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Affordance in augmented reality exhibits on dinosaur

Seok-Hyun Ga[1], Hyun-Jung Cha[2], Hye-Gyoung Yoon[2]

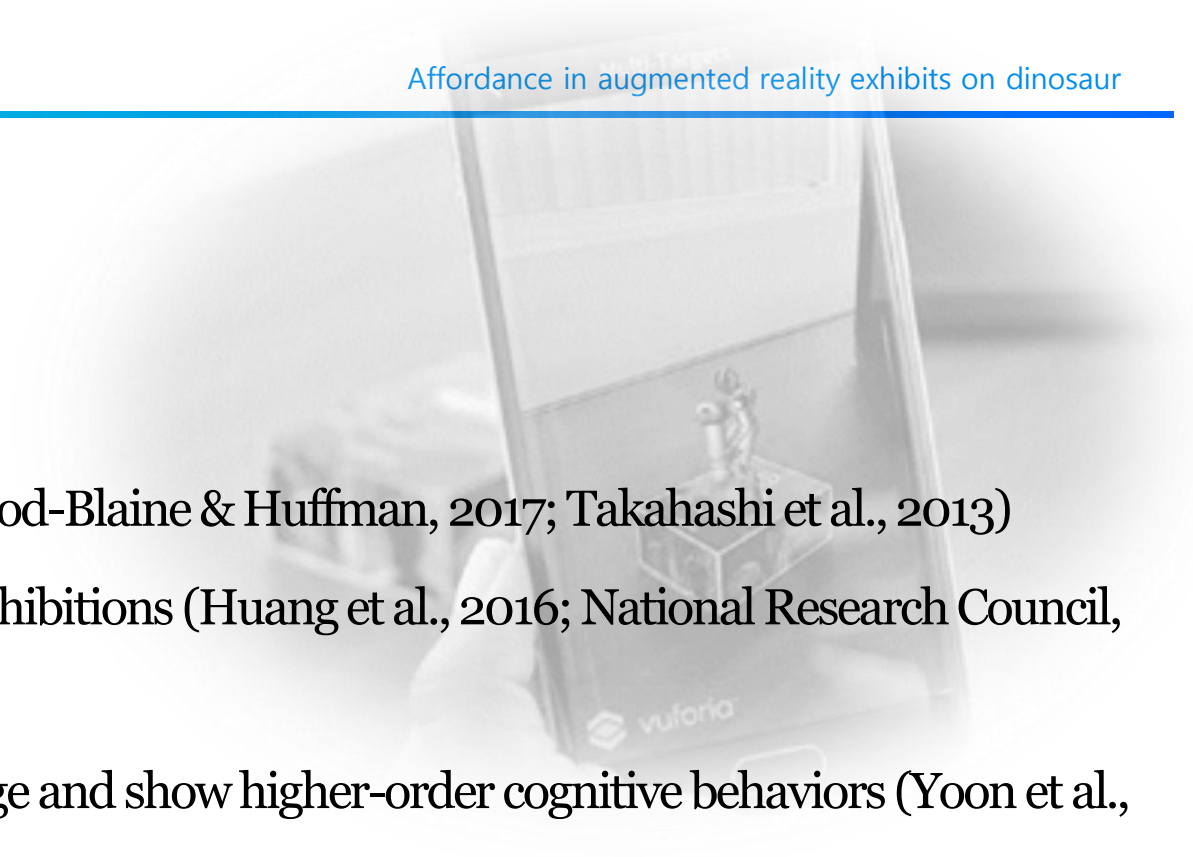
[1]National Taiwan Normal University, Taiwan

[2]Chuncheon National University of Education, Korea

1.1 Augmented Reality

- With the development of technology, science education contents are also evolving in various forms.
- As Mixed Reality (MR) technology, represented by Virtual Reality (VR) and Augmented Reality (AR), emerged as a key technology of the Fourth Industrial Revolution, various MR science education contents are being created.
- MR is one of the promising technology in the edtech due to
  - its immersive nature
  - ability to share information in new and engaging ways,
  - and potential to offer virtual experiences (Dick, 2021).

