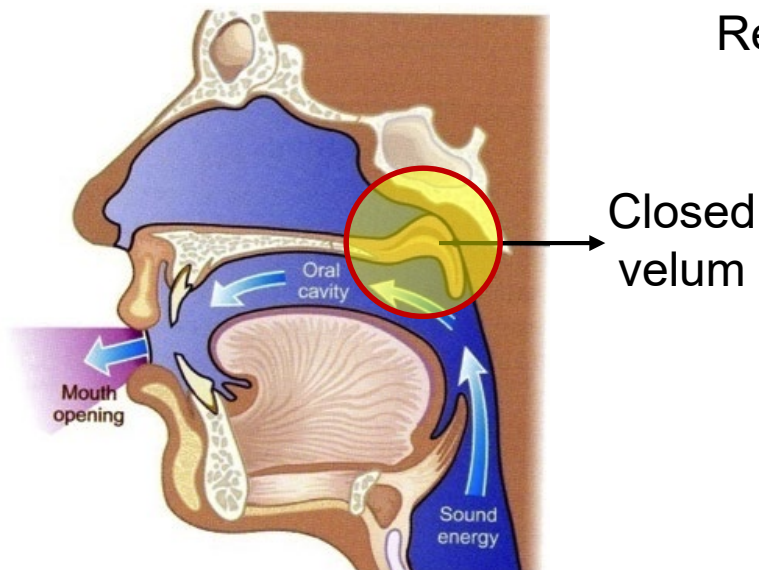
- ❑ Introduction
 - Background
 - Objectives of the Study
 - ❑ Ergonomic Nasometer Development
 - ❑ Results
 - ❑ Discussion
-

Voice Resonance

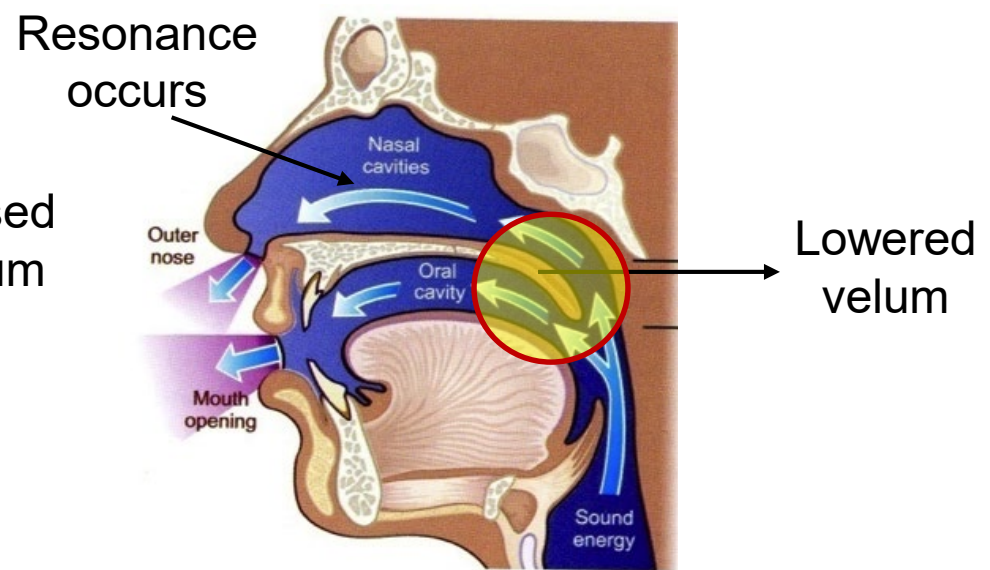
□ Production of sound while the **velum is lowered** → some **air resonates in nasal cavities** and escape through the nose. (Baken, 1987)

⇐ One of common problems in speech production is related to **degree of resonance**.

