



IMPACT OF THE NONVERBAL BEHAVIOR OF VIRTUAL AUDIENCE ON USERS' PERCEPTION OF SOCIAL ATTITUDES

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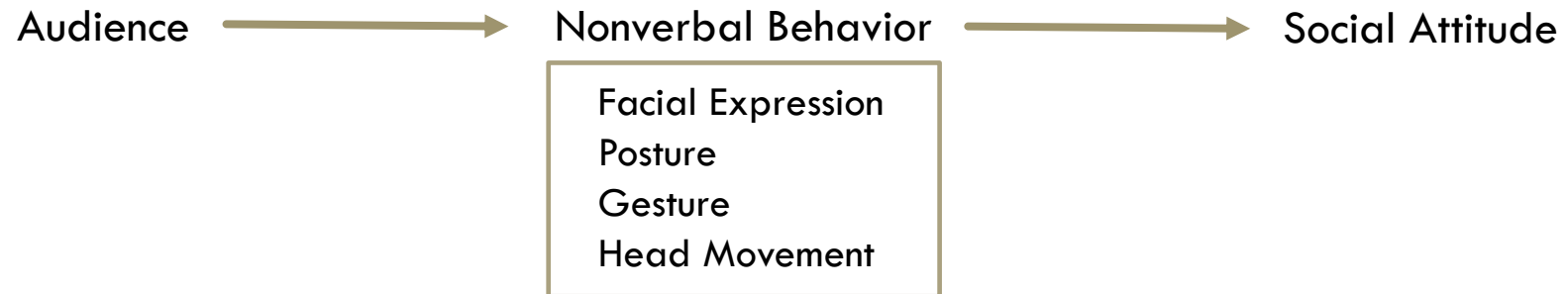
INTRODUCTION

- Virtual Reality (VR) as a training tool for public speaking



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- Importance of the nonverbal behavior of the Virtual Audience (VA)



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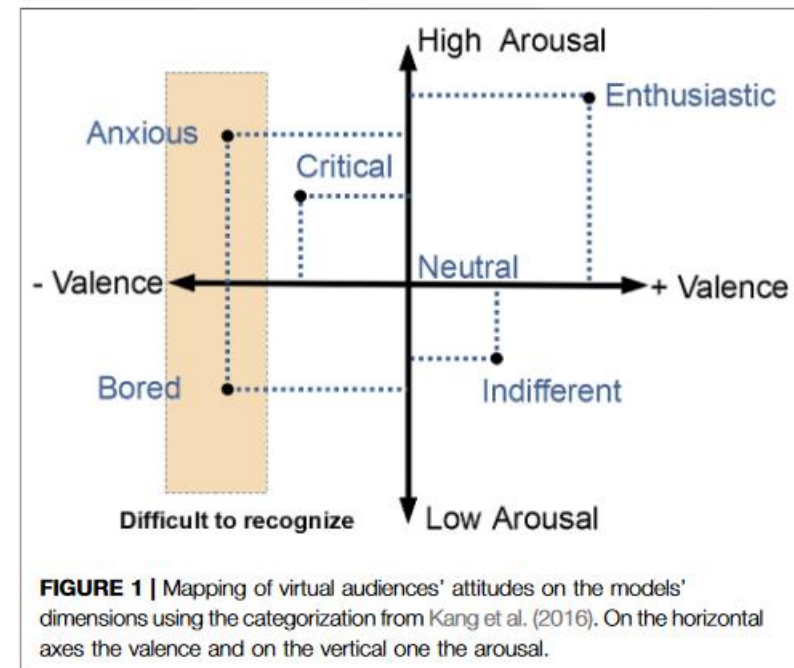
STATE OF THE ART – VIRTUAL AUDIENCE BEHAVIORAL MODEL

- Several continuous models to map an individual's emotional state along dimensions [Mehrabian, 1996]



Valence = the audience's **opinion** (positive or negative feelings they have about the speaker or the presentation [Chollet et al., 2017]).

Arousal = the audience's **engagement** in the presentation [Chollet et al., 2017].





STATE OF THE ART – VIRTUAL AUDIENCE BEHAVIORAL MODEL

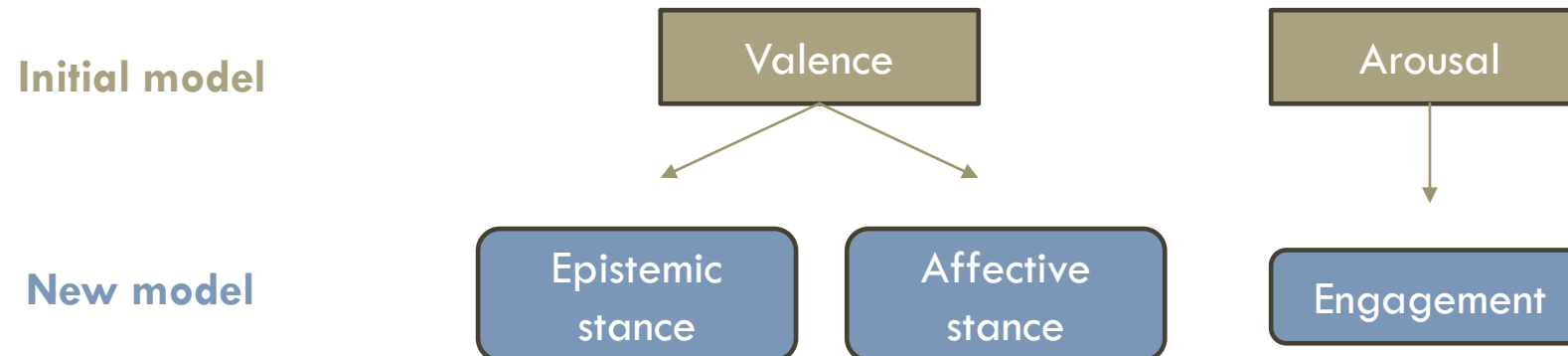
Problem ?

- **Valence** = This dimension only focuses on the **affective reaction** to the speaker or the presentation.
- What about the **audience's agreement** concerning what speaker is saying ?

STATE OF THE ART – VIRTUAL AUDIENCE BEHAVIORAL MODEL

Problem ?

- **Valence** = This dimension only focuses on the **affective reaction** to the speaker or the presentation.
- What about the **audience's agreement** concerning what speaker is saying ?



Epistemic Stance = **Agreement** → The judgement or evaluation of the speaker's statement.

Affective Stance = **Emotional state** → The emotional reaction expressed by the interlocutor [Chindamo et al., 2012].

STATE OF THE ART – PERCEPTION OF AUDIENCE’S NONVERBAL BEHAVIOR

Audience → Nonverbal Behavior → Social Attitude

Head Movement
Facial Expressions
Posture

Head Movement

Most important signal to convey the audience valence [Chollet and Scherer, 2017]

Head nod = Positive valence (opinion) [Glémarec et al., 2021]

Head shake = Negative valence (opinion) [Glémarec et al., 2021]

Head tilt = Negative stance showing the speaker’s uncertainty [Freigang et al., 2017] + Negative valence [Etienne et al., 2023]

STATE OF THE ART – PERCEPTION OF AUDIENCE’S NONVERBAL BEHAVIOR

Audience → Nonverbal Behavior → Social Attitude

Head Movement
Facial Expressions
Posture

Facial Expressions

Strong signal to convey the audience valence [*Chollet and Scherer, 2017*]

Smile = Positive valence (opinion) [*Glémarec et al., 2021*]

Frown = Negative valence (opinion) [*Glémarec et al., 2021*]

Raised eyebrows = Reflect doubt and uncertainty [*Ricci Bitti et al., 2014*]

STATE OF THE ART – PERCEPTION OF AUDIENCE’S NONVERBAL BEHAVIOR

Audience → Nonverbal Behavior → Social Attitude

Posture
(Arms position)

Head Movement
Facial Expressions
Posture

Signal that contribute significantly to the valence assessment [Chollet and Scherer, 2017]

Arms crossing = Disagreement, dominance and disinterest from the audience [Doody and Peter Bull, 2011; Fabrizio Palmas et al., 2019; Straßmann et al., 2016]

Arm crossing = closed posture = sign of disengagement [Chollet and Scherer, 2017]

STATE OF THE ART – PERCEPTION OF AUDIENCE’S NONVERBAL BEHAVIOR

Audience → Nonverbal Behavior → Social Attitude

Posture
(Torso position)

Head Movement
Facial Expressions
Posture

Signal that contribute significantly to the arousal assessment [Chollet and Scherer, 2017]

Leaning backwards = sign of disengagement [Chollet and Scherer, 2017]

Leaning forward = sign of engagement [Glémarec et al., 2021]

RESEARCH QUESTIONS



Q1

Can the **valence** dimension be **subdivided** into epistemic and affective stance?

