

# Effect of the horizontal panning on sense of presence in three-dimensional audio system based on multiple vertical panning

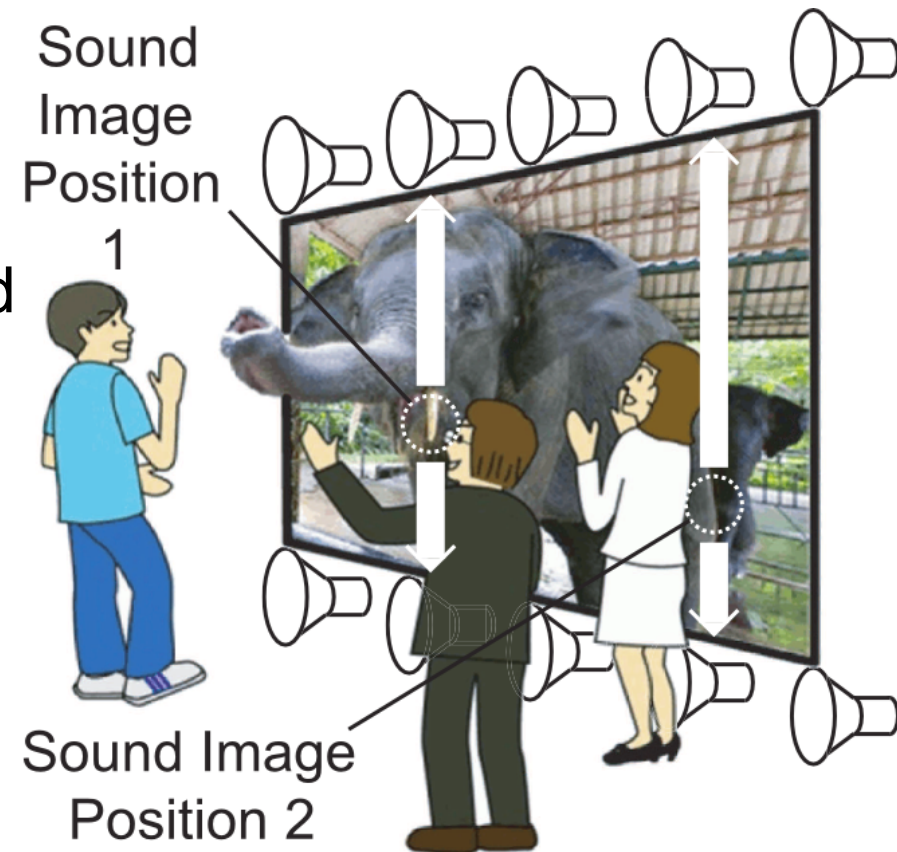
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<sup>2</sup>Center for Information and Neural Networks,  
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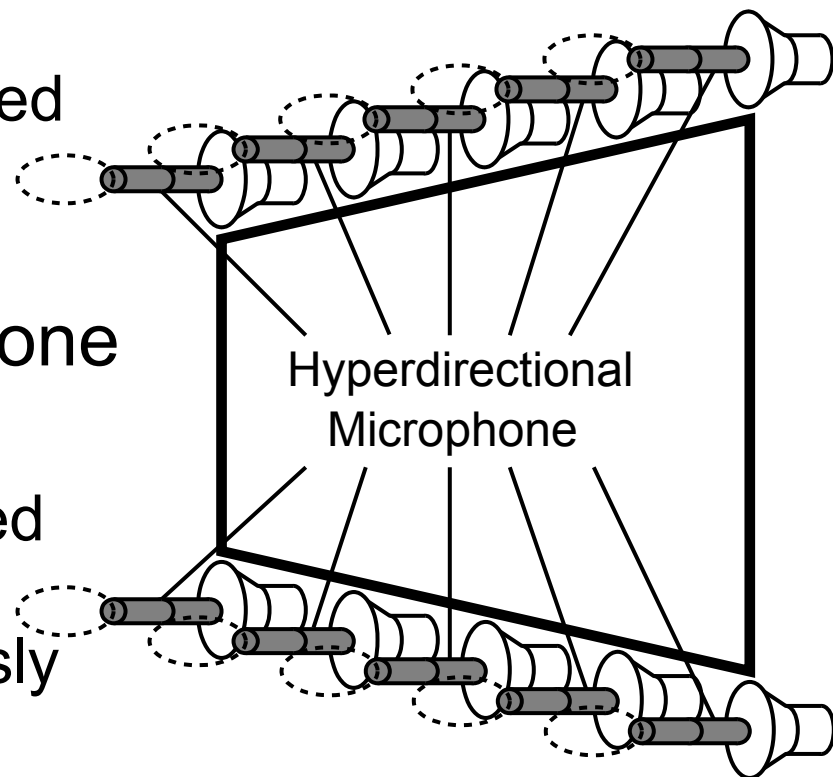
# Multiple Vertical Panning (MVP) method