Oral sounding speech

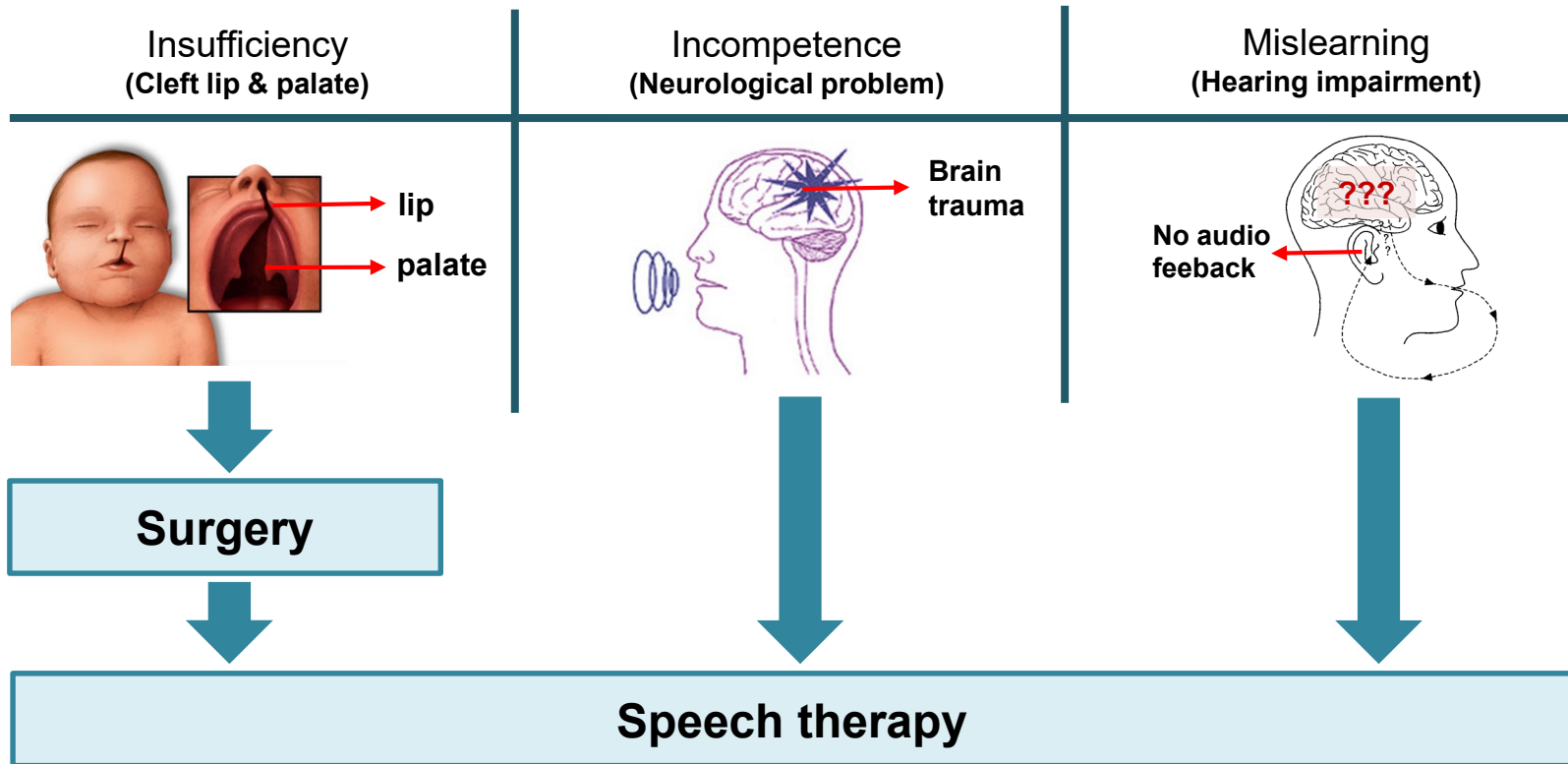


Nasal sounding speech



Resonance Disorder

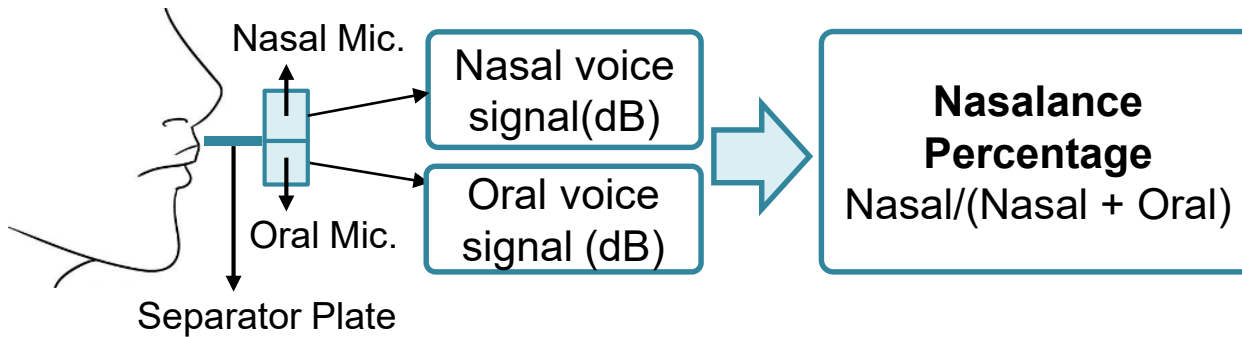
- ❑ People with **resonance disorder** can **NOT** produce a proper degree of resonance.
- ❑ **Speech therapy** is needed to help patient recovering from the disorder or post-surgery program.



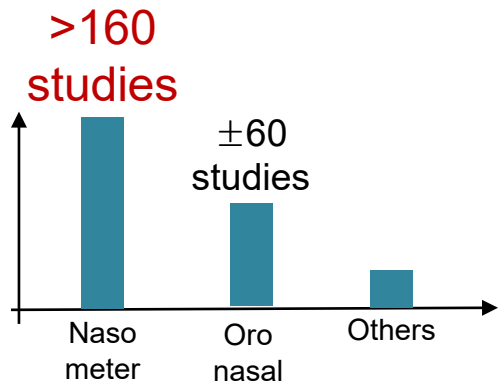
Nasalance Measurement (1/2)

- ❑ **Nasalance measurement** is important to **evaluate patient's speech**.
- ❑ Nasometer serves as a standard tool to assess resonance disorder (Awan et al., 2010)

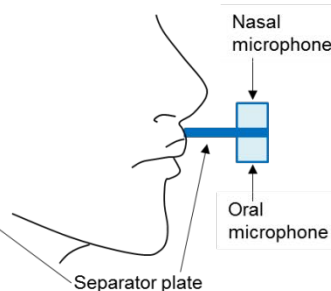
Nasalance measurement using Nasometer



Nasometer: Pioneer & golden standard of nasalance measurement device

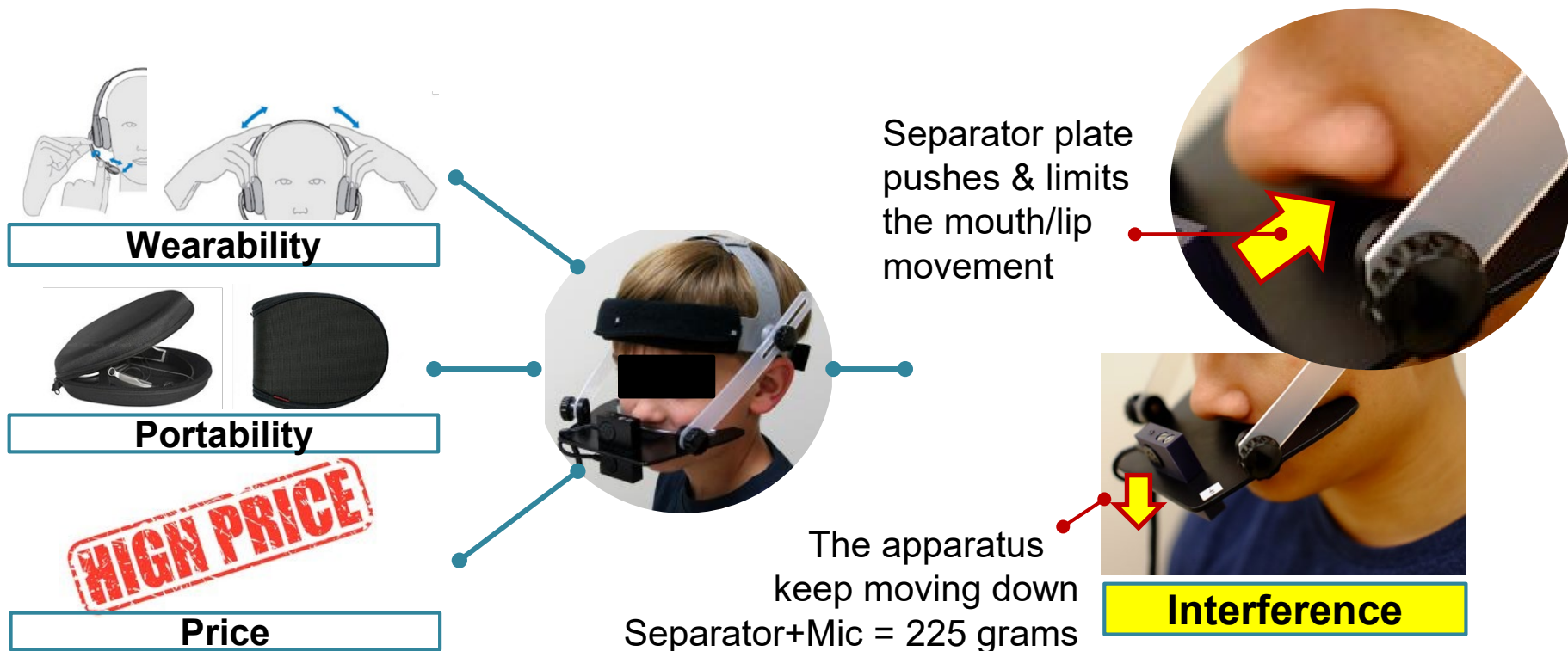


Various normative data available



Nasalance Measurement (2/2)

- ❑ Nasometer still has margin to improve mainly in terms of **Interference**.
 - **Separator** plate and **microphones** appears bulky and heavy.
 - Separator → **interfere natural movement of lip**.