1.2 AR in Science Museum



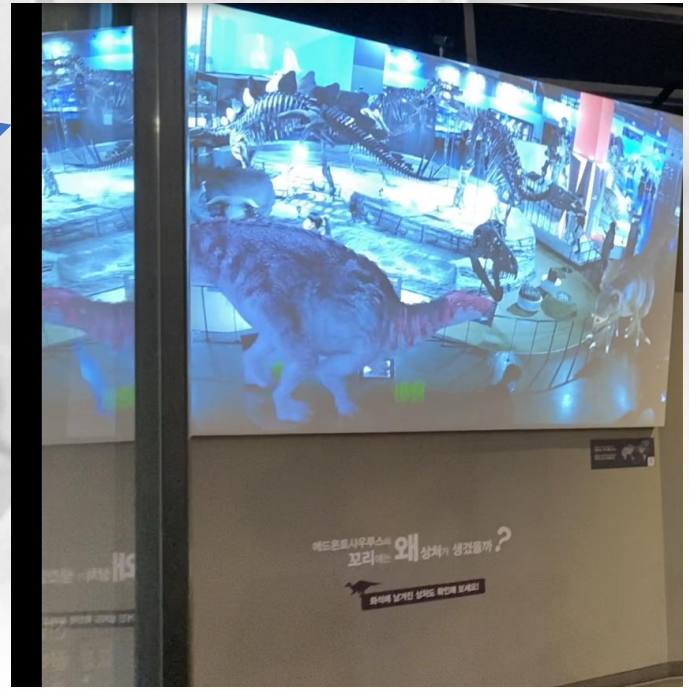
- Implications of Current Research
  - attracting attention and intriguing interest (Atwood-Blaine & Huffman, 2017; Takahashi et al., 2013)
  - making visitors more actively interact with the exhibitions (Huang et al., 2016; National Research Council, 2009; Yoon & Wang, 2014)
  - making visitors generate better content knowledge and show higher-order cognitive behaviors (Yoon et al., 2012; Yoon & Wang, 2014).
- Limitations of Current Research
  - Only studied the overall effect of the experience of AR exhibits on users.
  - It is rare to study the interaction of visitors with exhibits in detail.

In this research,

- Examining the effects of each affordance of an AR exhibit on users detailly
  - Target: an Augmented Reality exhibit dinosaurs in National Gwacheon Science Museum
    - One-way, non-interactive. The video is overlaid on the background of the interior of the exhibition hall and played repeatedly.
    - Reason for selection
      - recommended as a popular exhibit by an expert working in the same science museum
      - not an independent exhibition. installed in connection with the overall context of the exhibition hall
  - Analysis Unit: Affordance (Gibson, 1979; Norman, 1999; Gaver, 1991).

On the other side of the AR screen is the *Edmontosaurus* fossil having a tooth mark on its tail

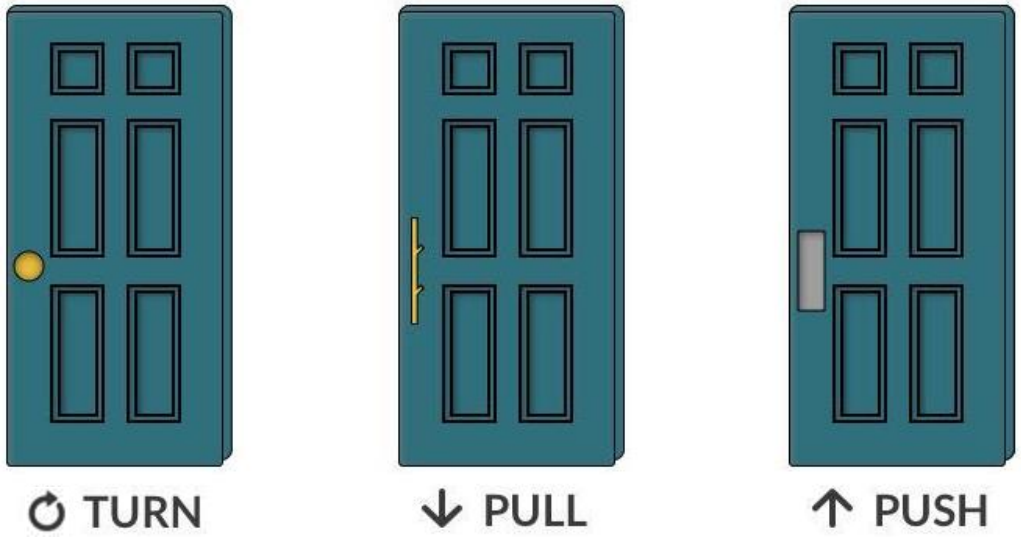
Natural History Exhibition Hall in Natl. Gwacheon Science Museum in Korea



Why did *Edmontosaurus* have a tooth mark on its tail?

