"PLEASE DO NOT TOUCH": RISK MITIGATION AND THE EFFICACY OF TOUCHING DETERRENTS

EVALUATION RESEARCH PROJECT

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Executive Summary

Background of the study
- This research looks at how visitors engaged with and make meaning of two 3D prints installed in galleries 20 and 21 of the Fitzwilliam Museum, and of one 3D print installed in the Museum of Cambridge.
- This study is part of the '"Please do not touch": risk mitigation and the efficacy of touching deterrents' research project.
- The 3D prints replicated parts of the objects: Egyptian Shrine (Room 20) and Honours for Antiochos I (Room 21)
- Visitors' engagement was qualitatively investigated through a combination of tracking (200 total), ethnographic observations, and semi-structured interviews (50 total).

Tracking results
Room 20
- The median dwell time was 123 seconds (2.05 minutes). The mean dwell time was 149 seconds (2.48 minutes)
- The Sarcophagus Lid and the Sarcophagus had the highest attractiveness, with respectively 96% and 88% of visitors stopping there.
- The Sarcophagus Lid and the Sarcophagus had the highest holding power (37s, and 34s).
Room 21
- The median dwell times was 148 seconds (2.46 minutes). The mean dwell time was 177 seconds (2.95 minutes)
- All elements of the display had similar attractiveness values, all lower than 50%.
- All elements had similar holding powers. Variations are mainly due to the content of cases and the length of interpretation panels.

Interview results
- Five pre-visit motivation categories were identified: a) learning (38); b) social (28); c) entertainment (16); d) place (12); e) flow and introspection (1). Visitors had multiple motivations for visiting, and they did not perceive different motivations as conflicting.
- Objects (11) and historical information (7) were identified as the favourite features of Room 20, followed by: the general experience offered (5); the interactive element (4); the personal connections with the history/objects on display (3); the conservation information (2); the Room layout (1).
- Objects (10) and historical information (7) were identified as the favourite features of Room 21, followed by: the personal connections with the history/objects on display (4); the general experience offered (2); and the interactive element (1).
- Least favourite aspects in Room 20 included poor lighting and lack of translations.
- Least favourite aspects in Room 21 included the presence of too many objects in the Room, the difficulty to follow the narrative, and the lack of translations.

Response to 3D prints
- 31 out of 100 tracked visitors touched the 3D print in Room 20.
- 25 out of 100 tracked visitors touched the 3D print in Room 21.
- The median dwell times were 12 seconds (Room 20), and 16 seconds (Room 21).

- The mean dwell times were 16 seconds (Room 20), and 17 seconds (Room 21).
- They had medium attractiveness values with 31% (Room 20) and 25% (Room 21) visitors stopping there.
- Only 4 interviewees (out of 50) recognised that the replicas were 3D printed.
- 23 interviewees (out of 50) claimed to be familiar with 3D technology
- 9 interviewees (out of the 23 familiar with 3D tech) mentioned that they came across 3D prints/models of other museums' artefacts.
- The response to 3D prints was generally positive. They were described as an engagement tool for children and adults, a learning tool, and a tool for conservation. In general, visitors expressed excitement and interest at the possibility of touching them.
- Criticism included the lack of information and interpretation, confusion for the material/ technology used, concerns about the value and the function in the galleries.
- Suggestions for improvement included to add more colours; to make signage clearer; to integrate with family activities; to better advertise them outside the Room; to increase the number of 3D prints in the whole museum; to add information about the 3D prints; to add a translation of the Greek text and of the hieroglyphics; to explain the technology.