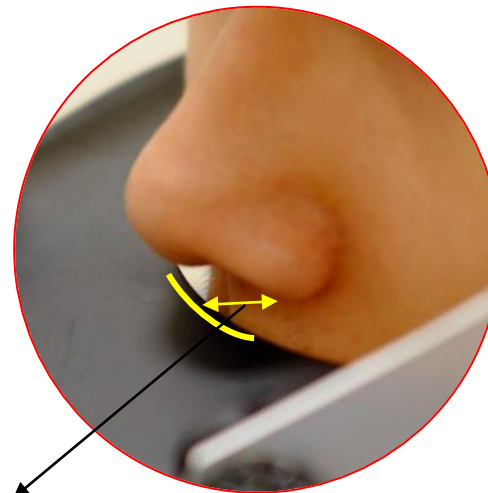
Objectives

1. **Develop an ergonomic nasometer with an untouched separator.**
 - **Propose a nasalance adjustment algorithm** to get an equivalent result with touched separator nasometer.
2. **Validate** the performance of **the proposed nasometer.**

Touched Separator



Untouched Separator



Separator gap



Method

S1. Development of an ergonomic nasometer design

S1.1. Measurement of nasalance
(using Kay Pentax Nasometer)

S1.2. Analysis of nasalance trend

S1.3. Development of nasalance
adjustment algorithm

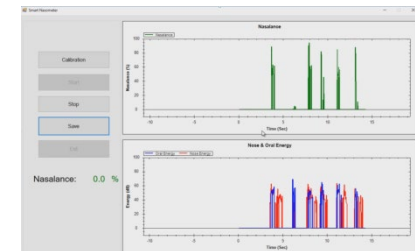
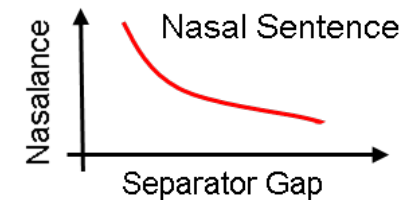
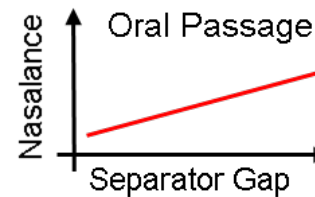
S1.4. Integration of nasalance
measurement hardware and
software (algorithm)

S2. Validation of the proposed ergonomic nasometer

Separator gap effect on nasalance

- Touched
- Untouched (5/10/15 mm)

Trend Analysis



Comparison of result between
proposed nasometer & Kay Pentax nasometer

Experimental Setup (1/2)

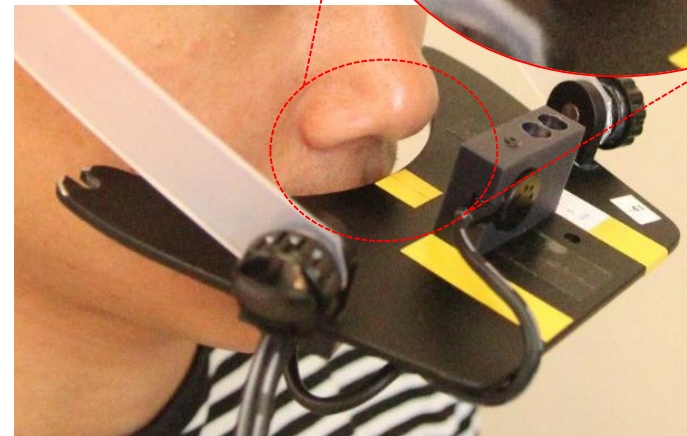
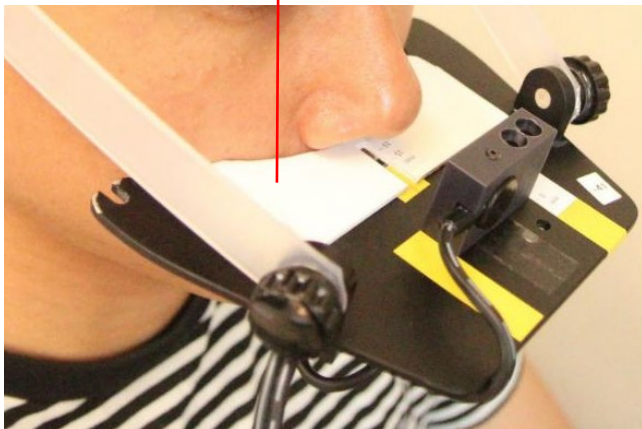
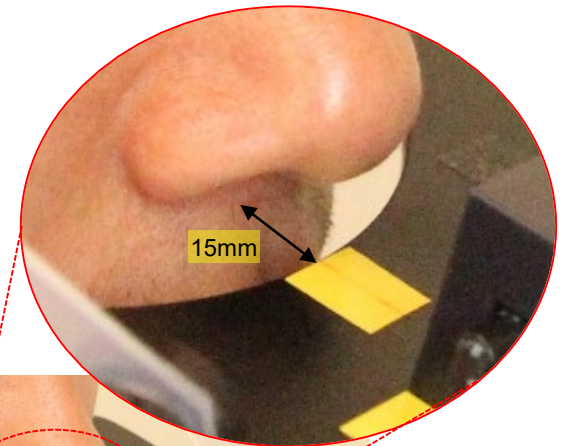
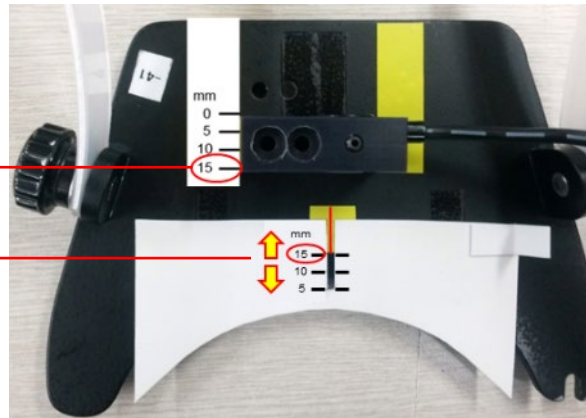
- ❑ Independent variable: **distance between separator and lip** (philtrum).
- ❑ Controlled variable: **distance between microphone and lip** should remain steady during testing.