1.3 What is affordance?

- Affordances were first introduced by psychologist James J. Gibson and written about in his 1977 article *The Theory of Affordances*.
  - Affordances "were the properties of an object that allow it to function." (Gibson, 1977)



sourced from Ettehadi (2021)

Physical clues of an object act as indicators of a desired action (Wesolko, 2015)

The shape of the handle determines the behavior of the person turning, pushing, or pulling.

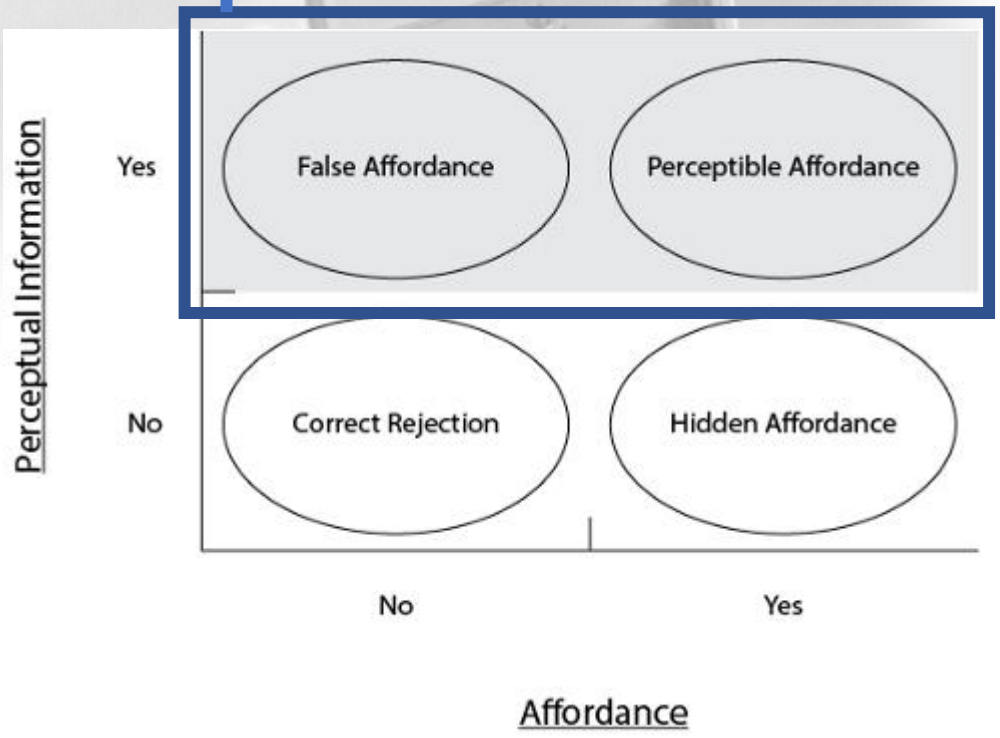
1.4 What is perceived affordance?

- Norman (1999) coined the phrase "perceived affordances" and began applying these principles to the field of human-computer interaction (HCI).
  - "perceived affordances by stating that **users perceive actions to be possible based on the design**, distinct from actions that are actually possible"

1.5 Gaver 's classification of affordance

- Gaver (1991) classified affordances according to the presence of perceptual information and affordance.
  - **perceptual information** ⇨ information perceptible to visitors about affordance
  - **affordance** ⇨ affordance intended by the exhibit

can be interpreted as 'perceived affordance' according to Norman (1999)'s view



Pros of Affordance view for exhibition researches

- By analyzing the affordances of the exhibit which affect the visitors, the interaction between the exhibit and the visitors can be examined more in-depth.
- It can offer detailed recommendations for how to enhance the exhibit.

2 Research Questions

1) What is the **intended affordance** of the dinosaur AR exhibit?

2) How does **the visitors' experience** about the intended affordance of the dinosaur AR exhibit?