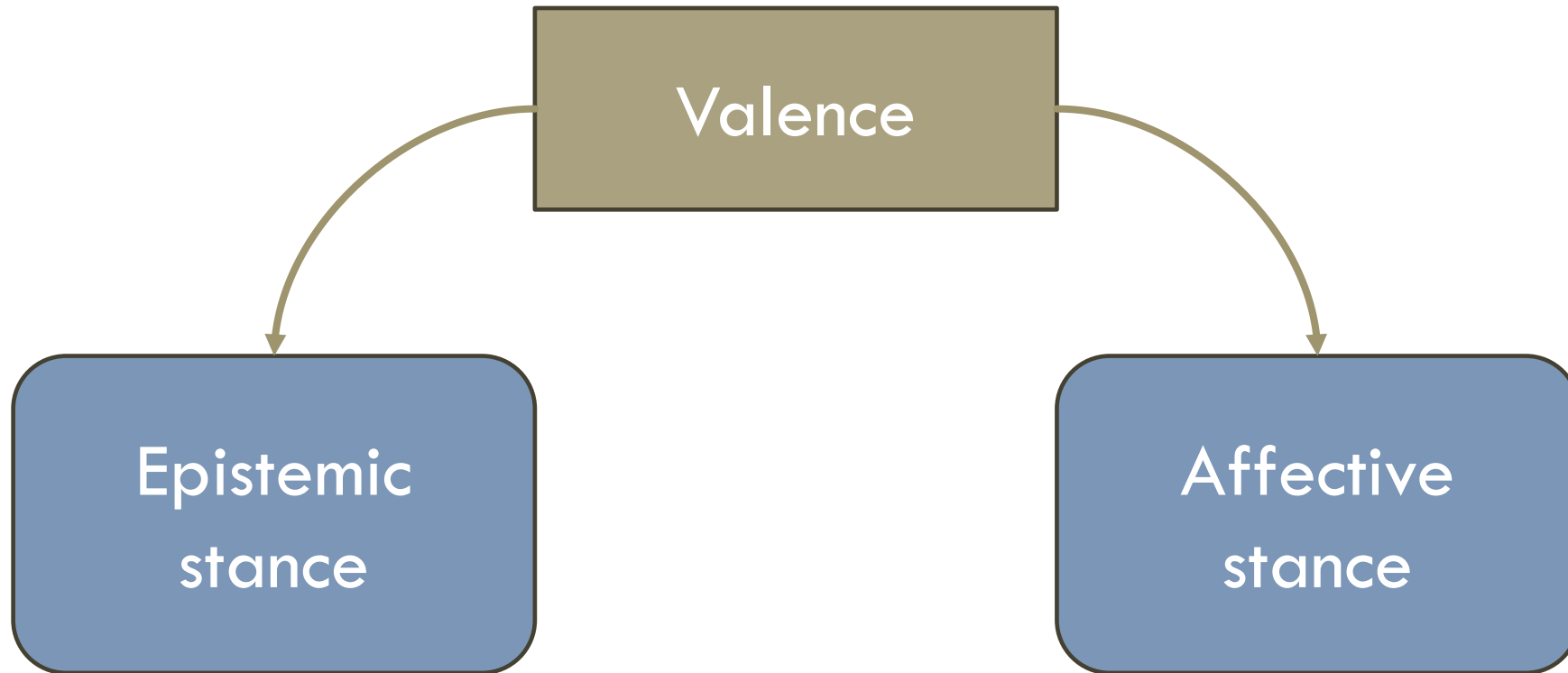
RESEARCH QUESTIONS



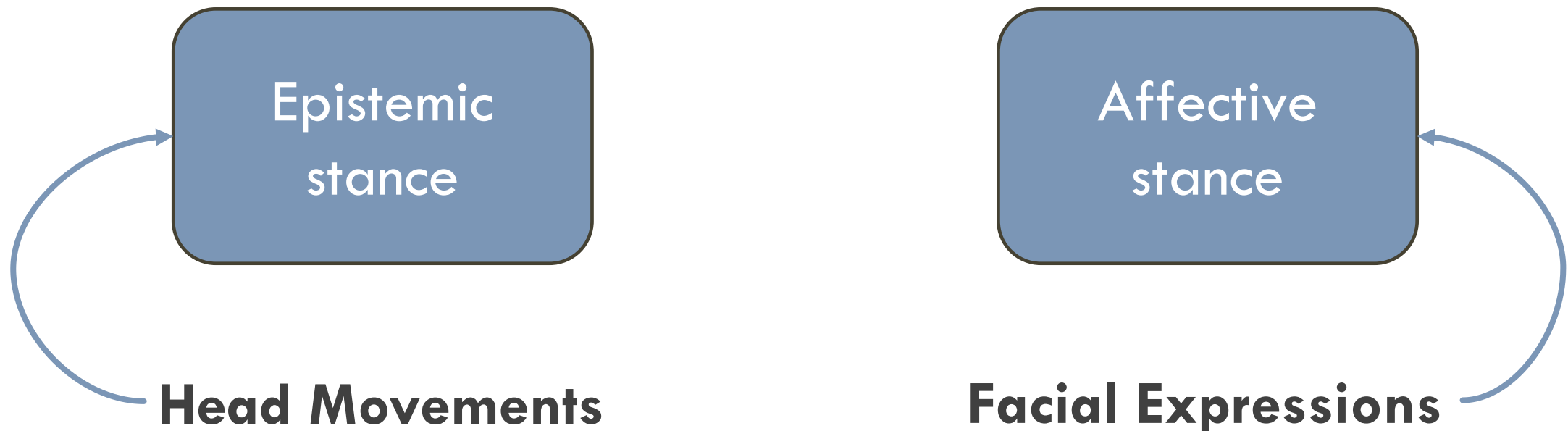
Q1 Can the **valence** dimension be **subdivided** into epistemic and affective stance?

Q2 Which **nonverbal behavioral signal** is most involved in the perception of these new dimensions?

HYPOTHESES – H1



HYPOTHESES – H2



Most influential signal for the perception of the
virtual character's ...

EXPERIMENTAL PROTOCOL: VIRTUAL ENVIRONMENT AND VIRTUAL CHARACTER'S NONVERBAL BEHAVIOR

Head Movement	Facial Expressions	Arms Position	Torso Position	Gaze Direction
Nod (Nod)	Smile (Smi)	Fist under the chin (Chi)	Forward (For)	Look at the speaker (look)
Shake (Sha)	Frown (Fro)	Arms crossed (Cro)	Backward (Bac)	Look away from the speaker (away)
Tilt (Til)	Doubt (Dou)	Hands on Thigh (Thi)	Straight (Str)	
No Movement (NoM)	No Expression (NoE)			

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No Movement (NoM)	No Expression (NoE)			

1 Animation = a combination of several modalities, one for each signal



EXPERIMENTAL PROTOCOL: MEASURES

Engagement

Attentive
Distracted
Indifferent
Interested

Epistemic Stance

Agree
Disagree
Doubtful

Affective Stance

Happy
Unhappy
Emotions
Realistic
Credible

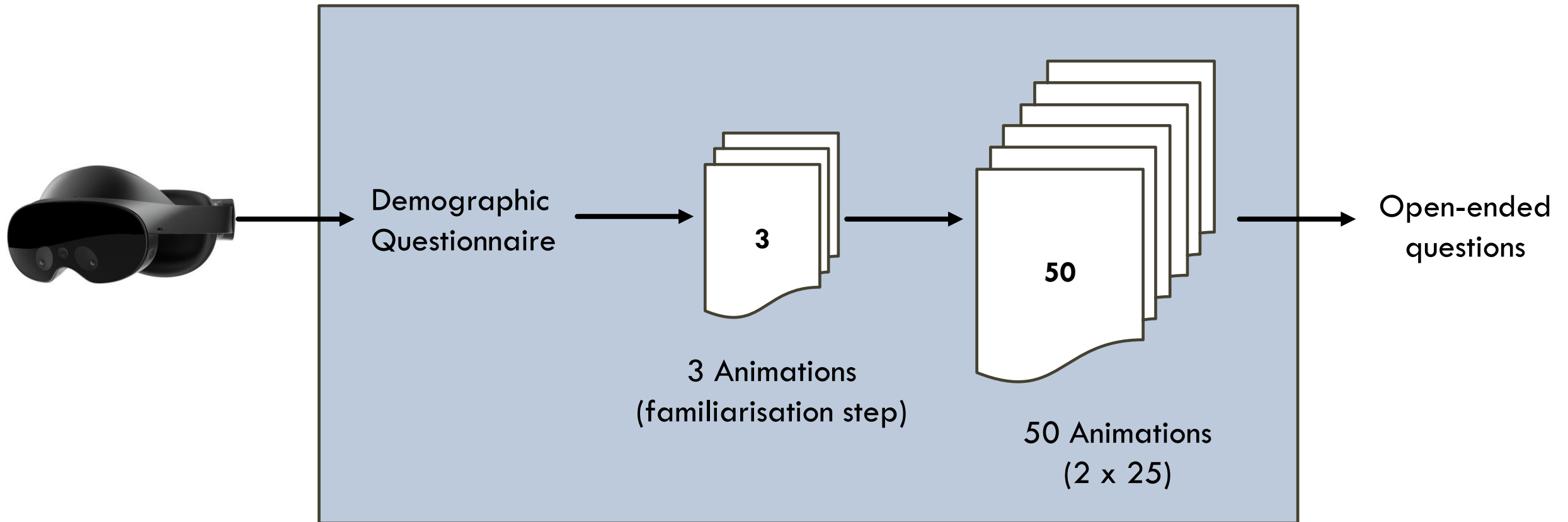
Strongly Disagree



Strongly Agree

7 points Likert scale

EXPERIMENTAL PROTOCOL: PROCEDURE



EXPERIMENTAL PROTOCOL: PROCEDURE FOR EACH ANIMATION

Animation (5s)