Detach the plate to get untouched separator condition(15mm)

Set microphone 15mm closer to lip

Set the separator marker to 15mm

Attach the plate to mark separator distance (15mm)



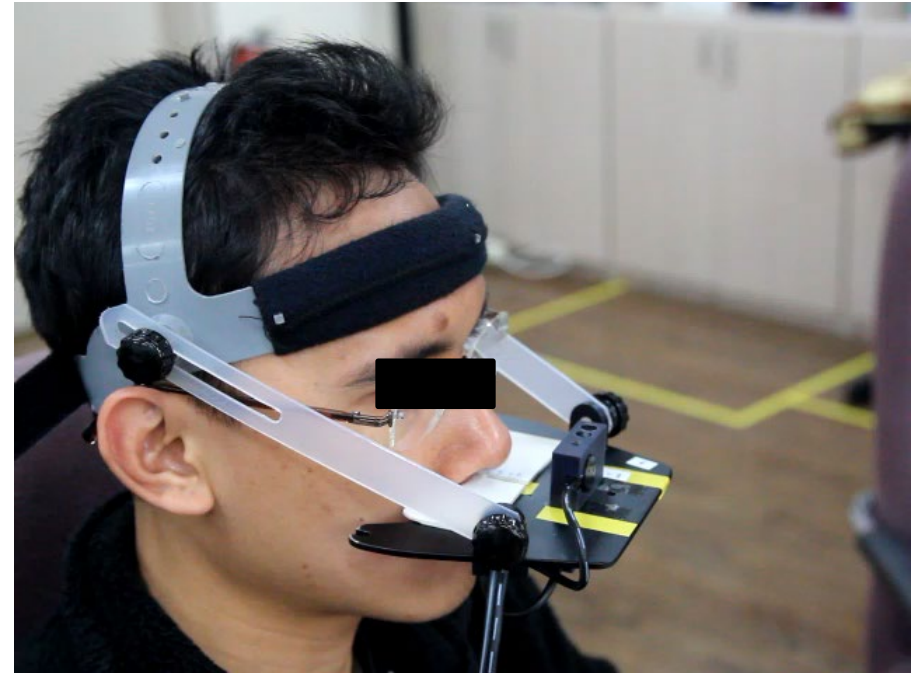
Experimental Setup (2/2)

- ❑ Independent variable: **distance between separator and lip** (philtrum).
- ❑ Controlled variable: **distance between microphone and lip** should remain steady during testing.

Mic & Separator Setting

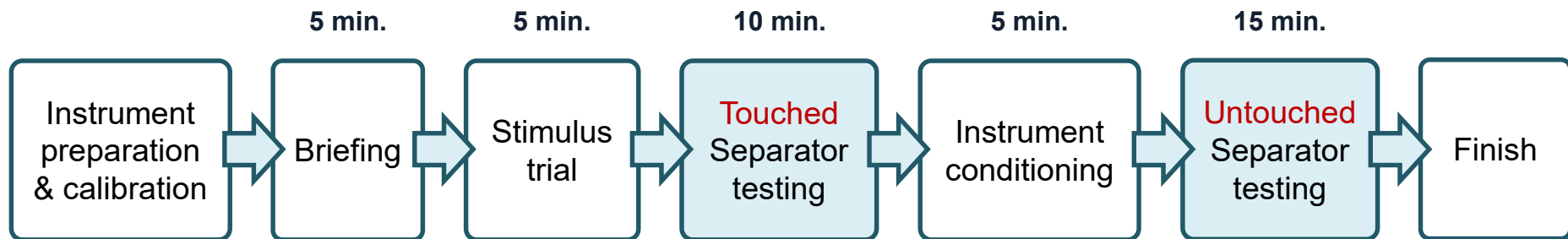


Untouched Separator



Experiment Procedure

- ❑ **Condition:** Touched separator & Untouched separator (5/10/15 mm).
- ❑ **Participants:** 10 males & 10 females.
- ❑ **Stimulus:** Nasal & Oral (3 repetition each).
- ❑ **Time/session = 40 min.**



Nasal Stimulus

Nasal Sentences (35% nasal consonant)

“Mama made some lemon jam.
Ten men came in when Jane rang.
Dan's gang changed my mind.
...”

Syllable

/ma..ma..ma/

Oral Stimulus

Zoo Passage (0% nasal consonant)

“Look at this book with us. It's a
story about a zoo. That is where
bears go. Today it's very cold out of
doors, but we see a cloud overhead
that's a pretty white fluffy shape.
...”

Syllable

/pa..pa..pa/

Analysis Summary: Passage Stimulus (1/2)

❑ Nasalance value and the variability on both passages are agree with normative data.

➤ Nasal sentence: Gap \uparrow \rightarrow Nasalance \downarrow

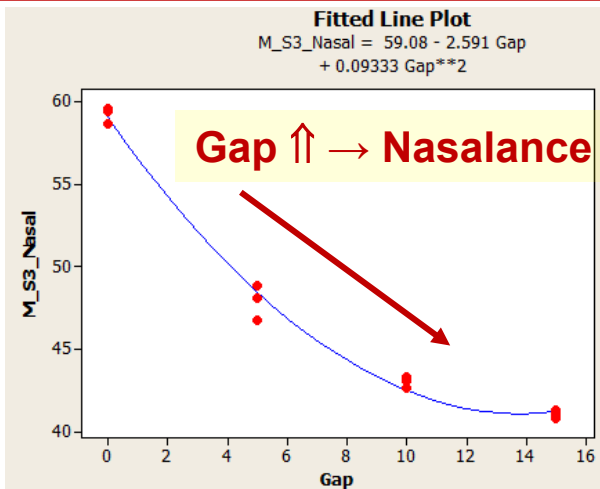
➤ Oral passage: Gap \uparrow \rightarrow Nasalance \uparrow

Within Subjects (Male)								
Statistics	Nasal Sentence				Oral Passage			
	0	5	10	15	0	5	10	15
Average	59.25	47.93	43.02	41.03	13.46	17.09	20.72	22.99
Variability	0.47	1.06	0.35	0.27	0.18	0.34	0.40	0.26
Min	58.72	46.78	42.64	40.77	13.34	16.71	20.28	22.77
Max	59.58	48.87	43.33	41.30	13.66	17.37	21.06	23.28