- Multiple "vertically panned loudspeakers" are placed at the upper and lower sides of the screen
  - 2 loudspeakers are placed at upper and lower sides of sound image positions
- Sound is played by the "vertical panning"
  - Viewers perceive a sound image between vertically panned loudspeakers
  - Multiple viewers can simultaneously feel the sound images at the position of visual objects



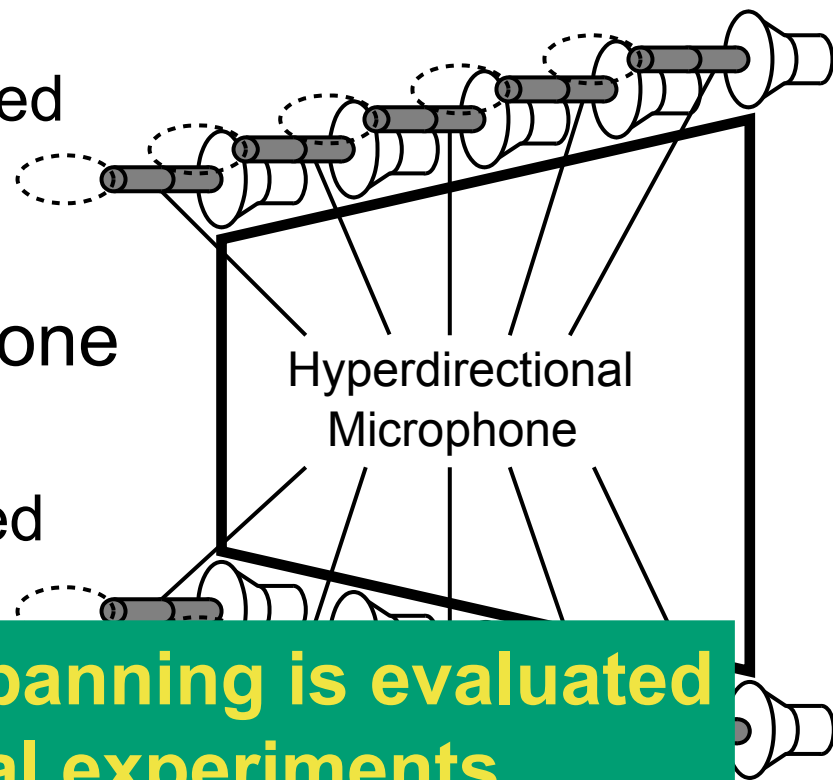
# Aim of Study

- MVP method in our previous studies
  - The localized performance is correct in the audio-visual presentation
  - The number of loudspeakers can be reduced to ten
- Teleconference system
  - Microphones can't be placed at the neighborhood of sound sources
- Hyperdirectional microphone array is designed
  - Horizontal panning is added since neighboring microphones simultaneously record a sound