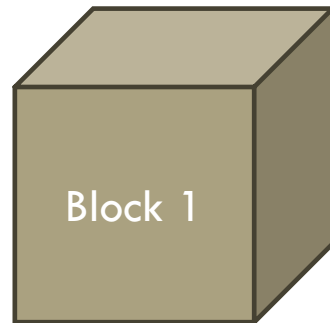


Next Animation



Replay

Evaluate

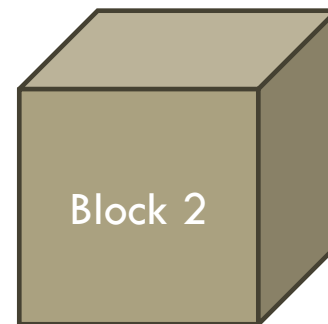


Engagement

Replay

Evaluate

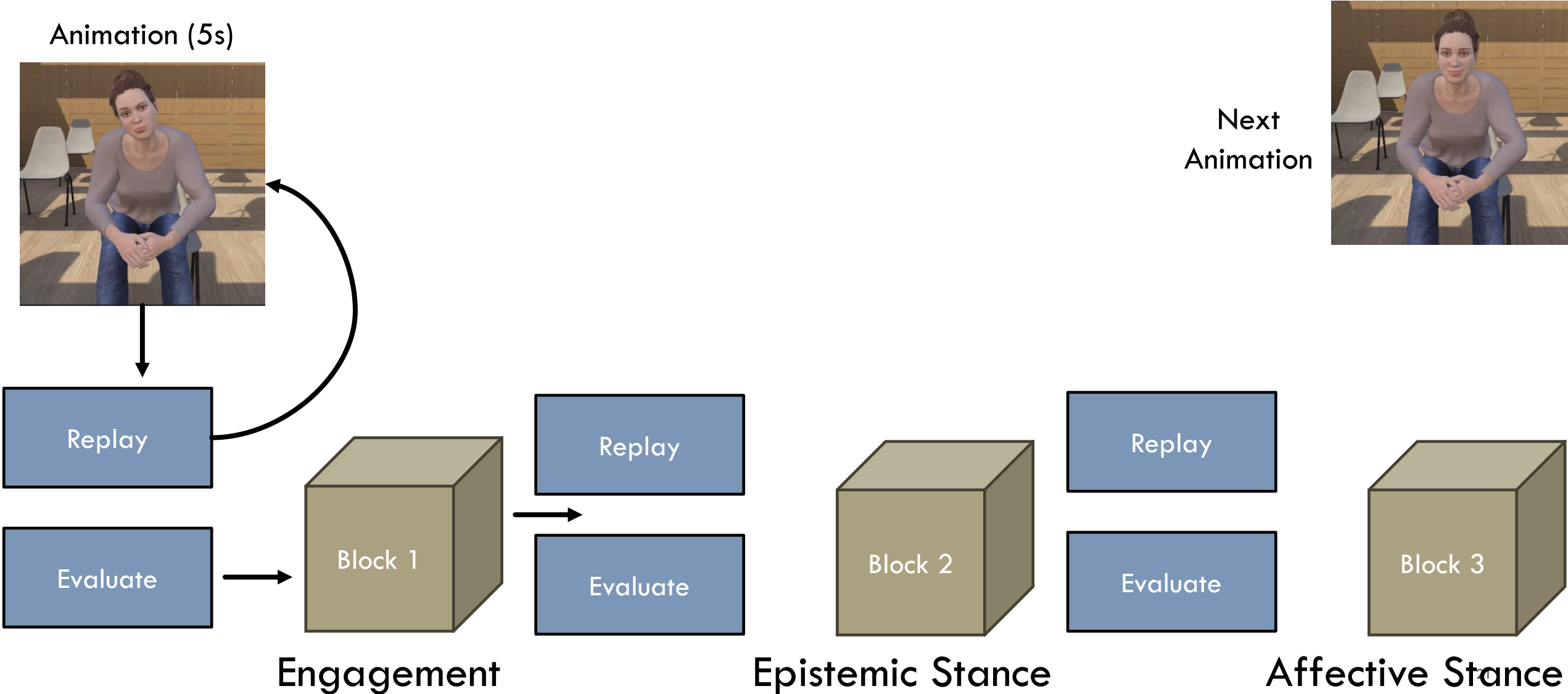
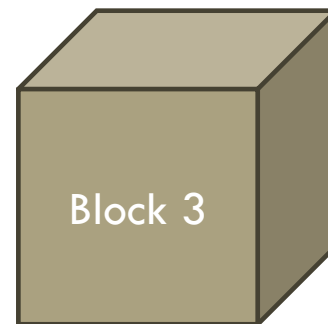
Epistemic Stance



Replay

Evaluate

Affective Stance



EXPERIMENTAL PROTOCOL: PROCEDURE FOR EACH ANIMATION

Animation (5s)

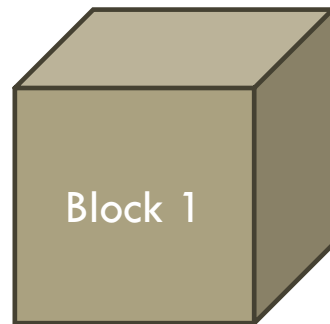


Next Animation



Replay

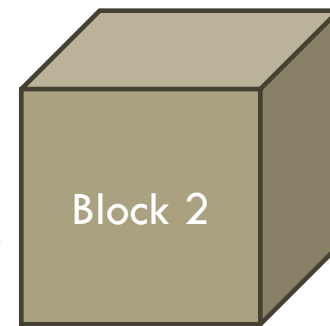
Evaluate



Engagement

Replay

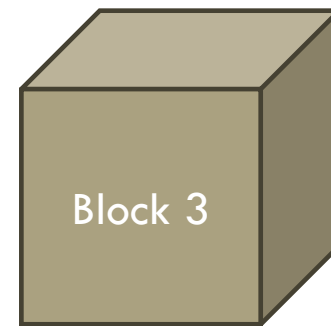
Evaluate



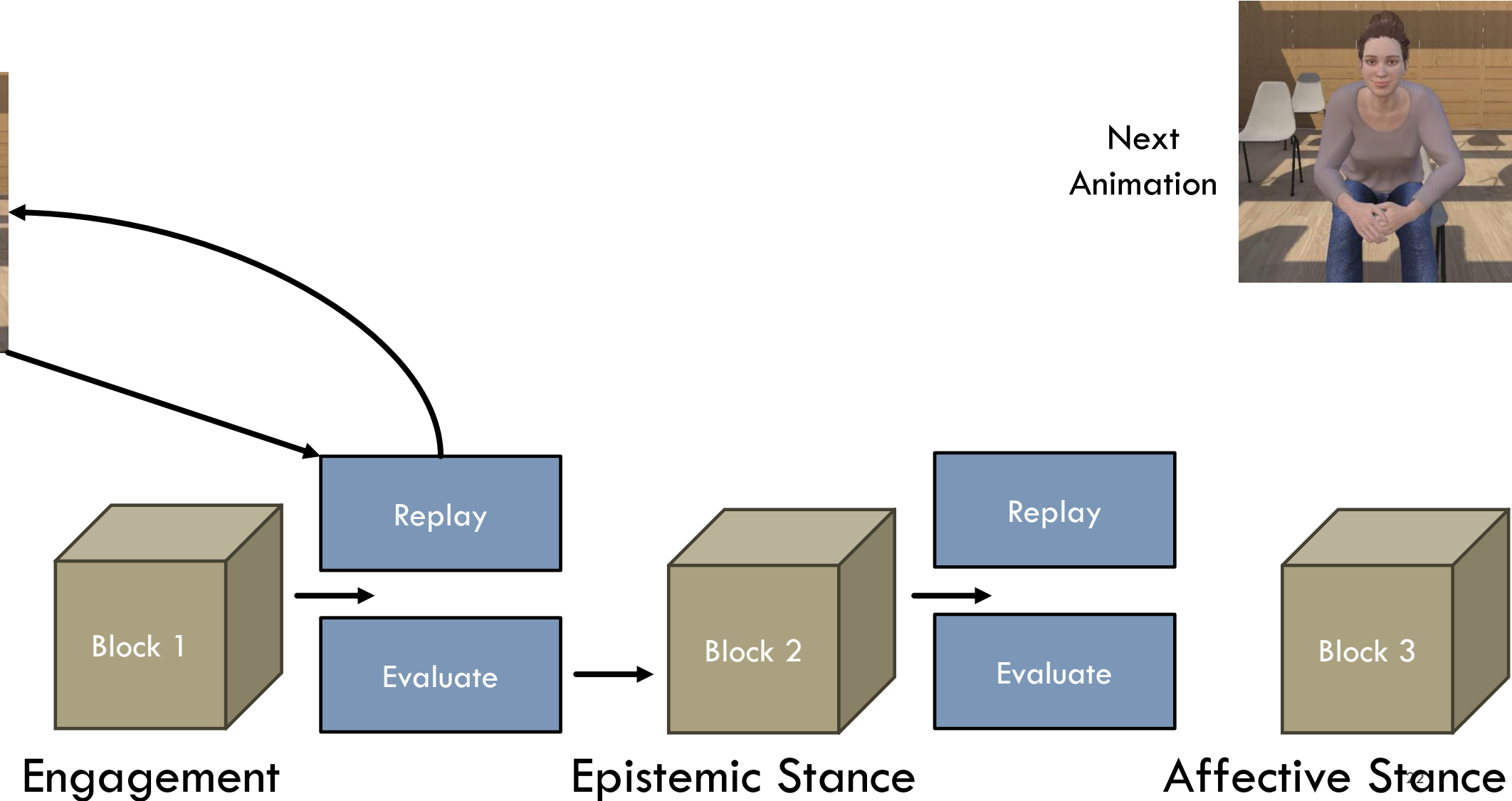
Epistemic Stance

Replay

Evaluate



Affective Stance



EXPERIMENTAL PROTOCOL: PROCEDURE FOR EACH ANIMATION

Animation (5s)