Ethnographic observations of interactions with 3D prints
- Different types of interactions were observed, depending on the group composition and the age of visitors.
- The majority of elderly visitors did not touch the 3D prints.
- Families' interactions were either initiated by an adult, or by the child (usually mirroring the strategy employed to explored together the rest of the gallery. Children tended to focus their attention on the 3D print, expressing enthusiasm at the possibility to touch. Adults guided the children in the tactile interaction with the 3D print and in the visual one with the original object.
- Single adults and groups of adults tended to either briefly touch them or to engage in meaningful interactions, comparing them with the original objects.
- Children part of organised groups tended to touch the 3D prints focusing on how they felt and on why they could touch those and not the original objects.
- Single adults tended to spend the longest time touching the 3D prints and engaging with the original objects.
- A minority of observed adults and children from each type of group touched other objects in both galleries, despite the 'please do not touch' signs.

Museum of Cambridge results
- Different types of interactions with the 3D print of the leather boot were observed, depending on the group composition and the age of visitors.
- Elderly visitors did not touch the 3D print.
- Organised groups either briefly touched it or followed the label interpretation.
- Families engaged the most with the 3D print, following the label interpretation and comparing it to the original objects.
- Single and groups of adults seemed less interested in the 3D print.

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1. Background

1.1 The 3D prints

The evaluation research is carried out as part of the '"Please do not touch": risk mitigation and the efficacy of touching deterrents' research project of the Fitzwilliam Museum, Cambridge. The project is testing the use of 3D models and prints of the Fitzwilliam Museum's collection to provide a tactile experience for visitors.

1.2 The display

As part of the project, two 3D prints have been installed in two permanent galleries of the Fitzwilliam Museum. Both 3D prints have been installed near the original object, with a purposefully designed 'Please touch' green sign. No other forms of interpretation (labels, panels etc.) were added.

- Object 1: Egyptian Shrine – Gallery: Gayer Anderson (Room 20)
- Object 2: Honours for Antiochos I – Gallery: Greek/Roman (Room 21)

Figure 1. Overview of the 3D print in Room 20.

Figure 2. Overview of the 3D print in Room 21.

1.3 Brief for Evaluation

The evaluation research protocol is designed to assess how visitors interact with the 'Do Not Touch' 3D printed objects in the two galleries and to inform the project's outcomes.

The objectives are to understand:

1. visitors' motivation.
2. visitors' interactions with 3D prints.
3. visitors' interactions with original object.
4. visitors' general understanding of original objects in relation to 3D prints.
5. visitors' understanding of the museum and conservation in relation to 3D prints.
6. values that visitors associate with 3D prints.
7. values of tangible properties visitors associate to 3D prints (colour, shape, material).
8. visitors' level of engagement with 3D prints and original objects.
9. visitors' desire to touch original objects and/or 3D prints.
10. impact of 3D prints on making of meaningful insights.
11. visitors' expectations regarding tactile resources and technology in the galleries.

2. Methodology

The evaluation research is carried out through applied research. The methodology is naturalistic qualitative.

2.1 Methods

- 'Pen and paper' tracking/field notes
- Ethnographic observations of interactions with 3D prints
- Semi-structured interviews with visitors that interacted with 3D prints
- Semi-structured interviews with visitors selected randomly

2.2 Target audience

General public

2.3 Alignment between objectives and methods

Objectives	Methods
1. visitors' motivation	Semi-structured interviews Ethnographic observation
2. visitors' interactions with 3D prints	Tracking/fieldnotes Semi-structured interviews Ethnographic observation
3. visitors' interactions with original object	Tracking/fieldnotes Semi-structured interviews Ethnographic observation
4. visitors' general understanding of original objects in relation to 3D prints	Semi-structured interviews
5. visitors' understanding of the museum and conservation in relation to 3D prints	Semi-structured interviews Ethnographic observation
6. values visitors associate with 3D prints	Semi-structured interviews Ethnographic observation

7. values of tangible properties visitors associate to 3D prints (colour, shape, material)	Semi-structured interviews
8. visitors' level of engagement with 3D prints and original objects	Tracking/fieldnotes Ethnographic observation
9. visitors' desire to touch original objects and/or 3D prints	Semi-structured interviews Ethnographic observation
10. impact of 3D prints on the meaning-making	Semi-structured interviews Ethnographic observation
11. visitors' expectations regarding tactile resources and technology in the galleries	Semi-structured interviews