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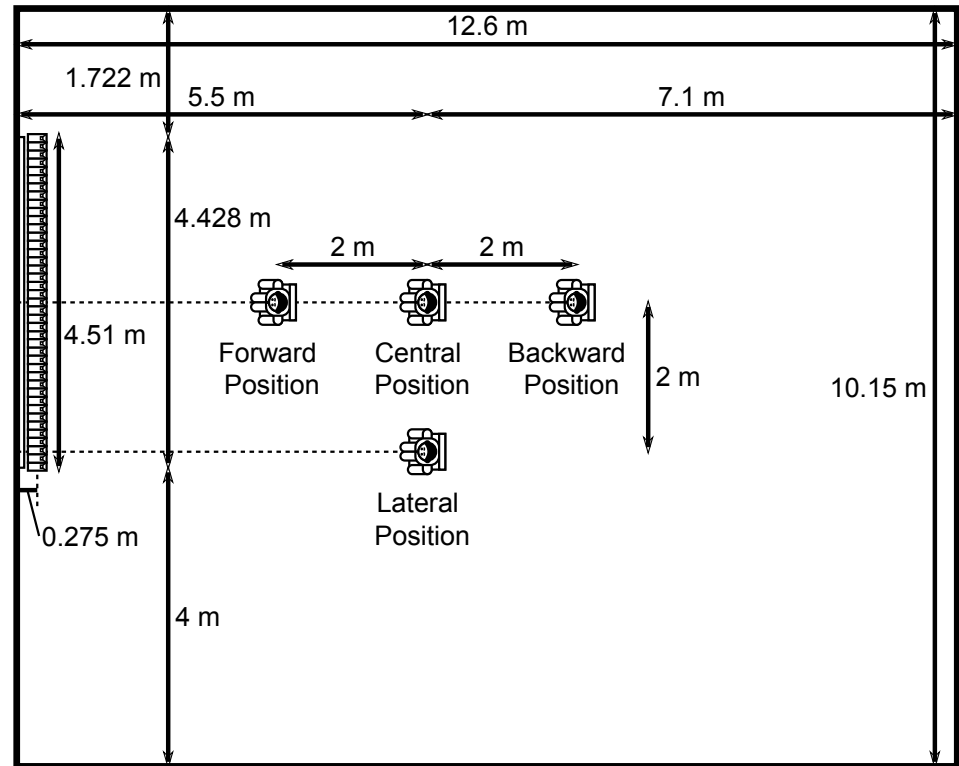


**The effect of horizontal panning is evaluated by two audio-visual experiments**

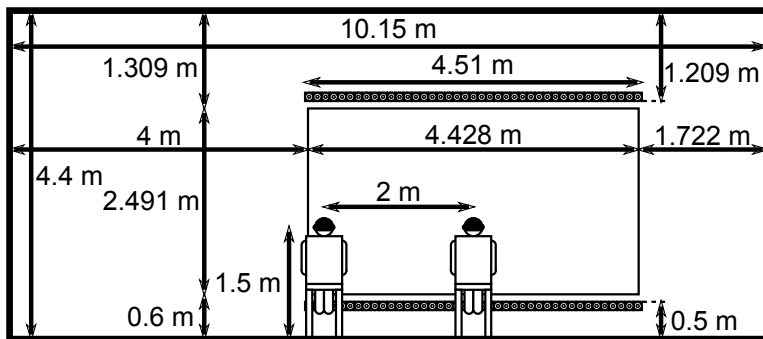
# Environment (Experiment 1)

- Conference room
  - Reverberation time
    - 402 ms
  - Background noise
    - 38 dBA
  - 82 loudspeakers
    - 41(upper), 41(lower)
  - 4 viewing positions
  - Sound pressure level
    - About 70 dBA