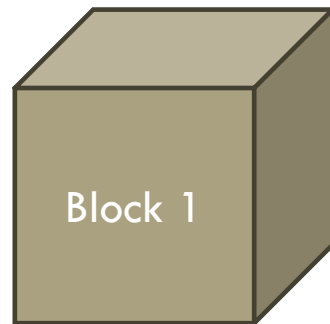


Next Animation



Replay

Evaluate

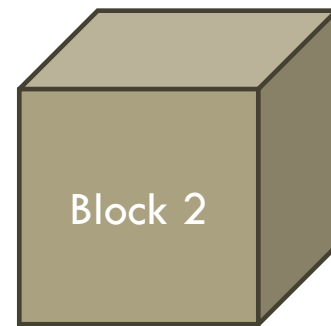


Engagement

Replay

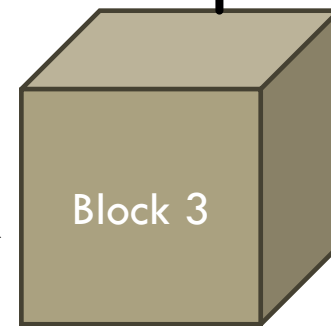
Evaluate

Epistemic Stance

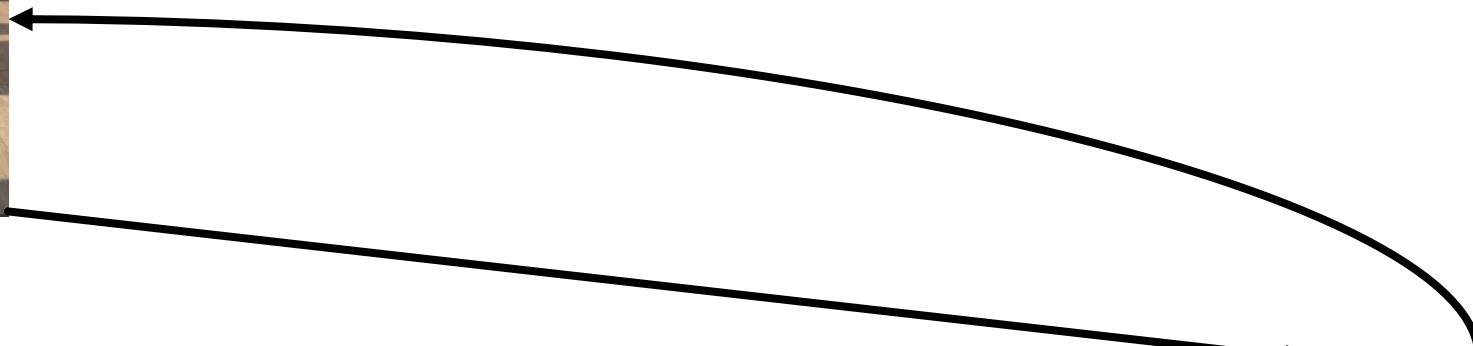


Replay

Evaluate



Affective Stance



RESULTS: COMPUTED SCORES

Score	Calcul	Range
Engagement score	(Attentive + Interested) – (Distracted + Indifferent) Cronbach's $\alpha = 0.83$	From -12 to 12
Epistemic stance score	Agree - Disagree Spearman's $\rho = -0.60, p\text{-value} < 0.001$	From -6 to 6
Affective stance score	Happy - Unhappy Spearman's $\rho = -0.40, p\text{-value} < 0.001$	From -6 to 6

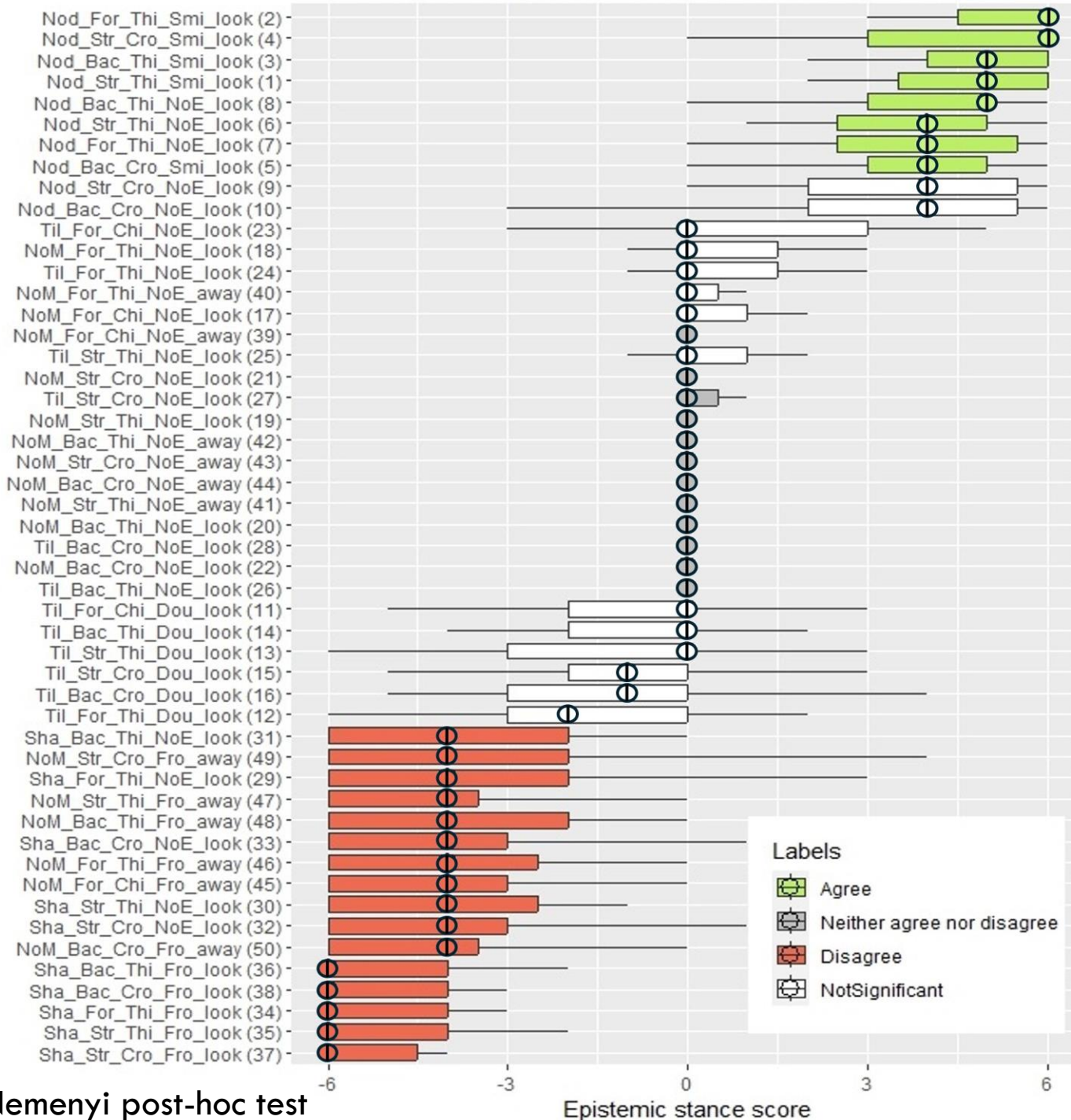
RESULTS: Q1 - REPRESENTATION OF THE VIRTUAL AUDIENCE'S SOCIAL ATTITUDE

H1 : Subdivision of valence into two dimensions : epistemic and affective stance

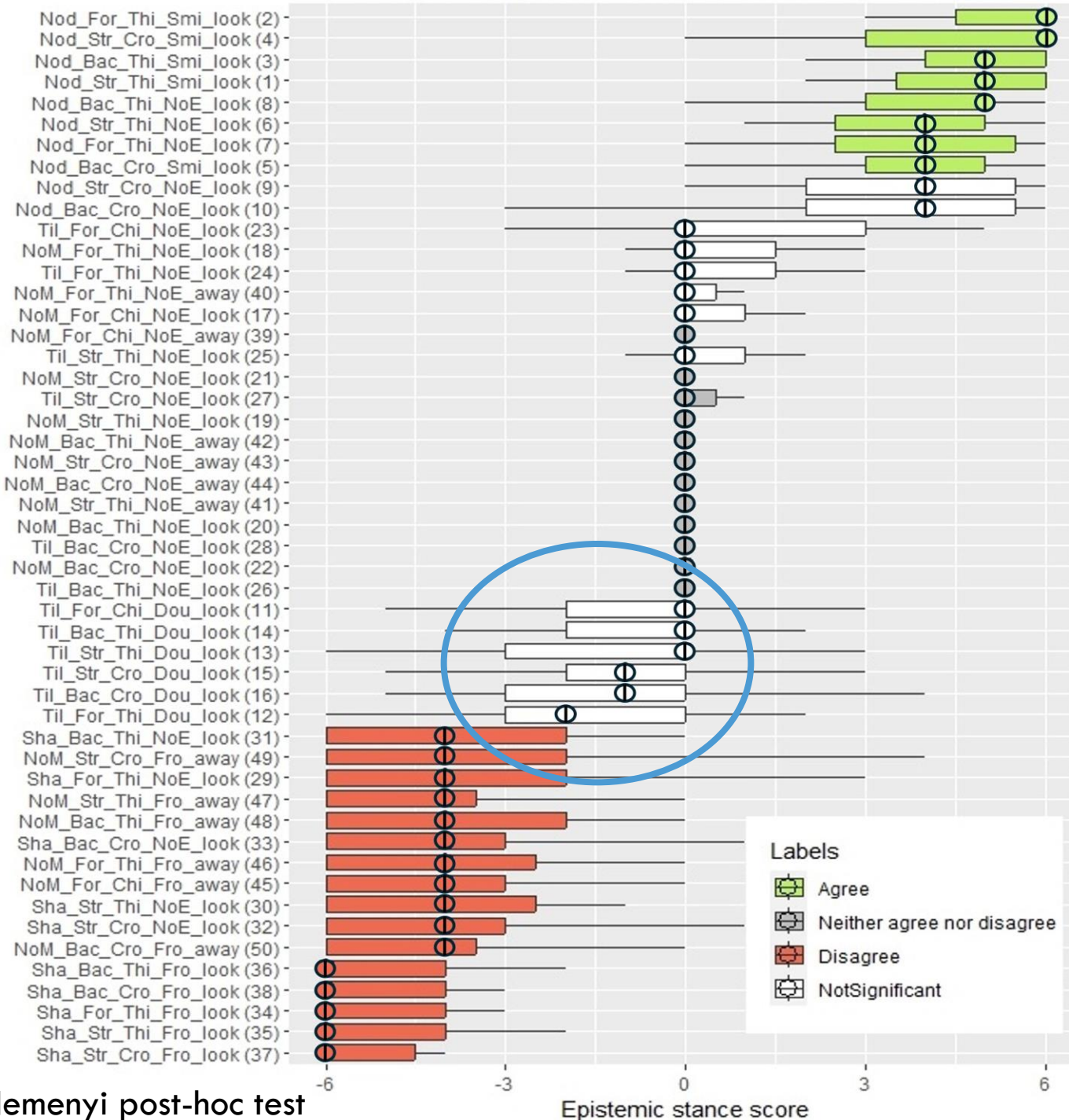
- IV = The animation identifier
- DV = Scores (engagement, epistemic stance and affective stance)

Score	Friedman Chi-Squared	DF	Significance
Engagement	453	49	p < 0.001
Epistemic stance	1477	49	p < 0.001
Affective stance	1410	49	p < 0.001

Q1 - DISTRIBUTION OF THE EPISTEMIC SCORE FOR EACH ANIMATION



Epistemic stance	M	SD
Agree	4.21	1.95
Neither agree nor disagree	0.09	1.43
Disagree	-4.25	2.10