2.4 Evaluation design

Tracking

As visitors moved through the exhibition space, the researcher observed them, tracking their movements on a map of the galleries (Appendix a). Tracking started once the visitor first set foot in the gallery; a random sample was tracked. One of the main components of the sheet was labelling the viewing strategy of the visitors[1]:

- <u>Browsers</u> are those who moved through the exhibition following a random path, stopping in front of elements that most caught their attention;
- <u>Followers</u> are those who moved through the space following a linear narrative path;
- <u>Completists</u> are those who stopped in front of all or most of the elements of the exhibition

200 visitors were tracked between the 13th of June 2019 and the 1st of September 2019.

Ethnographic observations

The researcher observed and took notes of how visitors interacted with the 3D prints and the original objects. Observation continued and it was recorded how visitors interacted with other elements of the exhibit (in particular, whether they touched other artefacts or not).

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[1] This categorisation comes from the British Museum meaning making framework (Batty et al. 2016) that implemented the model by Morris Hargreaves McIntyre (2005).

Semi-structured interviews

Visitors that interacted with the 3D prints were approached as they were leaving Room 20 or Room 21. Interactions comprised those who touched the 3D prints (15 visitors per Room) and those who looked at them but did not touch them (10 visitors per Room).
A thematic semi-structured protocol was used (Appendix c). 50 visitors agreed to be interviewed between the 13th of June 2019 and the 1st of September 2019.

3. Tracking results

This section records the behaviour in the gallery of the 200 tracked visitors. 100 visitors were tracked in Room 20, 100 visitors were tracked in Room 21.

3.1 Walkthroughs

Walkthroughs values represent those who did not spend sufficient time in the gallery or interact with enough of the exhibition for meaningful tracking.

The numbers of recorded walkthroughs were:

- Room 20: 21 from a total of 121
- Room 21: 24 from a total of 124
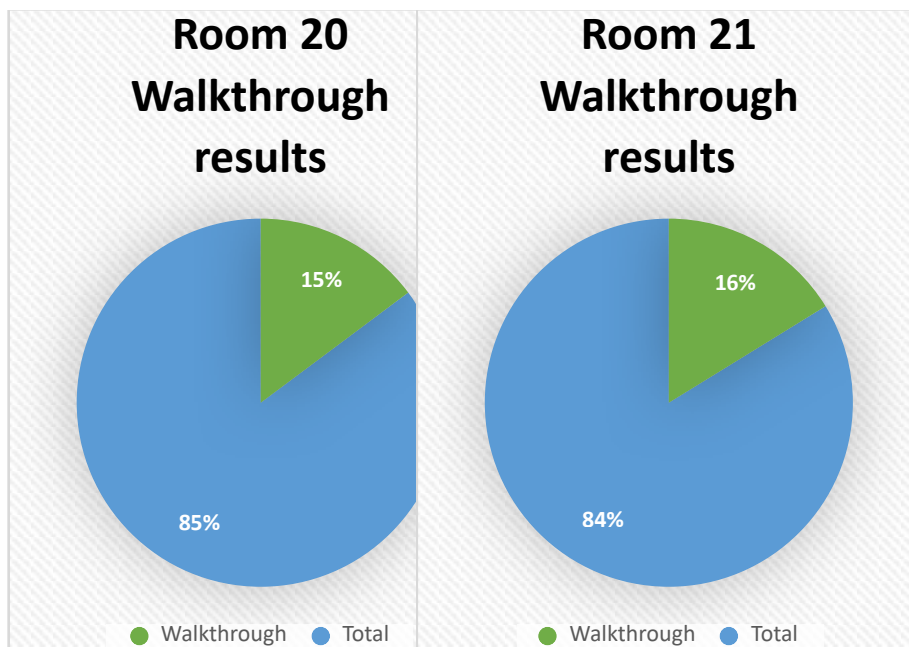
Figure 3. Walkthrough results expressed as percentages.