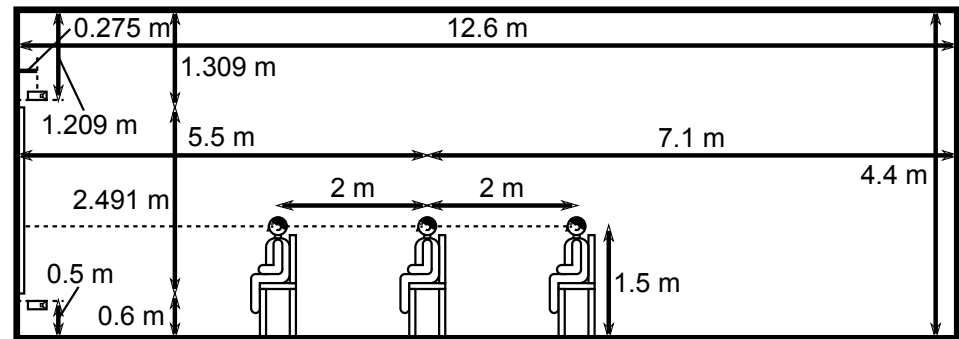
Plane View



Front View

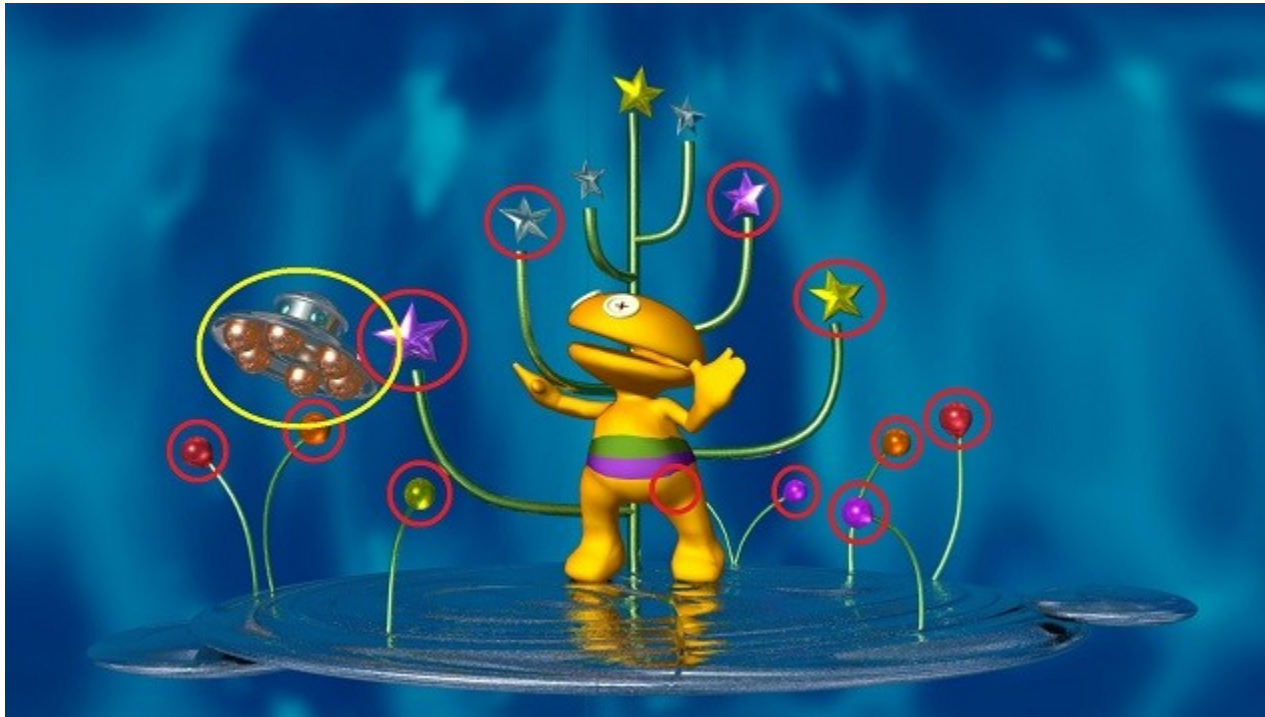


Cross-sectional View



# Condition (Experiment 1)

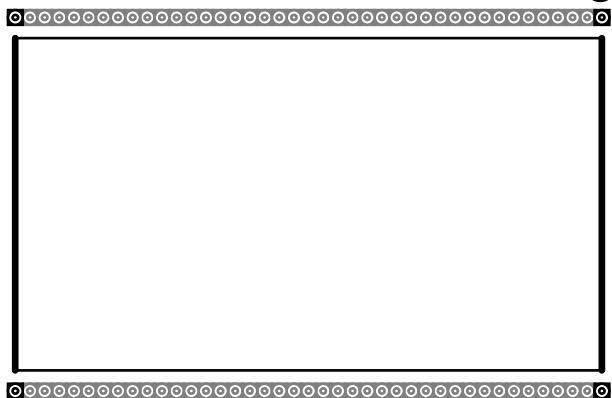
- 3D video (5 seconds)
  - Yellow oval
    - UFO that plays a sound is moving about the screen
  - Red circles
    - The sound of stars and balls is played when UFO touches them



# Condition (Experiment 1)

- Sound condition
  - Reference conditions: (a), (e) and (f)

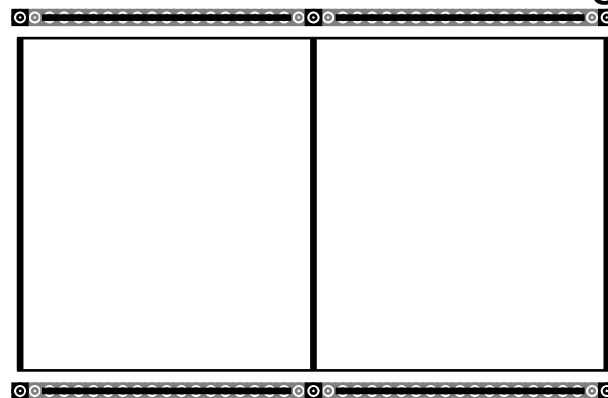
(a) 4 Loudspeakers,  
No Horizontal Panning