Q1 - DISTRIBUTION OF THE EPISTEMIC SCORE FOR EACH ANIMATION

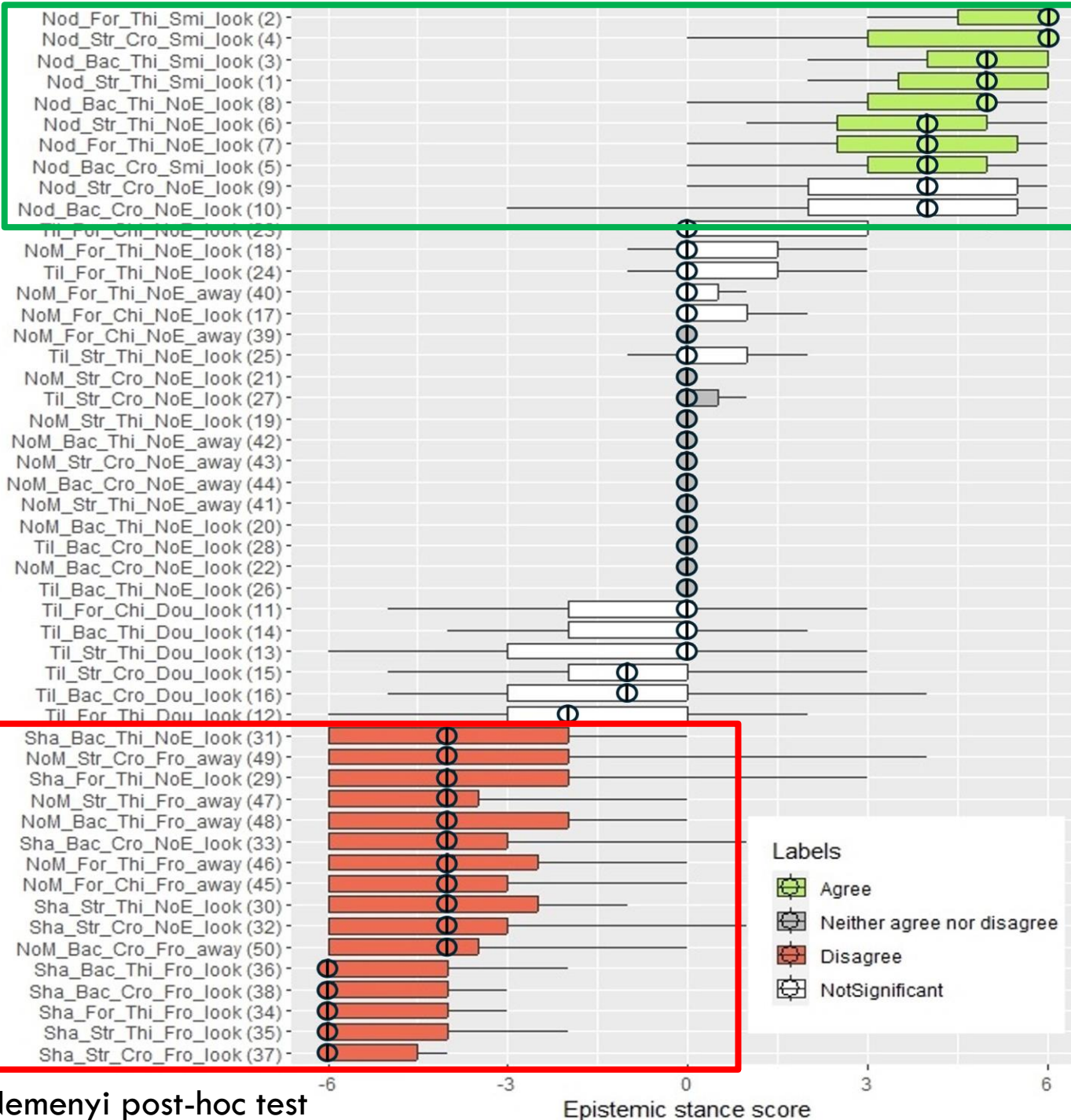
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Animations 11, 14, 13, 15, 16, 12 :
 → Head tilt + Doubt expression

Doubt score = 5.60 out of 7.

Animations ≠ from the green cluster
 But not from the red and grey clusters.

Doubt ≠ Neutral and not between agree and disagree.

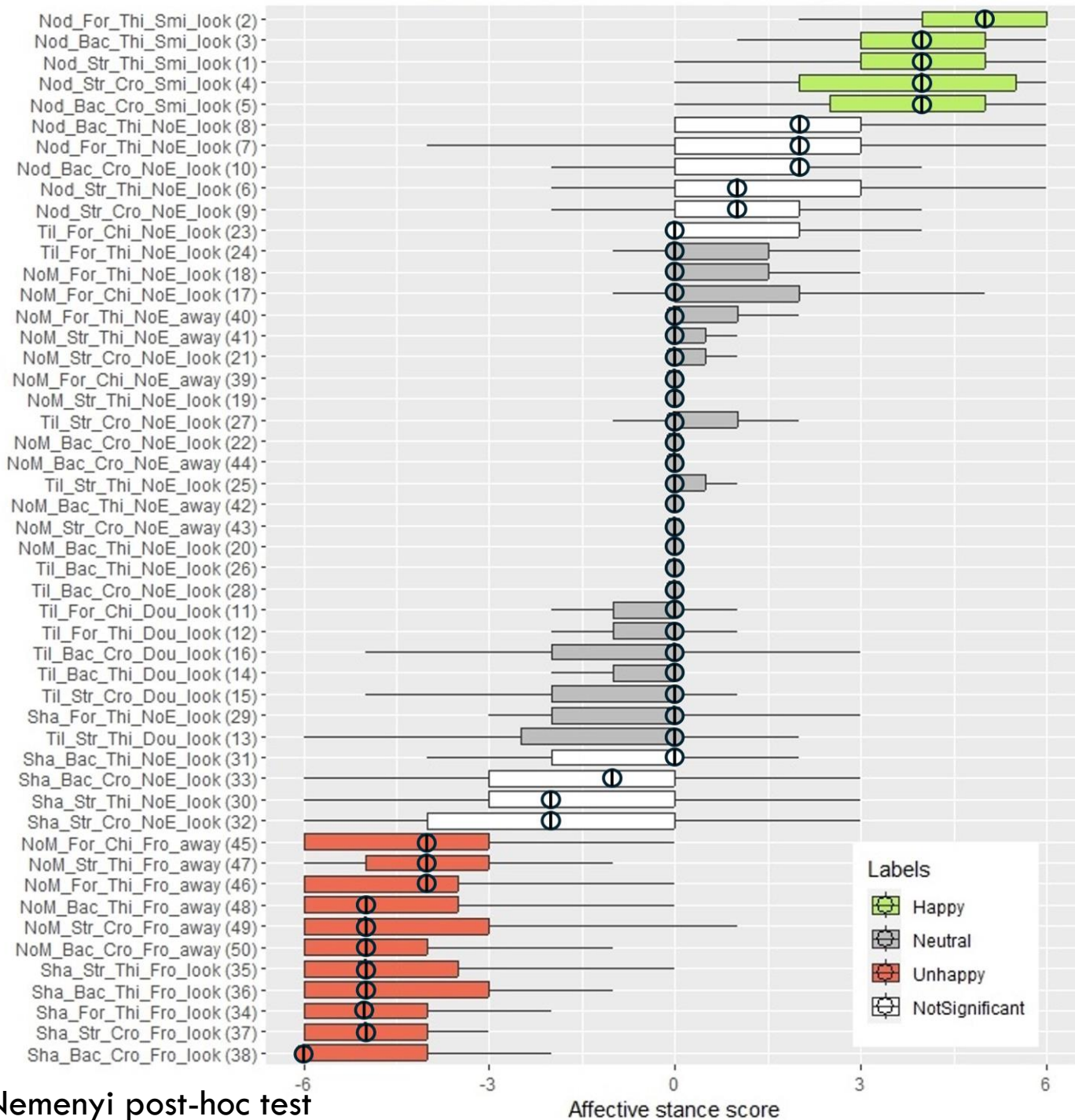


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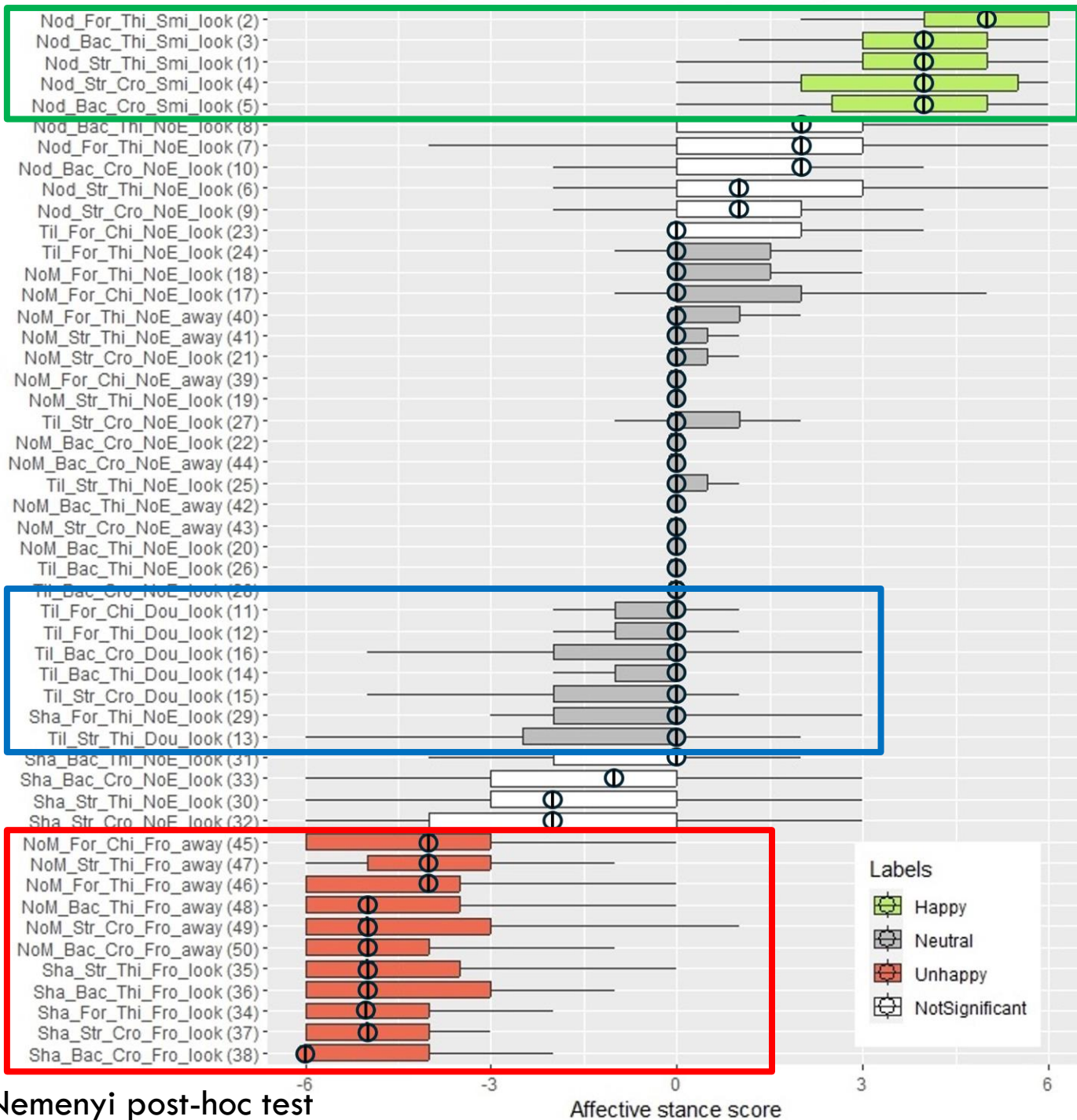
Nod and Smile → **Green** cluster (**Agree**)