3.1 Method – Intended Affordance of the exhibition

natural history museum
specialist interview

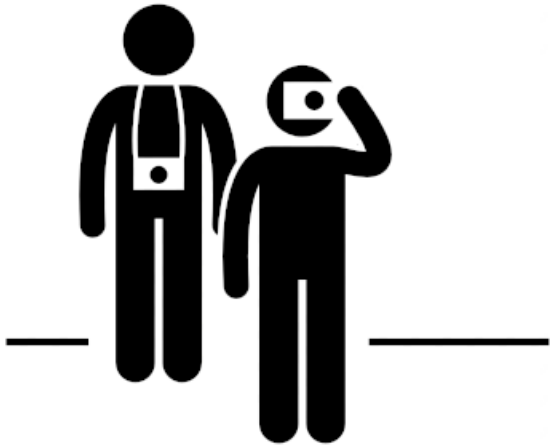
analysis

discussion among researchers

As a result, we discovered five intended affordance.

3.2 Method – Visitors' experience about the intended affordance

- Participants: 8 elementary school students 5-6 grade
- 2 visitors as a team, talking to each other and watching the exhibition hall

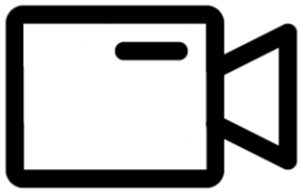


Explore freely the exhibition hall

interview about their experience

3.2 Method – Visitors' experience about the intended affordance

- The students' responses of each intended affordance were founded and classified as perceptible affordance, hidden affordance, and false affordance, according to Gaver's (1991) classification.



video

interview

first analysis

three times discussion among researchers

4.1 Results – Intended Affordance of the exhibition

	Photo	Contents	Intended Affordance
Affordance 1		A full-fledged dinosaur overlays above the dinosaur bone fossil.	It tells which fossil each dinosaur corresponds to and provides information about the actual dinosaur appearance of each fossil.
Affordance 2		Dinosaurs move around the audience	It draws the attention of visitors and induces interest by allowing them to feel the liveliness of dinosaurs.
Affordance 3		Footprints drawn on the floor	In the final scene of the video, a dinosaur threatens the visitors standing in the shape of a footprint, attracting their attention
Affordance 4		One Dinosaur Bites Another Dinosaur's Tail	To provide a scaffold for inferring the cause of tooth marks on Edmontosaurus fossils
Affordance 5		Below the AR screen is a text about th e focus to be seen in the video.	By telling visitors what to focus on in the video, it provides clues to the connection between the video and the existing fossil exhibits.

4.1 Results – Intended Affordance of the exhibition (Affordance 1)

- Contents: A full-fledged dinosaur overlays above the dinosaur bone fossil.
- Intention: It tells which fossil each dinosaur corresponds to and provides information about the actual dinosaur appearance of each fossil.

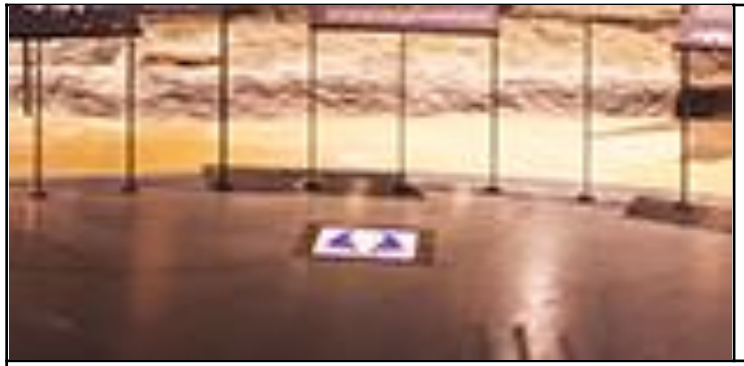
Perceived affordance	**Rate (%)**
A. trying to identify what kind of dinosaur fossils were (behavior)	Perceptible (37.5%) Hidden (62.5%)
B. succeeded in identifying which kind of dinosaurs were (cognition)	Perceptible (12.5%) Hidden (87.5%)

4.2 Results – Intended Affordance of the exhibition (Affordance 2)

- Contents: Dinosaurs move around the audience
- Intention: It draws the attention of visitors and induces **interest** by allowing them to feel the liveliness of dinosaurs.