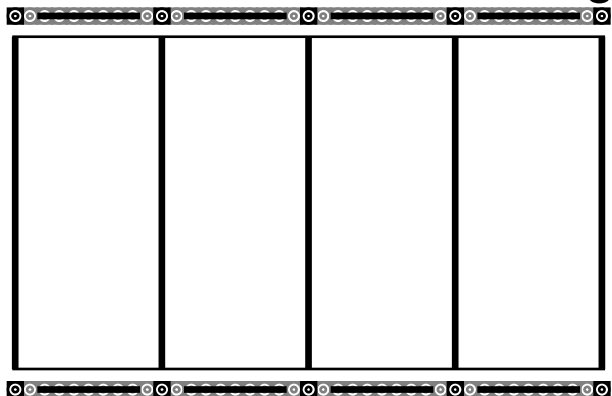
(b) 4 Loudspeakers,  
With Horizontal Panning



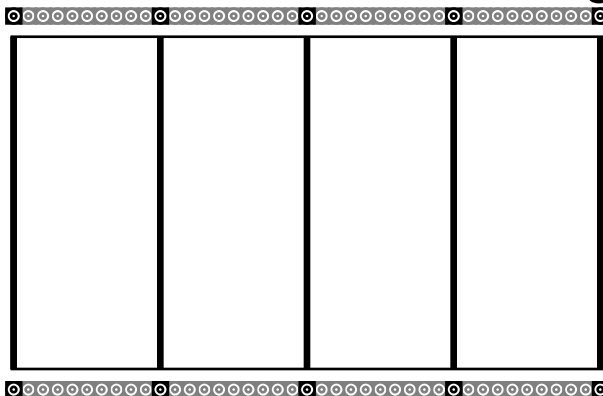
(c) 6 Loudspeakers,  
With Horizontal Panning



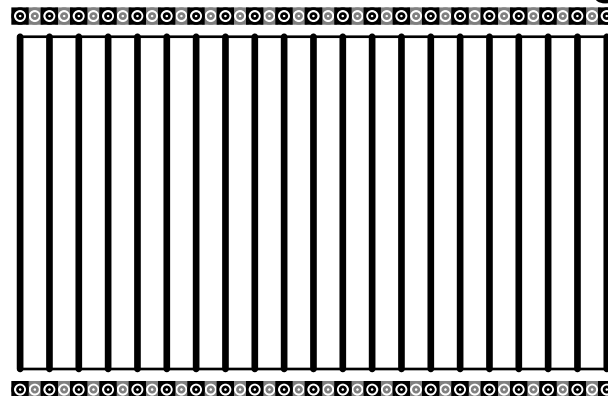
(d) 10 Loudspeakers,  
With Horizontal Panning



(e) 10 Loudspeakers,  
No Horizontal Panning



(f) 42 Loudspeakers  
No Horizontal Panning



# Design (Experiment 1)

- Method
  - Scheffe's paired comparison
- Evaluation criterion
  - The degree of coincidence of location (star and ball)
  - The degree of coincidence of movement (UFO)

- Viewer

- 9 persons
  - 5 males
  - 4 females
- Age
  - 27-38

Test

Evaluation 1	Evaluation 2
Order...Randomized (Sound Location or Movement)	

Evaluation

Session 1	Session 2	Session 3	Session 4
Order...Randomized (4 Viewing Positions)			

Session

Practice (6 trials)	Main (30 trials)
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Trial