The median dwell times for walkthrough were:

- Room 20: 18 seconds
- Room 21: 26 seconds

3.2 Dwell Time

The median dwell time of tracked visitors were:
- Room 20: 123 seconds (2.05 minutes)
- Room 21: 148 seconds (2.46 minutes)

The mean dwell time of tracked visitors were:
- Room 20: 149 seconds (2.48 minutes)
- Room 21: 177 seconds (2.95 minutes)

In both rooms, there was a slight dwell time difference between groups that consisted of adults alone, group of adults, and those that included children.
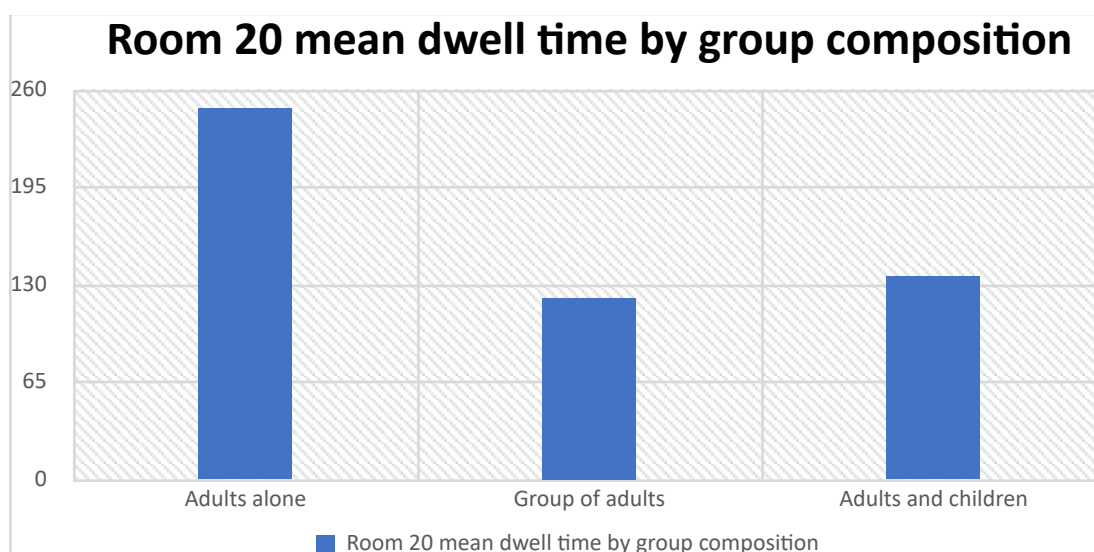
Figure 4. Room 20: mean dwell time by group composition.
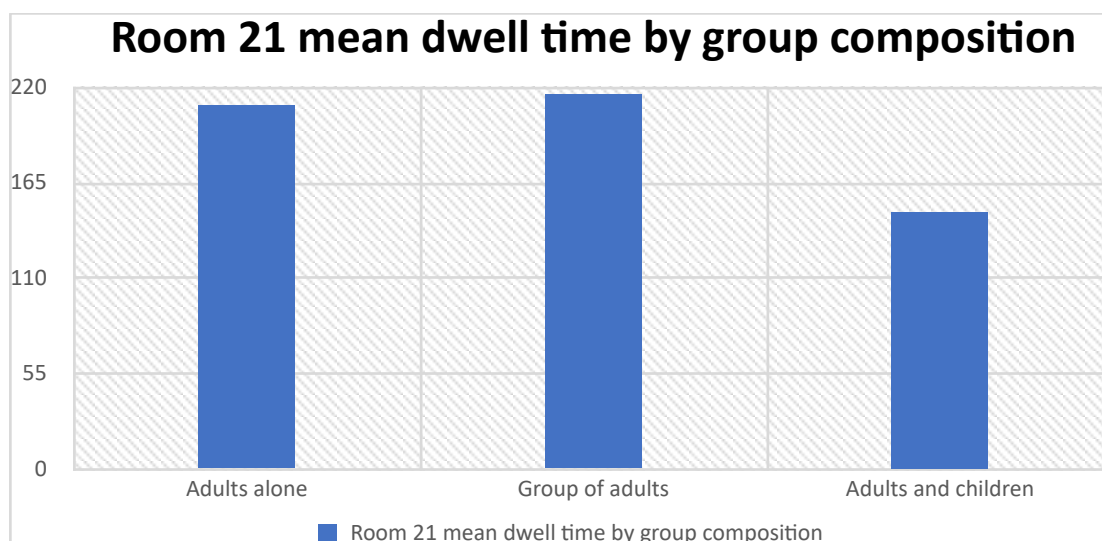
Figure 5. Room 21: mean dwell time by group composition.