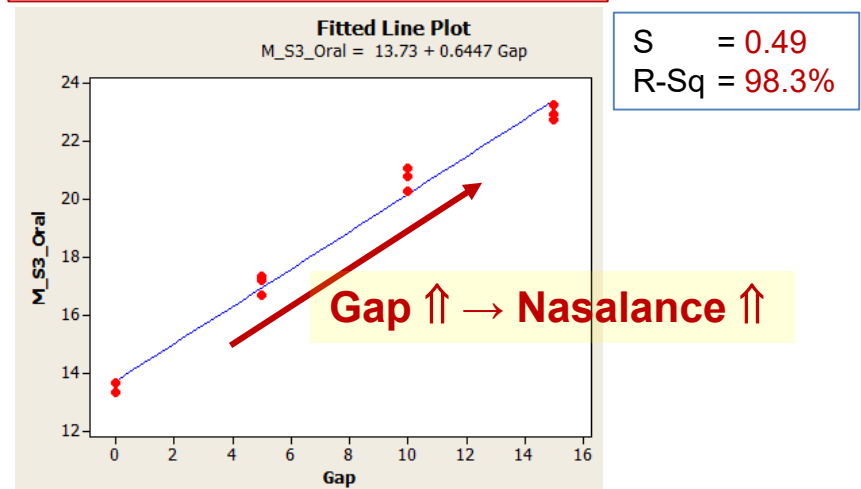
Statistics	Normative Data	
	Nasal Sentence	Oral Passage
Average	59.55	7.96
Variability	11.25	5.63

Agree with normative data

$$\text{Nasalance} = 59.08 + 2.59 \text{ Gap} - 0.09 \text{ Gap}^2$$



$$\text{Nasalance} = 13.73 + 0.64 \text{ Gap}$$



Analysis Summary: Passage Stimulus (2/2)

□ All regression model of **individual data** results in **high $Adj-R^2$ (> 90%)**.

➤ **Decrease** of nasalance on **nasal sentence**.

➤ **Increase** of nasalance on **oral passage**.

Gender	Subject	Stimulus	$Adj-R^2$	S	Regression Equation
Male	1	Nasal	95.2%	1.07	Nasalance = 55.46 – 1.64 Gap + 0.06 Gap ²
		Oral	98.1%	0.64	Nasalance = 6.65 + 0.78 Gap
	2	Nasal	98.5%	0.68	Nasalance = 57.18 – 1.44 Gap + 0.03 Gap ²
		Oral	91.8%	0.96	Nasalance = 11.26 + 0.55 Gap
	...				
	10	Nasal	97.6%	0.97	Nasalance = 54.72 – 1.81 Gap + 0.05 Gap ²
Oral		99.0%	0.56	Nasalance = 12.27 + 0.97 Gap	
Female	1	Nasal	97.6%	0.80	Nasalance = 56.96 – 1.43 Gap + 0.04 Gap ²
		Oral	96.4%	0.92	Nasalance = 7.49 + 0.81 Gap
	2	Nasal	94.3%	1.61	Nasalance = 61.73 – 2.53 Gap + 0.09 Gap ²
		Oral	96.5%	0.86	Nasalance = 9.34 + 0.78 Gap
	...				
	10	Nasal	98.5%	0.77	Nasalance = 57.64 – 1.88 Gap + 0.06 Gap ²
Oral		97.0%	1.18	Nasalance = 13.91 + 1.16 Gap	
Average			94.8%	0.86	

Nasalance Multiplier

- ❑ **Multiplier = Touched/Untouched** → 0mm nasalance/5mm nasalance.
- ❑ **High nasalance:** gap ↑ → nasalance ↓ → need **multiplier larger than 1**
- ❑ **Low nasalance:** gap ↑ → nasalance ↑ → need **multiplier lower than 1**

Gender	Subject	Nasalance (%)					
		Nasal			Oral		
		0mm	5mm	Multiplier	0mm	5mm	Multiplier
Male	1	55.54	48.49	1.15	6.94	10.17	0.68
	2	55.65	48.11	1.16	11.49	14.00	0.82
	3	59.25	47.93	1.24	13.46	17.09	0.79
	4	49.82	44.18	1.13	8.14	11.09	0.73
	5	49.32	43.16	1.14	8.03	15.10	0.53
	6	44.22	37.36	1.18	4.95	8.79	0.56
	7	44.89	40.43	1.11	6.44	13.60	0.47
	8	60.57	52.25	1.16	21.33	25.00	0.85
	9	55.01	46.13	1.19	12.33	16.79	0.73
Female	10	57.16	50.88	1.12	7.10	11.66	0.61
	11	62.33	49.79	1.25	9.79	13.04	0.75
	12	54.89	48.03	1.14	8.46	12.49	0.68
	13	55.88	47.73	1.17	8.16	12.09	0.67
	14	53.96	43.56	1.24	12.27	18.02	0.68
	15	60.97	49.24	1.24	19.90	23.44	0.85
	16	60.17	53.66	1.12	14.70	19.65	0.75
	17	57.62	50.75	1.14	12.37	17.38	0.71
	18	57.87	48.99	1.18	13.11	20.46	0.64