Sign (0.1 s)	Break (0.9 s)	Stimulus A (5 s)	Break (2 s)	Stimulus B (5 s)	Answer (4 s)
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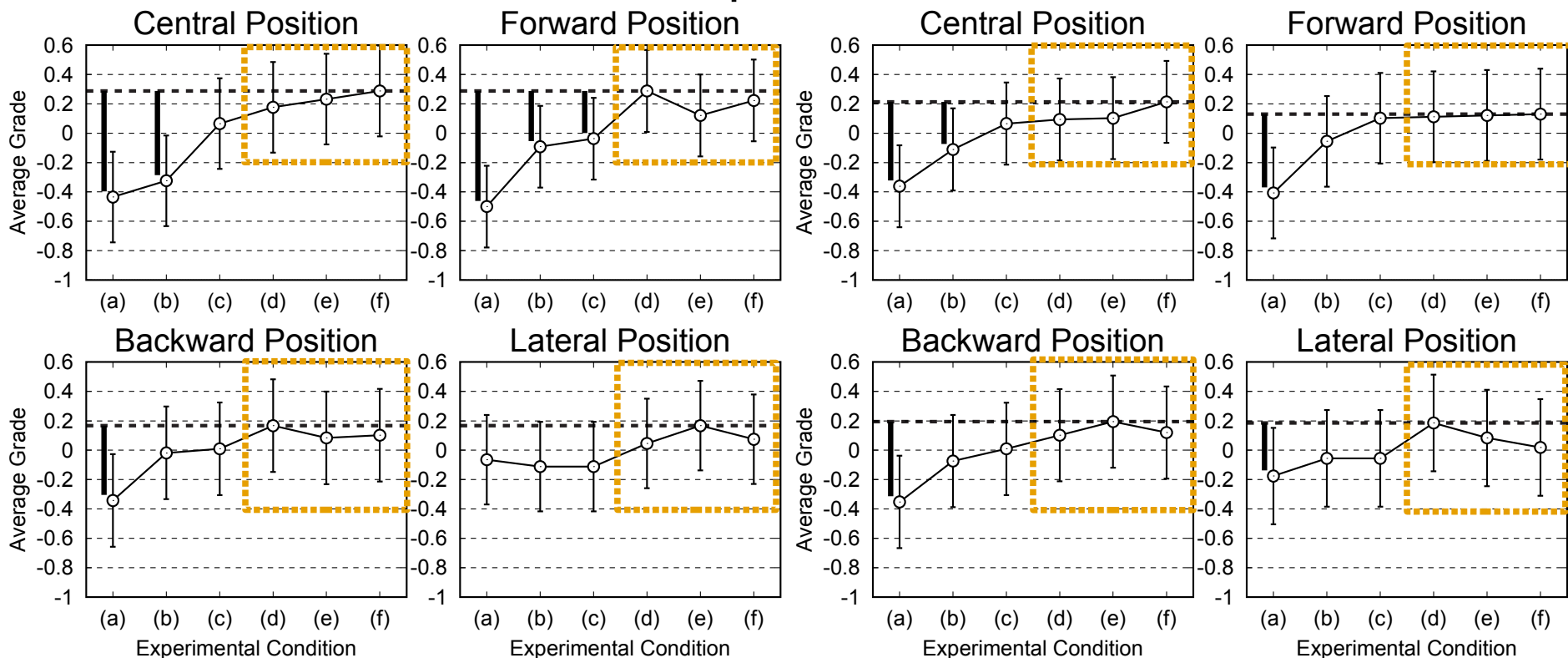
# Procedure (Experiment 1)

- Instruction
  - Grade the degree of the coincidence of stimulus B
    - Reference: Stimulus A
    - Grade index: 7 steps
  - Be allowed to move their head and upper body freely while listening to a sound

Grade	Judgment
3	Very good
2	Fairly good
1	Little good
0	The same
-1	Little bad
2	Fairly bad
3	Very bad

# Result (Experiment 1)

- Sound conditions (d) (Number: 10)
  - Viewers cannot discriminate the differences even if the horizontal panning is added
- Sound conditions (b) and (c) (Number: 4 & 6)
  - The number of loudspeakers is not reduced from 10



# Experiment 2

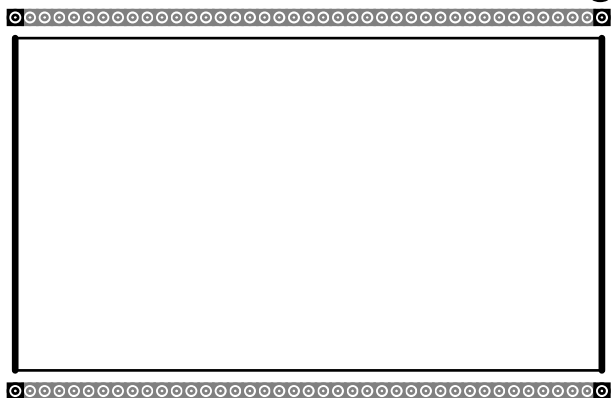
- Experiment 1
  - loudspeakers were always placed at four vertex positions of the rectangle display
- Teleconference system
  - It is not necessary to place loudspeakers at four vertex positions of the rectangle display
    - **Evaluate the effect of the sound conditions where loudspeakers are not placed at four vertex positions of the rectangle display**
- The same as Experiment 1
  - Environment, 3D video, Design and Procedure