Shake and Frown → **Red** cluster (**Disagree**)



Q1 - DISTRIBUTION OF THE AFFECTIVE SCORE FOR EACH ANIMATION

Epistemic stance	M	SD
Happy	4.06	1.62
Neutral	-0.02	1.61
Unhappy	-4.41	1.83



Q1 - DISTRIBUTION OF THE AFFECTIVE SCORE FOR EACH ANIMATION

Epistemic stance	M	SD
Happy	4.06	1.62
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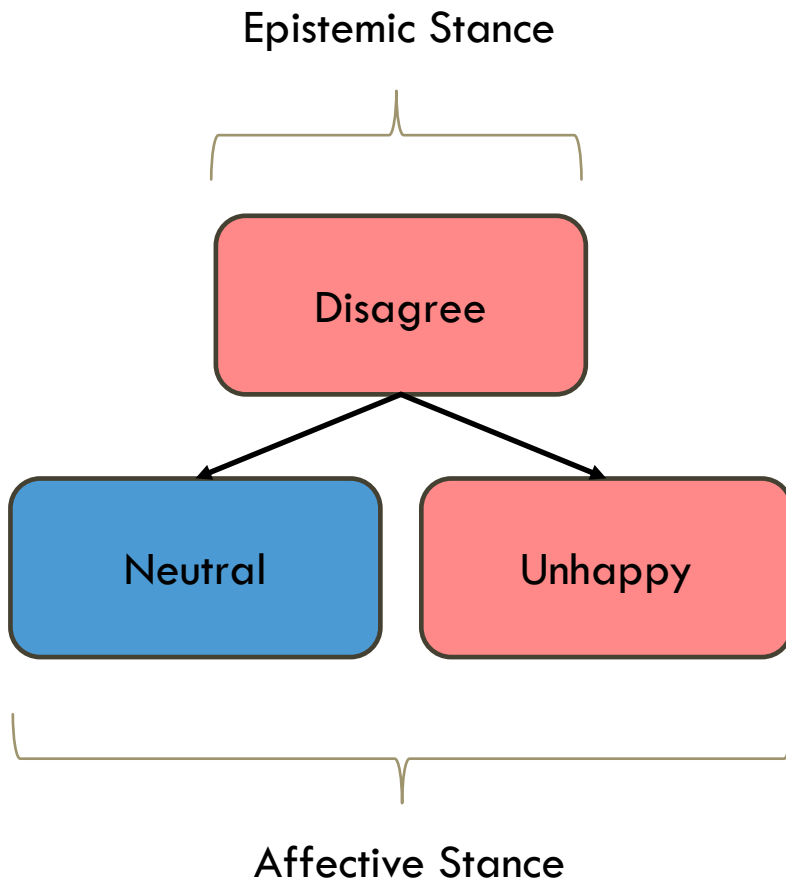
Smile → **Green** cluster (**Happy**)

Doubt → **Grey** cluster (**Neutral**)

Frown → **Red** cluster (**Unhappy**)

Doubt = Neutral and is between happy and unhappy.

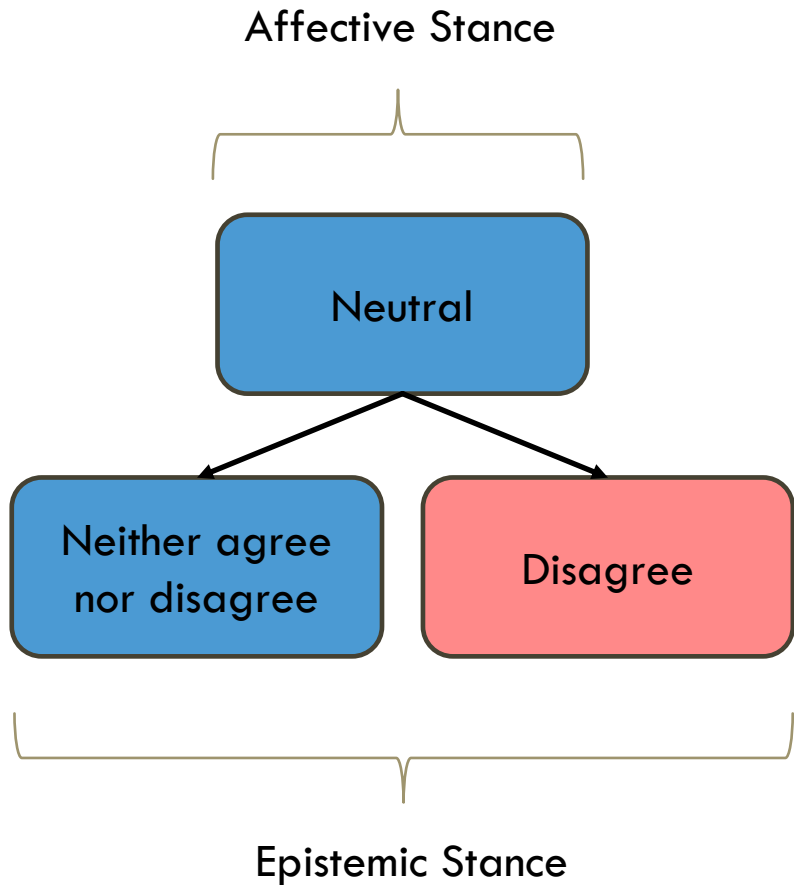
H1



Animations	Epistemic Stance			Affective Stance		
	Md	IQR	Label	Md	IQR	Label
Sha_For_Thi_NoE_look (29)	-4	2.0	D	0	2.0	N
Sha_Bac_Thi_NoE_look (31)	-4	2.0	D	0	2.0	N
Sha_Bac_Cro_NoE_look (33)	-4	3.0	D	-1	3.0	N
Sha_For_Thi_Fro_look (34)	-6	2.0	D	-5	2.0	U
Sha_Str_Thi_Fro_look (35)	-6	2.0	D	-5	2.5	U
Sha_Str_Cro_Fro_look (37)	-6	1.5	D	-5	2.0	U
Sha_Bac_Cro_Fro_look (38)	-6	2.0	D	-6	2.0	U

Table 1: Level of affective stance for a given epistemic stance. The seven animations are rated disagree (D) for the epistemic stance, three are rated neutral (N) and four are rated unhappy (U) for the affective stance.