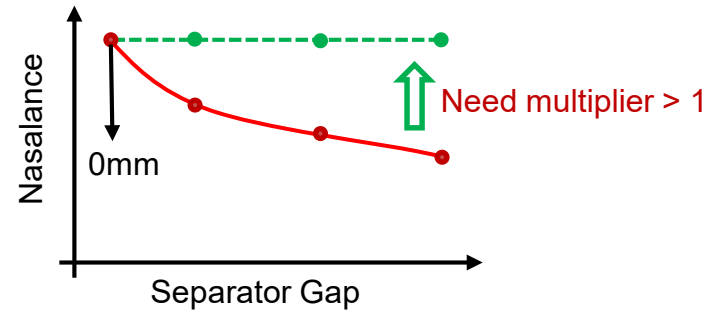
Multiplier 1.17

Multiplier 0.70

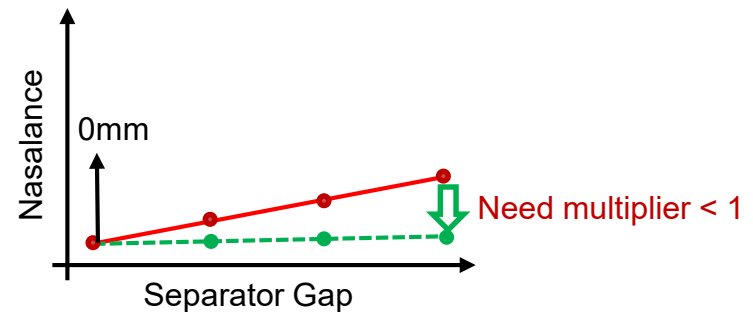
Multiplier for **high** nasalance ←

→ Multiplier for **low** nasalance

High Nasalance Trend



Low Nasalance Trend

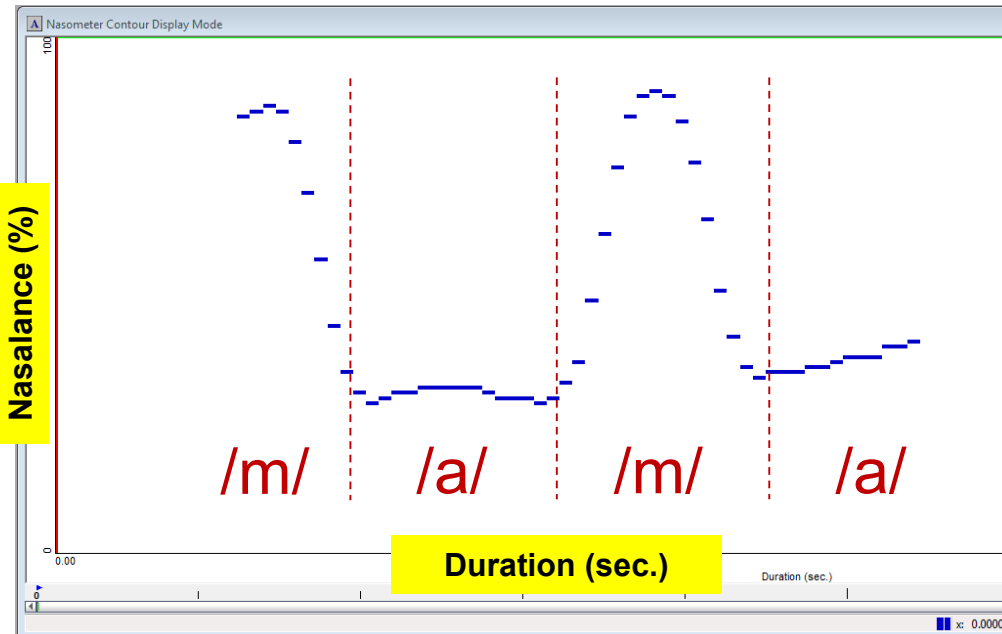


Validation Analysis: Nasal (1/2)

❑ Experiment (4 subjects): nasalance of syllable **/ma/** for nasal voice agree with normative data.

- /m/ nasalance: 70~95%
 - /a/ nasalance: 20~40%
- } Mean Nasalance = 54.25%

Result from Kay Pentax Naso



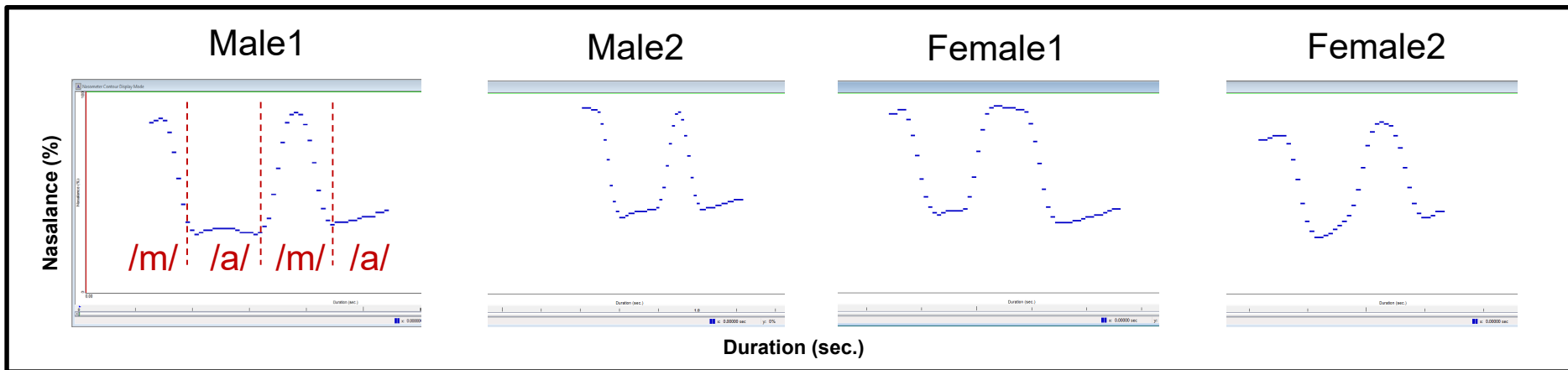
Nasalance Data

	Mean	SD
Normative Data	53	13
Kay Pentax Naso	54.25	5.64
Smart Naso	51.31	8.51

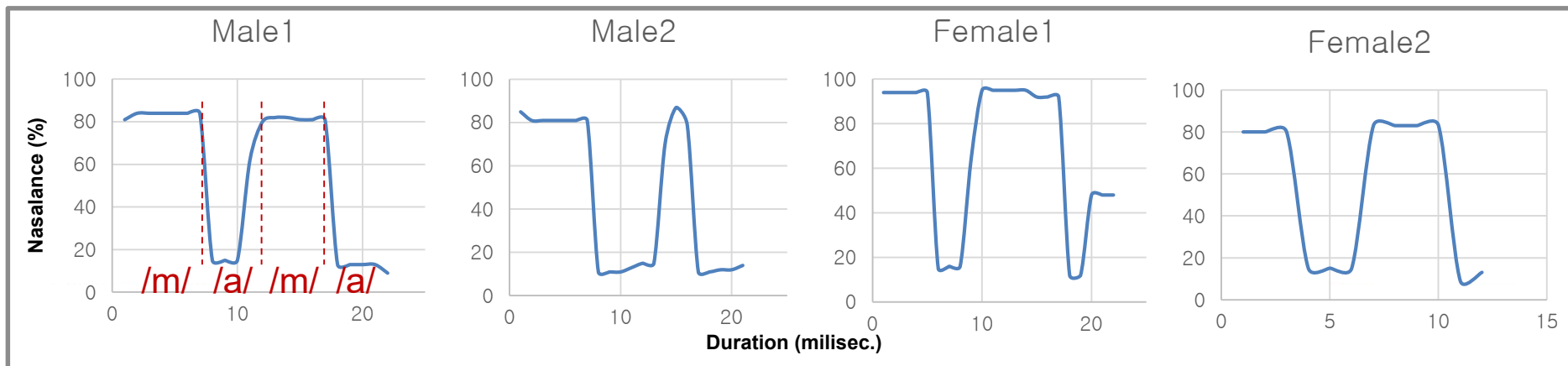
Validation Analysis: Nasal (2/2)

- ❑ **Pattern** in Kay Pentax Naso and Proposed Naso **is similar** on four subjects → **high nasalance on /m/** and **low nasalance on /a/**.