# Condition (Experiment 2)

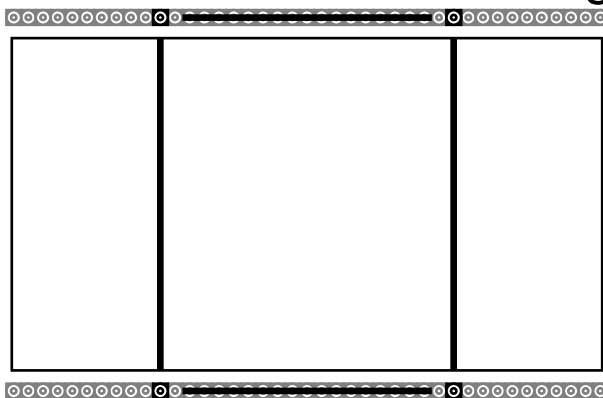
- Sound condition

- Reference conditions: (a), (e) and (f)

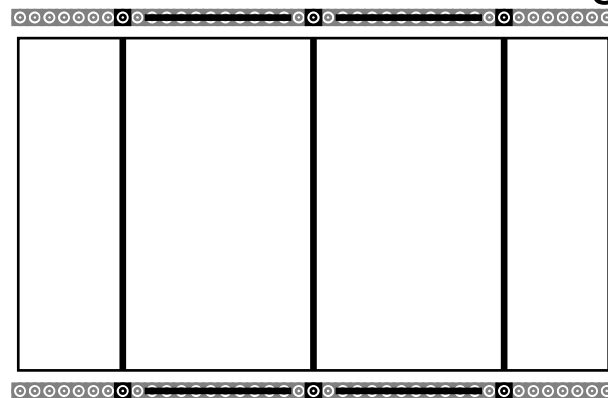
(a) 4 Loudspeakers,  
No Horizontal Panning



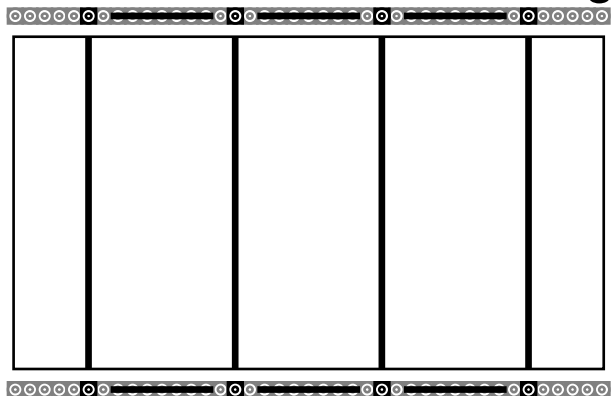
(b) 4 Loudspeakers,  
With Horizontal Panning



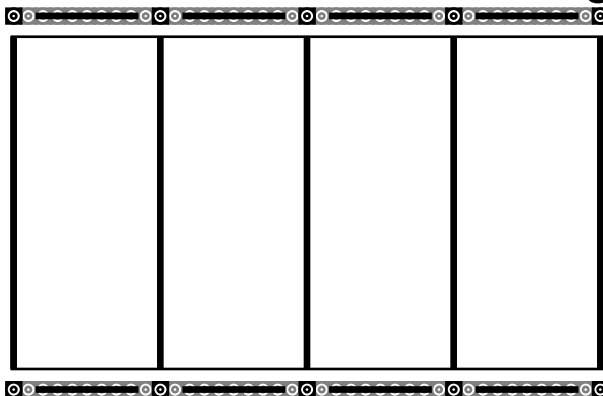
(c) 6 Loudspeakers,  
With Horizontal Panning



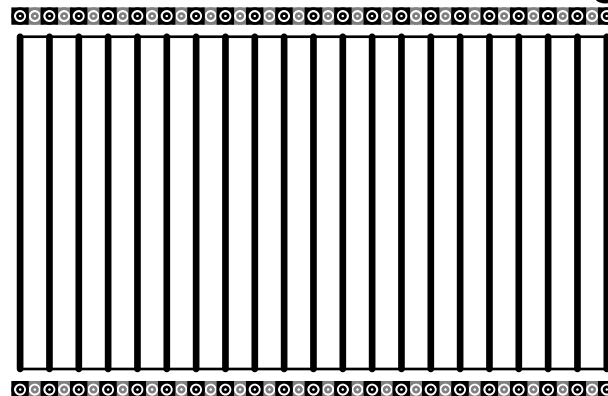
(d) 8 Loudspeakers,  
With Horizontal Panning