- Room 20

The longest tracked visit lasted 1554s (25.09m), by a single adult visitor. 3 other tracked visits lasted longer than 15 minutes, 2 of which were single adults, and 1 of which was a group of adults and children. The longest tracked visit by a group that included children was of 927s (15.45m). The shortest tracked visit was 38s and consisted of a group of two adults.

- Room 21

The longest tracked visit lasted 1077s (17.95m), by a single adult visitor. 11 other tracked visits lasted longer than 10 minutes, 4 of which were single adults, 5 of which were groups of adults, and 2 of which were groups of adults and children. The longest tracked visit by a group that included children was 687s (11.45m). The shortest tracked visit was 44s and consisted of a group of three adults.

3.3 Viewing strategy

After tracking, visitors were assigned to one of the three categories of viewing strategy: browser, follower and completist.

Figure 6. Room 20 breakdown of viewing strategy.
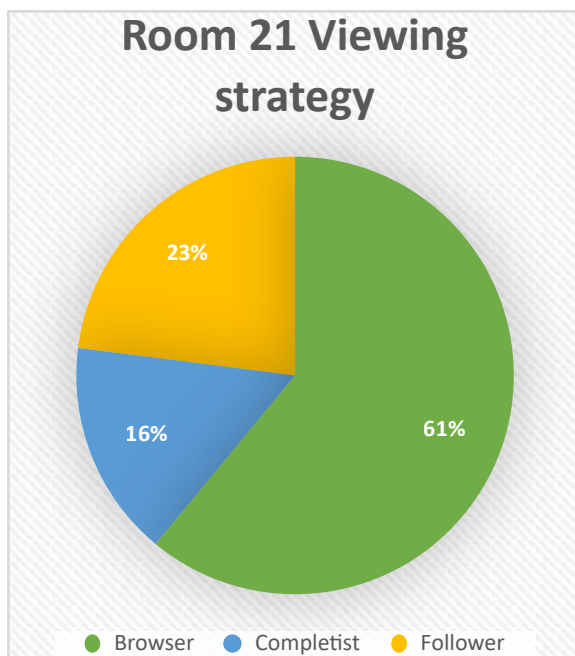
Figure 7. Room 21 breakdown of viewing strategy.

Based on visitors' path, number of stops, and dwell time at each case stopped at, each track was grouped into one of three different categories. Categories come from Francis' (2016) and MHM (2005) frameworks of viewing strategy classification.

These results show in both rooms an overwhelming amount of 'browsers' at 57% and 61%, succeeded by 'followers' at 23% and 23%, and 'completest' visitors coming after at 20% and 16%. This is not surprising as studies that employ a similar system of categories find the distribution of visitors to heavily favour 'browsers', with 'followers' coming in second. This suggests that the majority of visitors in the room tend not to use continuously the 'narrative' set by the museum, as they simply browse through the gallery. These findings are consistent with the motivations explored in section 4.2.3.