Perceived affordance	**Rate (%)**
A. feel the presence of being with a dinosaur (emotion)	Perceptible (37.5%) Hidden (62.5%)
B. Shaking hands (behavior)	False (12.5%)

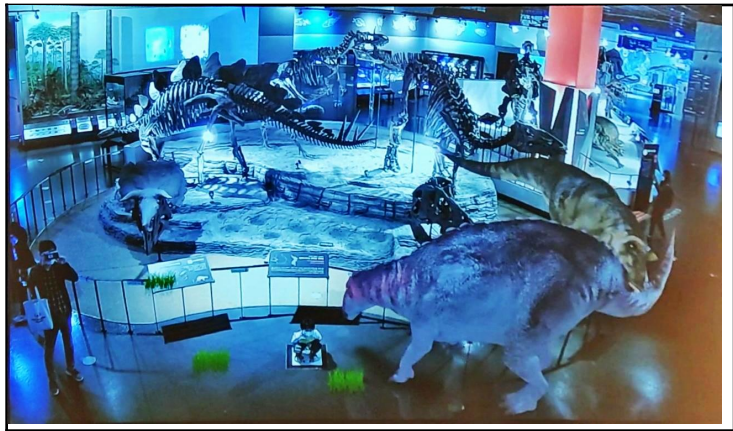
4.3 Results – Intended Affordance of the exhibition (Affordance 3)



- Contents: Footprints drawn on the floor
- Intention: It draws the attention of visitors and induces **interest** by allowing them to feel the liveliness of dinosaurs.

Perceived affordance	**Rate (%)**
A. Standing on the footprint (behavior)	Perceptible (25%) Hidden (75%)
B. Frightened or surprised to see a dinosaur threatening towards the location of the footprint (emotion)	Perceptible (0%) Hidden (100%)
C. Visitors think that the video starts when they stand in the footprint (cognition)	False (25%)

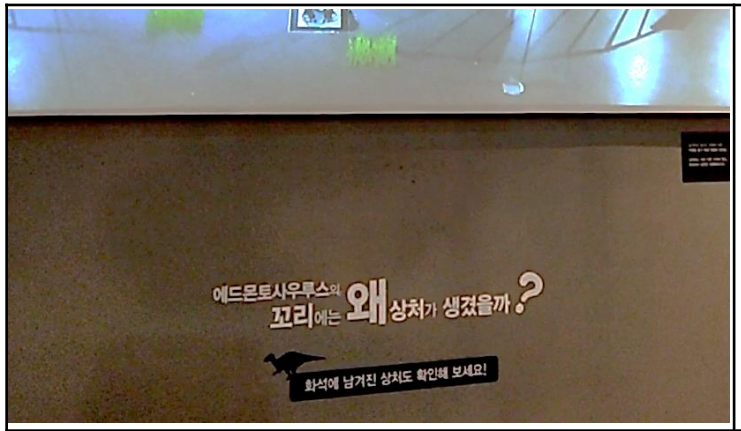
4.4 Results – Intended Affordance of the exhibition (Affordance 4)



- Contents: One Dinosaur Bites Another Dinosaur's Tail
- Intention: To provide a scaffold for inferring the cause of tooth marks on Edmontosaurus fossils

Perceived affordance	**Rate (%)**
A. Discover the cause of the wound on the dinosaur's tail (cognition)	Perceptible (25%) Hidden (75%)
B. Surprised or afraid to see a dinosaur appearing around visitors in AR video (emotion)	False (25%)

4.5 Results – Intended Affordance of the exhibition (Affordance 5)



- Contents: Below the AR screen is a text about the focus to be seen in the video.

  "Why is the Edmontosaurus tail scarred?"

- Intention: By telling visitors what to focus on in the video, it provides clues to the connection between the video and the existing fossil exhibits.

Perceived affordance	**Rate (%)**
A. reading the text (behavior)	Perceptible (75%) Hidden (25%)
B. trying to the reason of the tooth mark, following the text (cognition)	Perceptible (25%) Hidden (75%)

5 Discussion

- The dinosaur AR exhibit was **successful in attracting people**.
  - In general, the attraction power of visitors to the exhibits is only 5~26% (Boisvert & Slez, 1995)
    - attraction power: defined as “the percentage of visitors who stop and observe an exhibit for 5 seconds or more” (Boisvert & Slez, 1995)
  - Surprisingly, the attraction power of the dinosaur AR exhibit is 100% among all 8 participants.

5 Discussion

- We found three limitations in this AR exhibit.