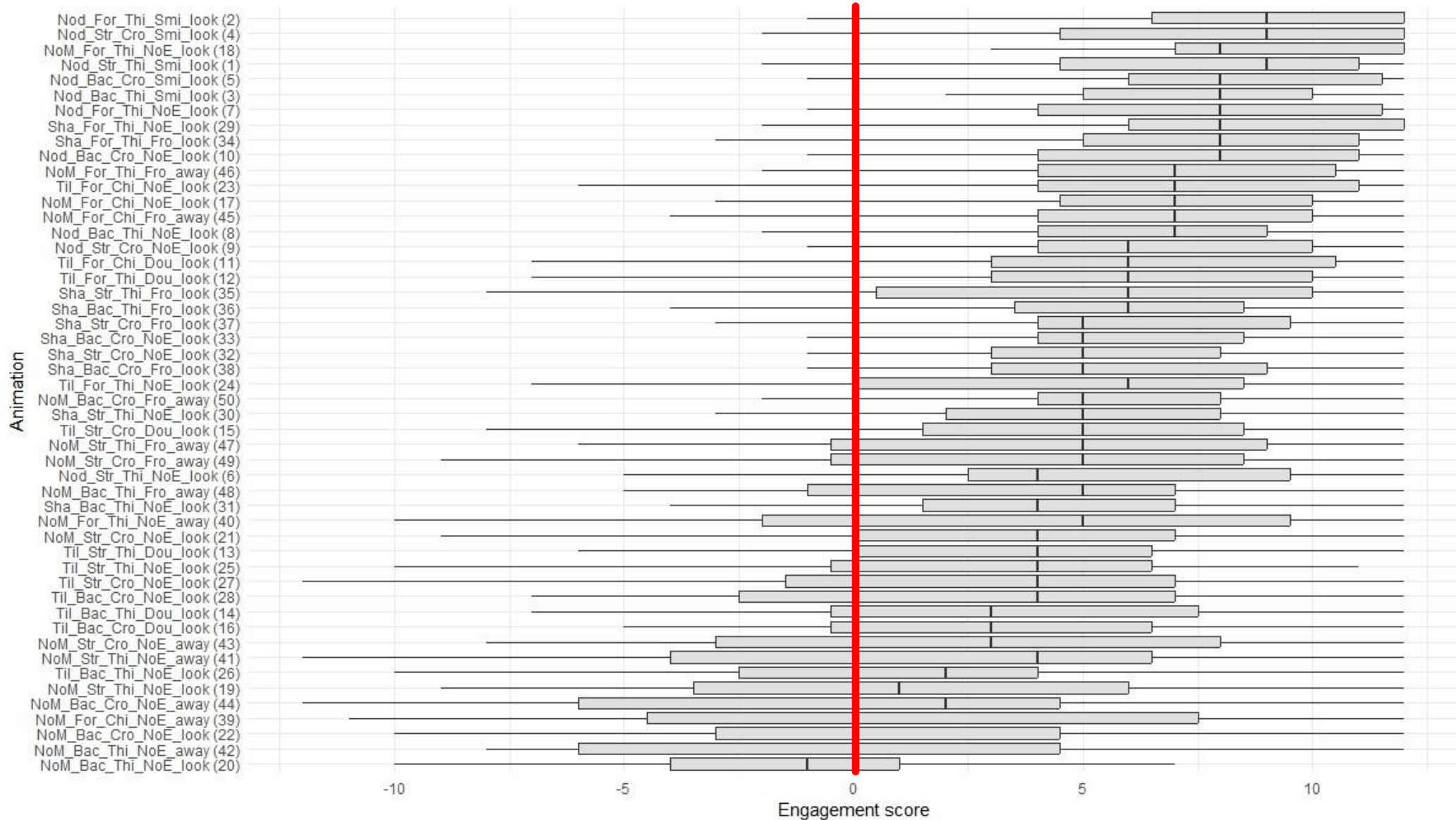
H1



Animations	Affective Stance			Epistemic Stance		
	Md	IQR	Label	Md	IQR	Label
Sha_For_Thi_NoE_look (29)	0	2.0	N	-4	4.0	D
Til_For_Chi_Dou_look (11)	0	1.0	N	0	2.0	N
NoM_For_Chi_NoE_look (17)	0	2.0	N	0	1.0	N
NoM_For_Thi_NoE_look (18)	0	1.5	N	0	1.5	N
NoM_Str_Thi_NoE_look (19)	0	0.0	N	0	0.0	N
NoM_Bac_Thi_NoE_look (20)	0	0.0	N	0	0.0	N
NoM_Str_Cro_NoE_look (21)	0	0.5	N	0	0.0	N
NoM_Bac_Cro_NoE_look (22)	0	0.0	N	0	0.0	N
Til_For_Thi_NoE_look (24)	0	1.5	N	0	1.5	N
Til_Str_Thi_NoE_look (25)	0	0.5	N	0	1.0	N
Til_Bac_Thi_NoE_look (26)	0	0.0	N	0	0.0	N
Til_Str_Cro_NoE_look (27)	0	1.0	N	0	0.5	N
Til_Bac_Cro_NoE_look (28)	0	0.0	N	0	0.0	N
NoM_For_Chi_NoE_away (39)	0	0.0	N	0	0.0	N
NoM_For_Thi_NoE_away (40)	0	1.0	N	0	0.5	N
NoM_Str_Thi_NoE_away (41)	0	0.5	N	0	0.0	N
NoM_Bac_Thi_NoE_away (42)	0	0.0	N	0	0.0	N
NoM_Str_Cro_NoE_away (43)	0	0.0	N	0	0.0	N
NoM_Bac_Cro_NoE_away (44)	0	0.0	N	0	0.0	N

Table 2: Level of epistemic stance for a given affective stance. All animations are rated as neutral (N) for the affective stance, one is rated as disagreeing (D) and eighteen are rated as neither agreeing nor disagreeing (N) for the epistemic stance.

DISTRIBUTION OF THE ENGAGEMENT SCORE FOR EACH ANIMATION



RESULTS: Q2 - BEHAVIORAL SIGNALS CONVEYING SOCIAL DIMENSIONS

H2 : The main non-verbal behavioural signals involved in evaluating each stance are different: (H2.1) **Head movement for epistemic** stance and (H2.2) **facial expression for affective** stance.

- IV = The behavioral signals
- DV = Scores (engagement, epistemic stance and affective stance)

RESULTS: Q2 - BEHAVIORAL SIGNALS CONVEYING SOCIAL DIMENSIONS

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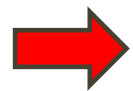
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Bayesian Models

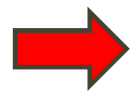
Bayesian Model

$$BF_{01} = \frac{\text{likelihood of data given } H_0}{\text{likelihood of data given } H_1}$$

- This method makes it possible to **confirm one hypothesis rather than another** thanks to the strength of the evidence [*Jarosz and Wiley, 2014*]
- Some authors have tried to **quantify the strength of the evidence** in order to conclude based on the result of the previous ratio, thanks to **different scales** [*Jeffreys, 1998; Kass and Raftery, 1995*].



Our threshold $\rightarrow BF > 10$ [*Procházka et al., 2017*]



If $BF > 100 \rightarrow$ we report $\ln(BF)$ [*Mascret et al., 2019*]

Statistic (BF or inverse of BF)	Support for H (Jeffreys's scale)
1-3	Anecdotal
3-10	Substantial
10-20	Strong
20-30	Strong
30-100	Very Strong
100-150	Decisive
> 150	Decisive

RESULTS: H2.1 – HEAD MOVEMENTS PREDOMINATE FOR THE EPISTEMIC STANCE

Epistemic stance prediction using Bayes factor ANOVA

Models	P(M)	P(M data)	$\log(BF_M)$	$\log(BF_{10})$	BF_{10}	error %
(3.1) Null model (incl. ID)	0.01	0.00	-1266.98	0.00	1.00	
(3.2) H.	0.01	1.16×10^{-167}	-379.27	887.71	3.39×10^{385}	0.76
(3.3) Exp.	0.01	2.01×10^{-268}	-611.28	655.70	5.81×10^{284}	0.72

Simple models of :

- Head Movements (H.)
- Facial Expressions (Exp.)



H2.1 – HEAD MOVEMENTS PREDOMINATE FOR THE EPISTEMIC STANCE

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Comparison of **the influence of head movements and facial expressions** on the perception of epistemic stance :

$$\ln(BF) = \text{Model 3.2} / \text{Model 3.3} = 232.02$$

The Head Movements are the first and most important signals for assessing the epistemic stance, **followed by Facial Expressions.**

RESULTS: H2.2 – FACIAL EXPRESSIONS PREDOMINATE FOR THE AFFECTIVE STANCE

Affective stance prediction using Bayes factor ANOVA

Models	P(M)	P(M data)	$\log(BF_M)$	$\log(BF_{10})$	BF_{10}	error %
(4.1) Null model (incl. ID)	0.01	0.00	-1266.98	0.00	1.00	
(4.2) Exp.	0.01	5.77×10^{-76}	-168.13	1027.82	2.41×10^{446}	0.59
(4.3) H.	0.01	2.41×10^{-294}	-670.97	524.99	9.80×10^{227}	1.13

Simple models of :

- Facial Expressions (Exp.)
- Head Movements (H.)



H2.2 – FACIAL EXPRESSIONS PREDOMINATE FOR THE AFFECTIVE STANCE

Affective stance prediction using Bayes factor ANOVA

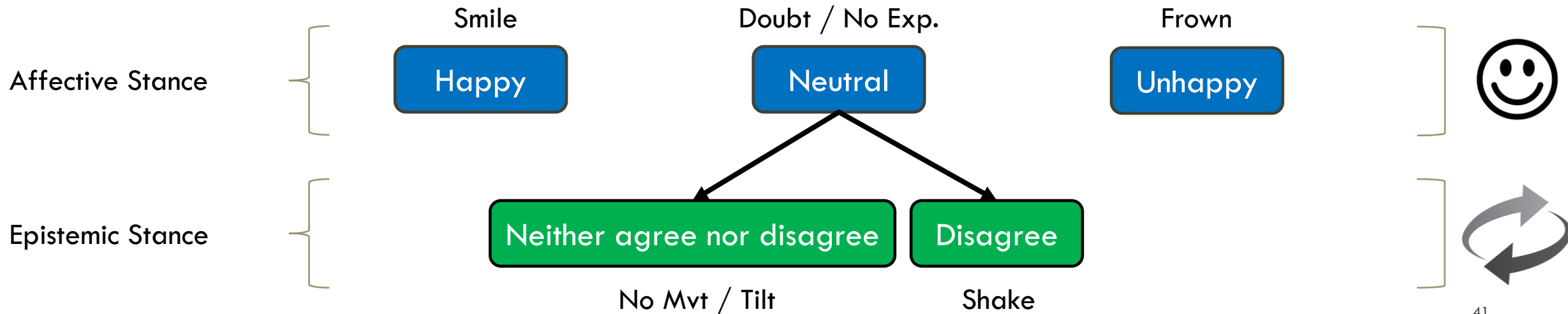
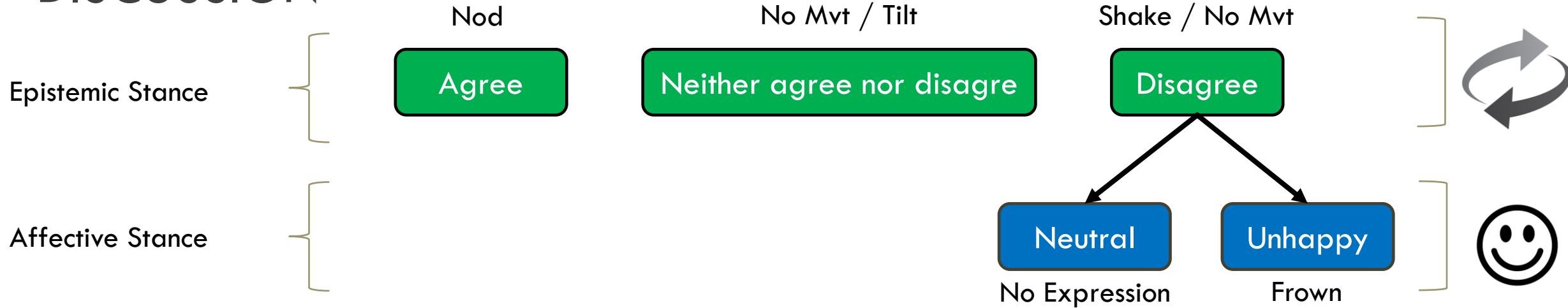
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Comparison of **the influence of facial expressions and head movements** on the perception of affective stance :