Result of Kay Pentax Naso



Result of Proposed Naso

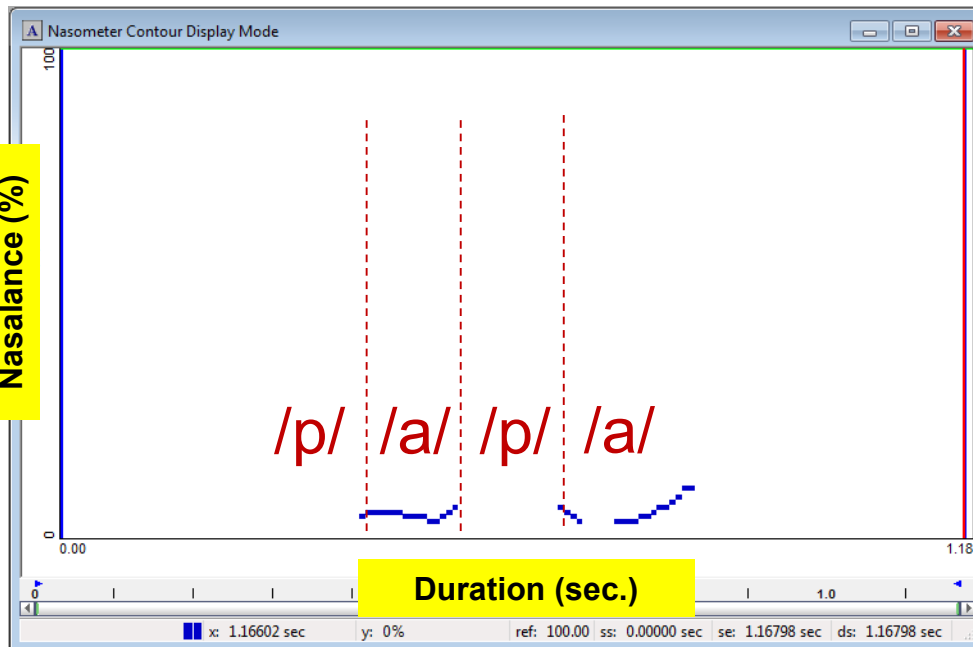


Validation Analysis: Oral (1/2)

- ❑ Experiment (4 subjects using Kay Pentax Naso): nasalance of syllable **/pa/** for oral voice agree with normative data.

- /p/ nasalance: 0%
 - /a/ nasalance: 0~10%
- Mean Nasalance = 8%

Result from Kay Pentax Naso



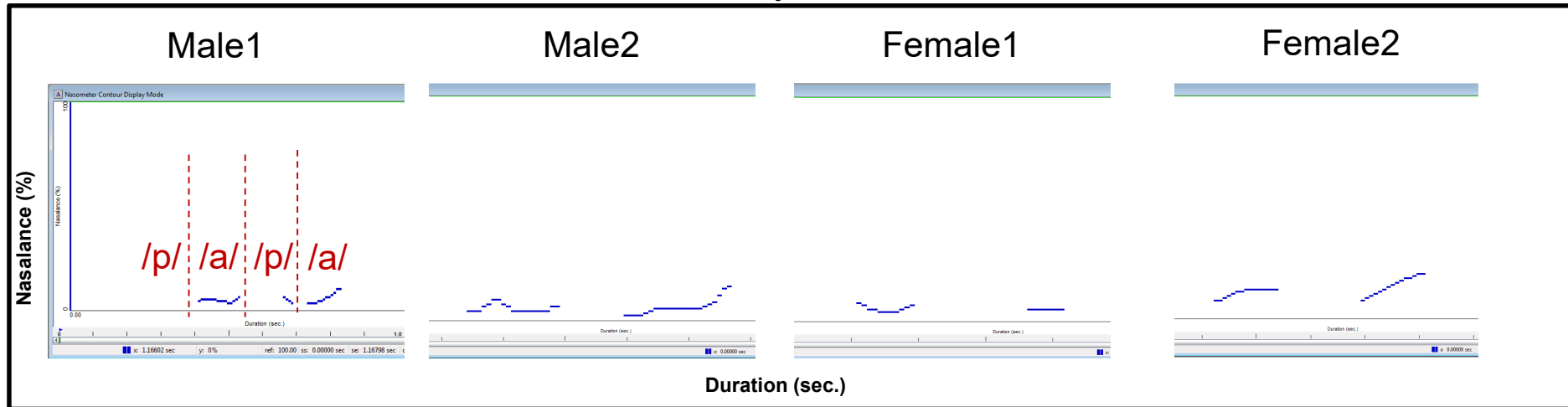
Nasalance Data

	Mean	SD
Normative Data	6	3
Kay Pentax Naso	8	4
Smart Naso	7.25	1.77

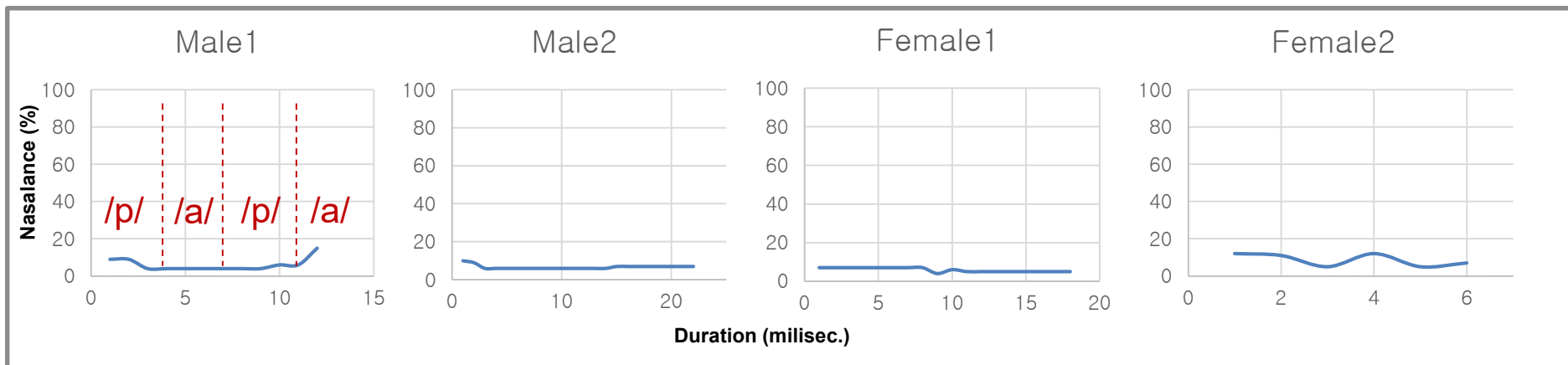
Validation Analysis: Oral (2/2)

- ❑ **Pattern** in Kay Pentax Naso and Proposed Naso **is similar** on four subjects → **low nasalance on /p/** and **low nasalance on /a/**.