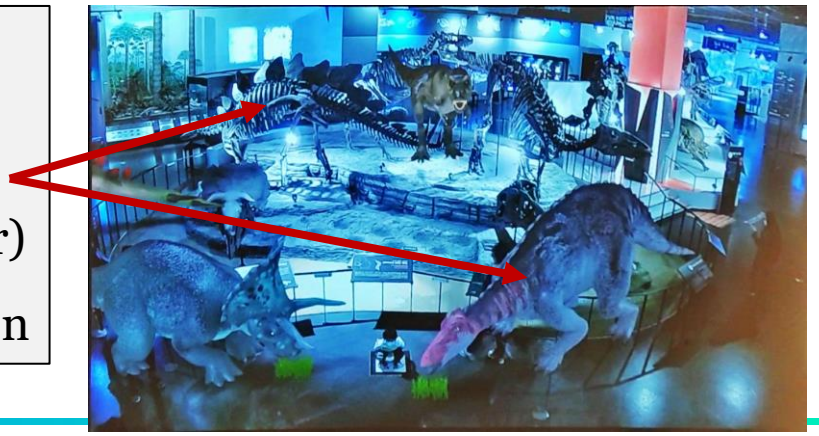
1. Visitors noticed that the dinosaurs in the video corresponding to the dinosaur fossils in the background. However, they did not try to find out what kind of dinosaur it was until the end.

(Looking at *Gorgosaurus*)

Visitor 2: Is it *Tyrannosaurus*?

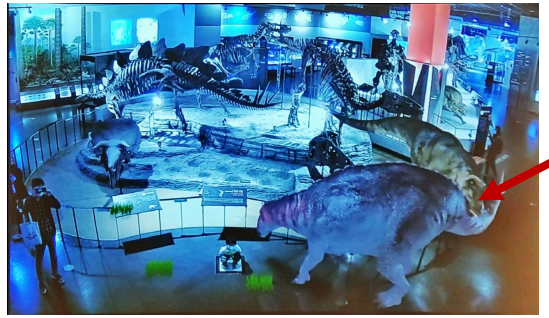
(only guessed for a moment and didn't try to find an exact answer)

*Excerpt from the transcript of the conversation



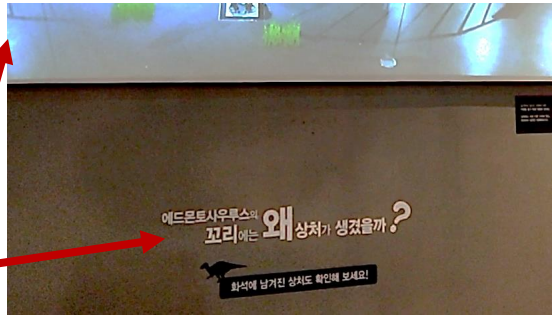
5 Discussion

2. The visitors did not notice the main purpose of the exhibition in terms of scientific reasoning.
   - Main purpose: Finding the cause of the tooth mark on the tail of the *Edmontosaurus* fossil
   - The students did not read the text below the AR screen.



Visitors don't think it has anything to do with the tooth-marked dinosaur fossil.

Due to the high illuminance of the AR screen, the text could not draw visitors' attention.