$$\ln(BF) = \mathbf{Model\ 4.2} / \text{Model 4.3} = 502.86$$

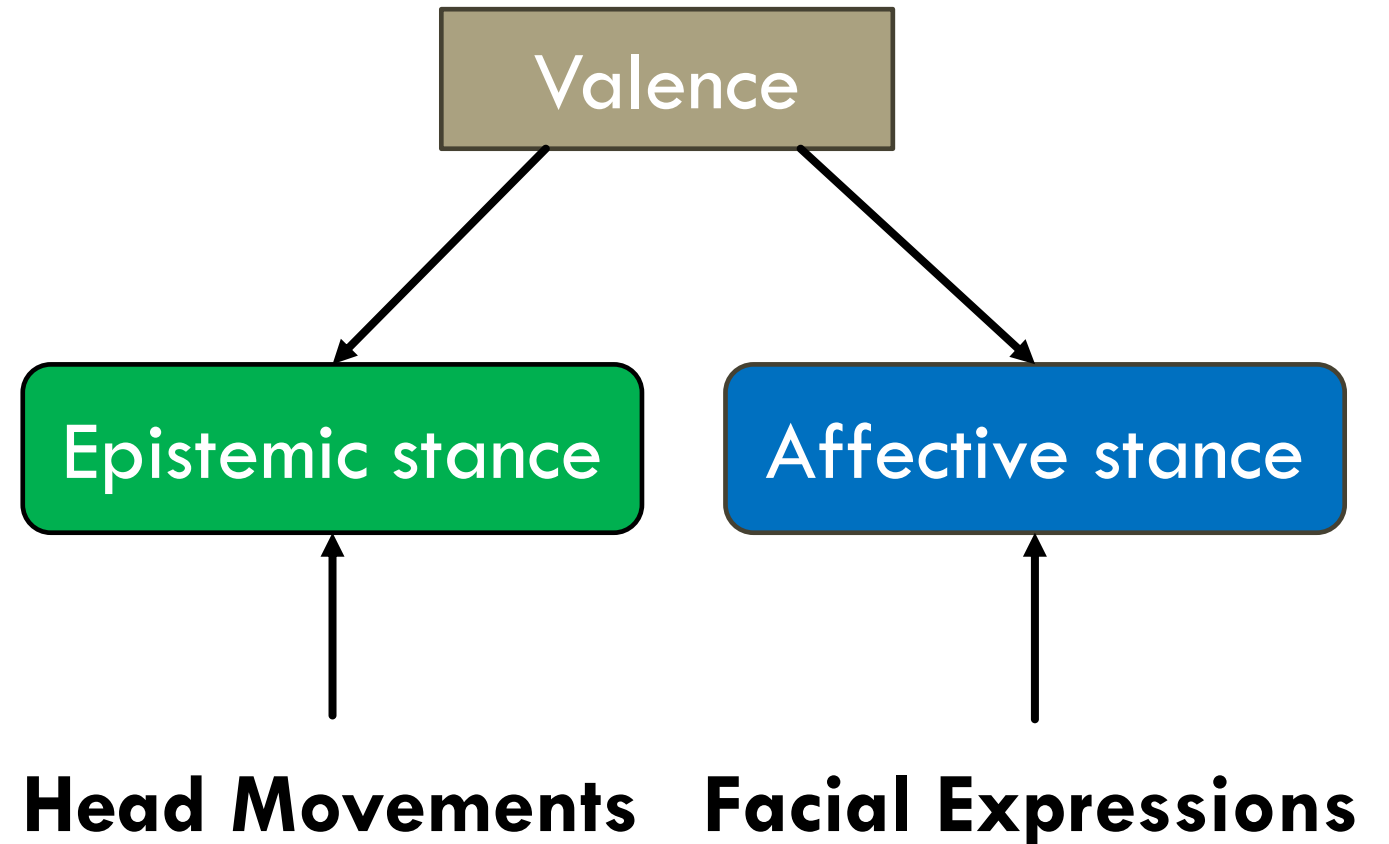
The Facial Expressions are the first and most important signals for assessing the affective stance, followed by Head Movements.

DISCUSSION



CONCLUSION

- The valence dimension can be subdivided into two dimensions : The Epistemic Stance and Affective Stance.
- Each dimension is conveyed by different nonverbal behavioral signals.
- Doubt is perceived as a neutral expression but does not correspond to a neutral agreement.
- We were unable to represent disengagement based on the gaze direction.



PERSPECTIVES

- Use a **male** character
- Model :
 - Identify the **labels** associated with each combination of dimensions
 - **Formalise the model** and propose a diagram
- Study **the impact of these attitudes** on the user's perceived difficulty in public speaking
- Study the perception of the **overall attitude** by varying the % of each attitude (80% benevolent and 20% critical)
- For the corpus collection : **Positive / Negative attitude** → Choose the animations perceived as the most negative and the most positive.



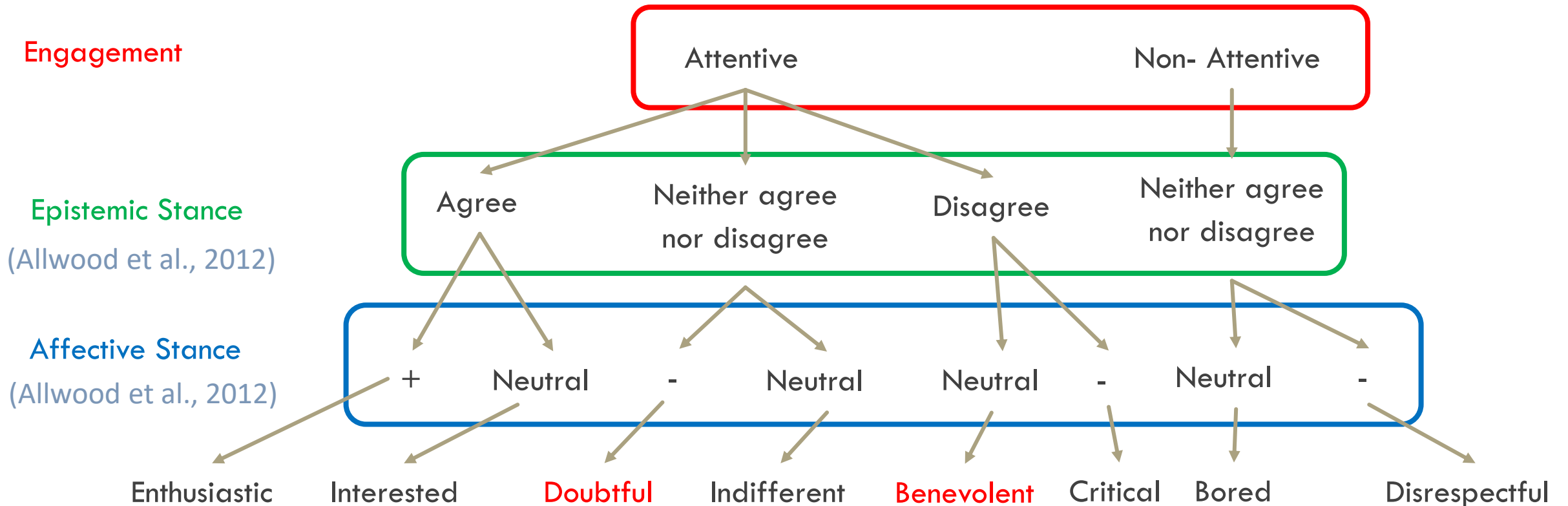
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OUR VIRTUAL AUDIENCE BEHAVIORAL MODEL

- Valence / Arousal model : 6 social attitudes → Critical, Bored, Indifferent, Interested, Enthusiastic, Disrespectful (Glémarec et al., 2021)





H2.1 – HEAD MOVEMENTS PREDOMINATE FOR THE EPISTEMIC STANCE

Models	P(M)	P(M data)	$\log(BF_M)$	$\log(BF_{10})$	BF_{10}	error %
(3.1) Null model (incl. ID)	0.01	0.00	-1266.98	0.00	1.00	
(3.2) H.	0.01	1.16×10^{-167}	-379.27	887.71	3.39×10^{385}	0.76
(3.3) Exp.	0.01	2.01×10^{-268}	-611.28	655.70	5.81×10^{284}	0.72
(3.4) H. + Exp.	0.01	2.91×10^{-34}	-72.11	1194.87	8.56×10^{518}	0.92
(3.5) H. + Exp. + H. * Exp.	0.01	1.10	2.96	1269.83	3.20×10^{551}	2.19

Table 3: Epistemic stance prediction using Bayes factor ANOVA: The table reports the results for the simple models of head movements (H.), facial expressions (Exp.), their association (+) and their interaction (*).



H2.2 – FACIAL EXPRESSIONS PREDOMINATE FOR THE AFFECTIVE STANCE

Models	P(M)	P(M data)	$\log(BF_M)$	$\log(BF_{10})$	BF_{10}	error %
(4.1) Null model (incl. ID)	0.01	0.00	-1266.98	0.00	1.00	
(4.2) Exp.	0.01	5.77×10^{-76}	-168.13	1027.82	2.41×10^{446}	0.59
(4.3) H.	0.01	2.41×10^{-294}	-670.97	524.99	9.80×10^{227}	1.13
(4.4) H. + Exp.	0.01	4.13×10^{-14}	-25.71	1170.25	1.80×10^{508}	1.10
(4.5) H. + Exp. + H. * Exp.	0.01	2.62×10^{-4}	-3.13	1192.82	1.24×10^{518}	7.93

Table 4: Affective stance prediction using Bayes factor ANOVA: The table reports the results for the simple models of head movements (H.), facial expressions (Exp.), their association (+) and their interaction (*).