Result of Kay Pentax Naso

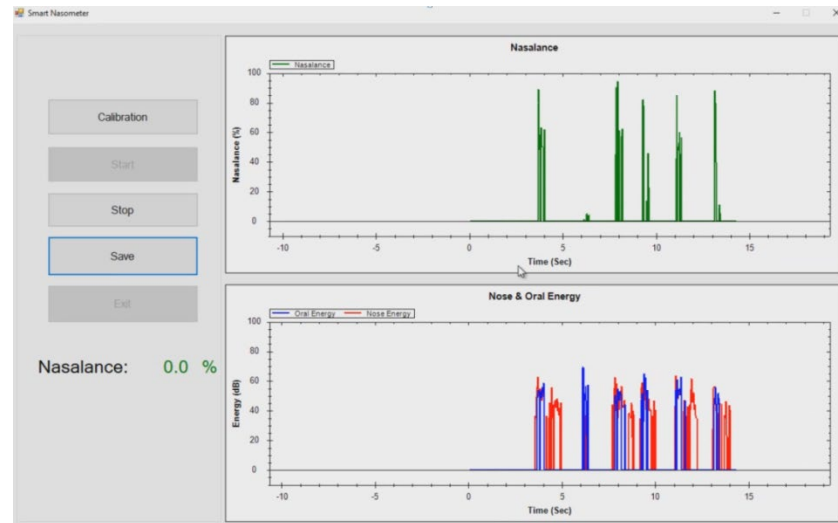


Result of Smart Naso



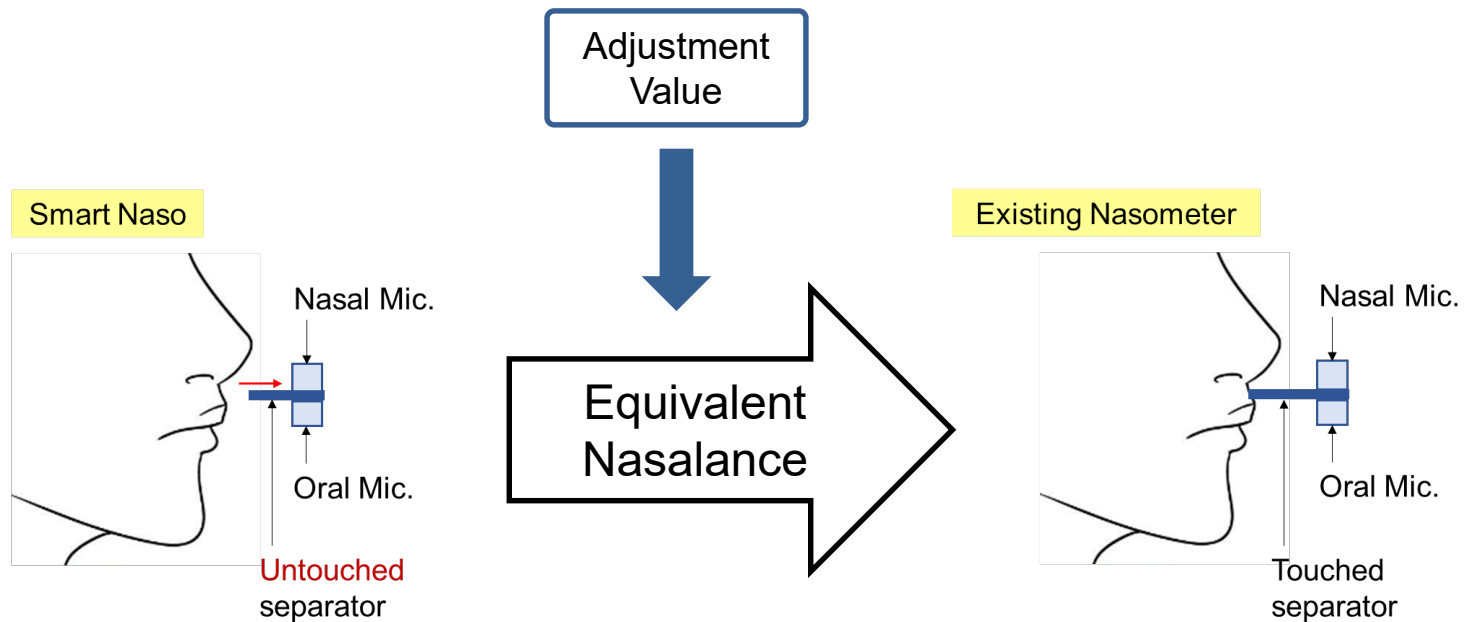
Discussion: Contribution (1/3)

- ❑ Proposed a **new system of nasometer**.
 - Introduce the use of **untouched and lightweight material voice separator**.
 - Untouched separator → **reduce the interference to user's mouth** during assessment.
 - Provide a **measurement application for recording and analyzing** user's resonance.



Discussion: Contribution (2/3)

- ❑ Provide a **method to adjust the nasalance** in untouched separator.
 - Examine the **effect of separator-lip distance** on nasalance measurement.
 - Identify the **cause of nasalance trend** in 5/10/15mm separator gap.
 - Determine a **customized multiplier** to adjust nasalance of **specific user**.



Discussion: Contribution (3/3)

- ❑ **Validation** test for the new nasalance measurement system.
 - Compared **nasalance value** from assessment using existing and proposed nasometer.
 - Compared **pattern** of the nasalance on syllable stimulus .
 - **Nasalance value** of proposed system **agree with** Kay Pentax **Normative data**.
 - **Nasalance pattern** of new system **showed similarity with the Kay Pentax nasometer**.
 - ✓ **High nasalance on nasal character** (e.g. /m/).
 - ✓ **Low nasalance on non-nasal character** (e.g. /p/, /a/).



Discussion: Limitations & Further Study

❑ Limitations

- Used only **small sample size for validation experiment** (need more subjects).
- Used only **participant without resonance disorders**.

❑ Further Study

- Identify the **effect of individual factors** (intonation, speech tempo, nasal vowel voice etc.) on nasalance.
- Use **Korean passages** in evaluation for **Korean users**.
- Conduct **experiment** with larger sample **to obtain normative data** of the proposed system.
- Conduct clinical testing to identify the efficacy of the proposed system.

Q&A

*Thank
you*