5 Discussion

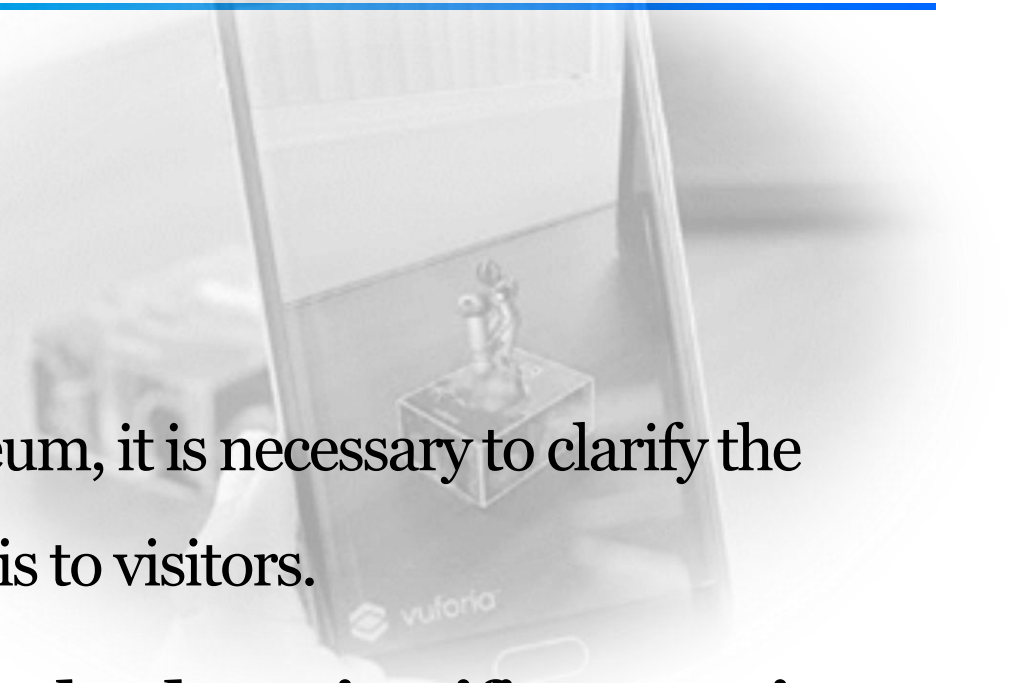
3. Visitors attempted unintended interactions with the exhibits (false affordance)

- related to their past experience (Osiurak et al., 2017)
- A false affordance is an opportunity to develop an exhibit.
- New function can be added to the exhibit so that the false affordance becomes a perceived affordance.

waving their hands at the dinosaur in AR

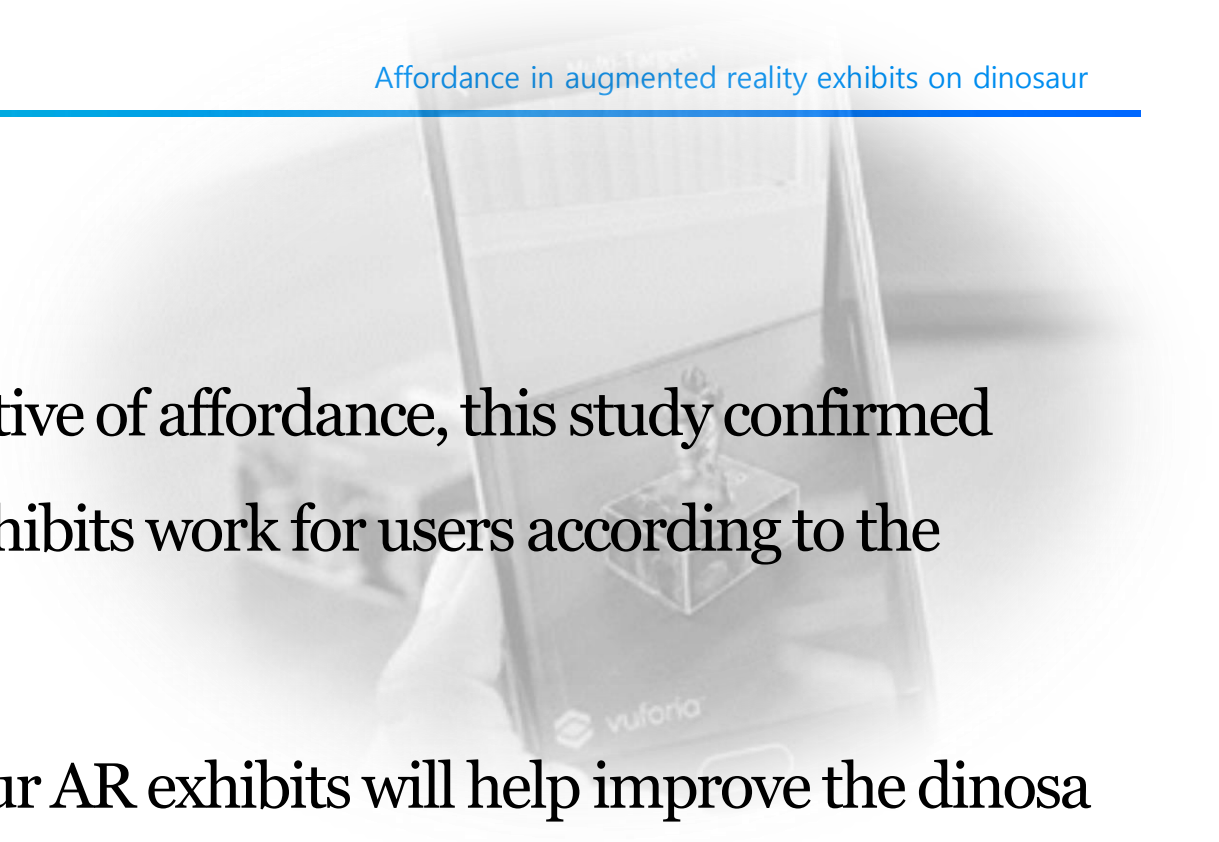
thinking the video starts when standing at the footsteps