(e) 10 Loudspeakers,  
With Horizontal Panning



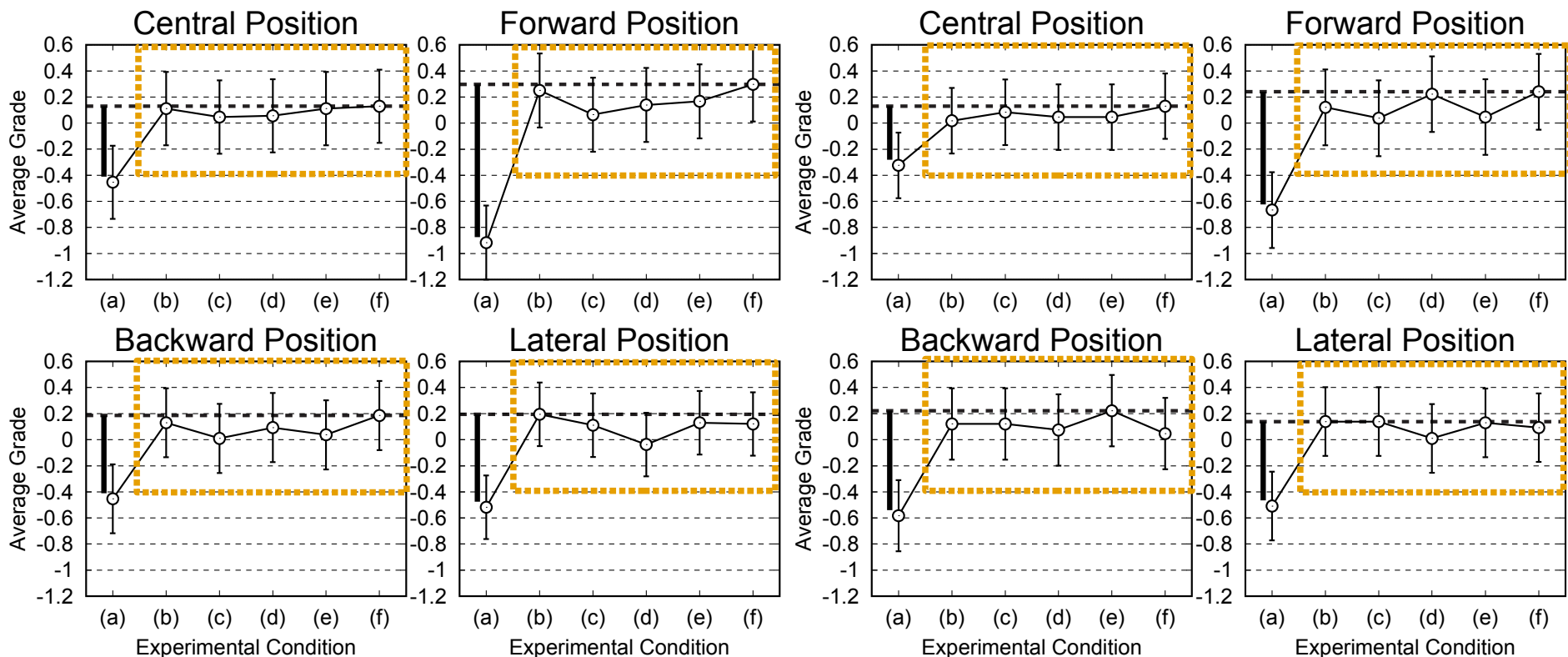
(f) 42 Loudspeakers  
No Horizontal Panning



# Result (Experiment 2)

- Sound conditions (b) to (f)
  - There are no significant differences in all the sessions

→ The number of loudspeakers can be reduced to 4



# Conclusion

- Proposed 3D audio system (MVP method)
  - Audio-visual experiment was performed to evaluate the effect of the horizontal panning
- Experiment 1
  - The performance is maintained even if the horizontal panning was added
  - The number of loudspeakers is not reduced from 10
- Experiment 2
  - The number of loudspeakers can be reduced to 4
- Future work
  - Implementation of teleconference system
    - Construction of microphone array for MVP method
  - Performance evaluation of implemented system