6 Conclusion



- Perceptible affordance is under 25~37.5%.
- When planning an AR exhibition at a science museum, it is necessary to clarify the intended affordance and review how perceptible it is to visitors.
- The main affordance was not perceived and **did not lead to scientific reasoning**.
- If appropriate content related to false affordance is added, false affordance will beco me an effective perceptible affordance.

6 Conclusion



- By analyzing AR exhibits from the perspective of affordance, this study confirmed whether the affordances composing AR exhibits work for users according to the intention of the exhibits.
- The detailed research results of the dinosaur AR exhibits will help improve the dinosaur AR exhibits to become more effective exhibits for science education.

7 References

- Atwood-Blaine, D., & Huffman, D. (2017). Mobile Gaming and Student Interactions in a Science Center: The Future of Gaming in Science Education. *International Journal of Science and Mathematics Education*, *15*(1), 45–65. https://doi.org/10.1007/s10763-017-9801-y
- Boisvert, D. L., & Slez, B. J. (1995). The relationship between exhibit characteristics and learning-associated behaviors in a science museum discovery space. *Science Education*, *79*(5), 503–518. https://doi.org/10.1002/sce.3730790503
- Dick, E. (2021). *The Promise of Immersive Learning: Augmented and Virtual Reality's Potential in Education*. Information Technology and Innovation Foundation. https://itif.org/publications/2021/08/30/promise-immersive-learning-augmented-and-virtual-reality-potential
- Ettehadi, O. (2021, August 6). How to Avoid Bad Designs. *Njkhanh.Com*. https://njkhanh.com/how-to-avoid-bad-designs-p5f32333831
- Gaver, W. W. (1991). Technology affordances. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems Reaching through Technology - CHI '91*, 79–84. https://doi.org/10.1145/108844.108856

7 References

- Gibson, J. J. (1977). The Theory of Affordances. In R. Shaw & J. Bransford (Eds.), *Perceiving, Acting and Knowing: Toward an Ecological Psychology* (1st edition, pp. 67–82). Routledge.
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Houghton Mifflin.
- Huang, T.-C., Chen, C.-C., & Chou, Y.-W. (2016). Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment. *Computers & Education*, *96*, 72–82. https://doi.org/10.1016/j.compedu.2016.02.008
- National Research Council. (2009). *Learning Science in Informal Environments: People, Places, and Pursuits*. https://doi.org/10.17226/12190
- Norman, D. A. (1999). Affordance, conventions, and design. *Interactions*, *6*(3), 38–43. https://doi.org/10.1145/301153.301168
- Osiurak, F., Rossetti, Y., & Badets, A. (2017). What is an affordance? 40 years later. *Neuroscience & Biobehavioral Reviews*, *77*, 403–417. https://doi.org/10.1016/j.neubiorev.2017.04.014

7 References

- Takahashi, T. B., Takahashi, S., Kusunoki, F., Terano, T., & Inagaki, S. (2013). Making a Hands-On Display with Augmented Reality Work at a Science Museum. *2013 International Conference on Signal-Image Technology Internet-Based Systems*, 385–390. https://doi.org/10.1109/SITIS.2013.69
- Wesolko, D. (2016, October 31). The Theory of Affordances. *Medium*. https://danewesolko.medium.com/the-theory-of-affordances-cb51fd138b3e
- Yoon, S. A., Elinich, K., Wang, J., Steinmeier, C., & Tucker, S. (2012). Using augmented reality and knowledge-building scaffolds to improve learning in a science museum. *International Journal of Computer-Supported Collaborative Learning*, *7*(4), 519–541. https://doi.org/10.1007/s11412-012-9156-x