3.4 First and second stop

On the heat maps below are shown the first stop for tracked visitors and the pathway they followed. The path is more defined in Room 20, where there are only 2 entrances and one main gateway object, the sarcophagus lid. It is more difficult to identify the route in Room 21, as there are 4 different entrances, and no gateway object was identified.

Room 20

	0-1%
	2-3%
	9-25%
	60+%
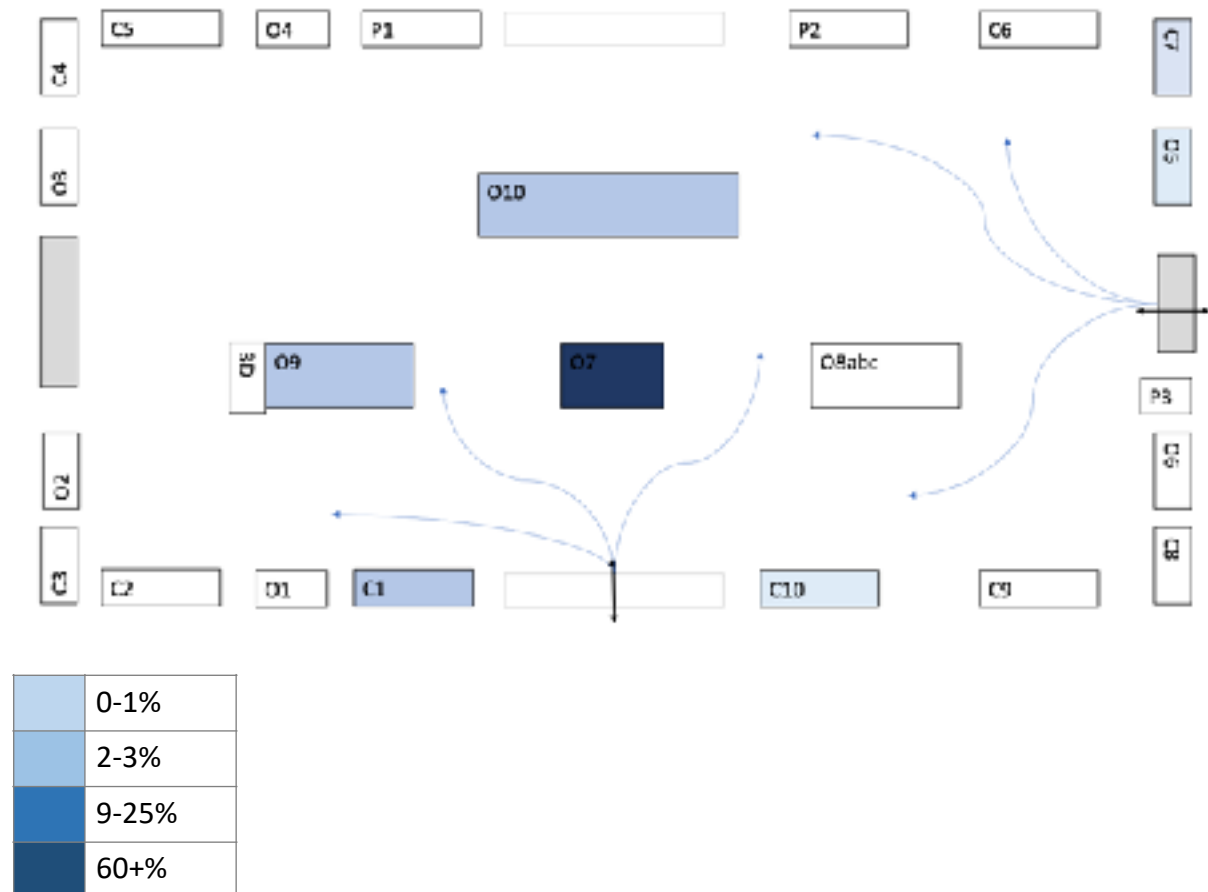
Figure 8. Room 20: heat map showing first stop (colour blocks) and direction of second stop of the tracked visitors (arrows).

Room 21
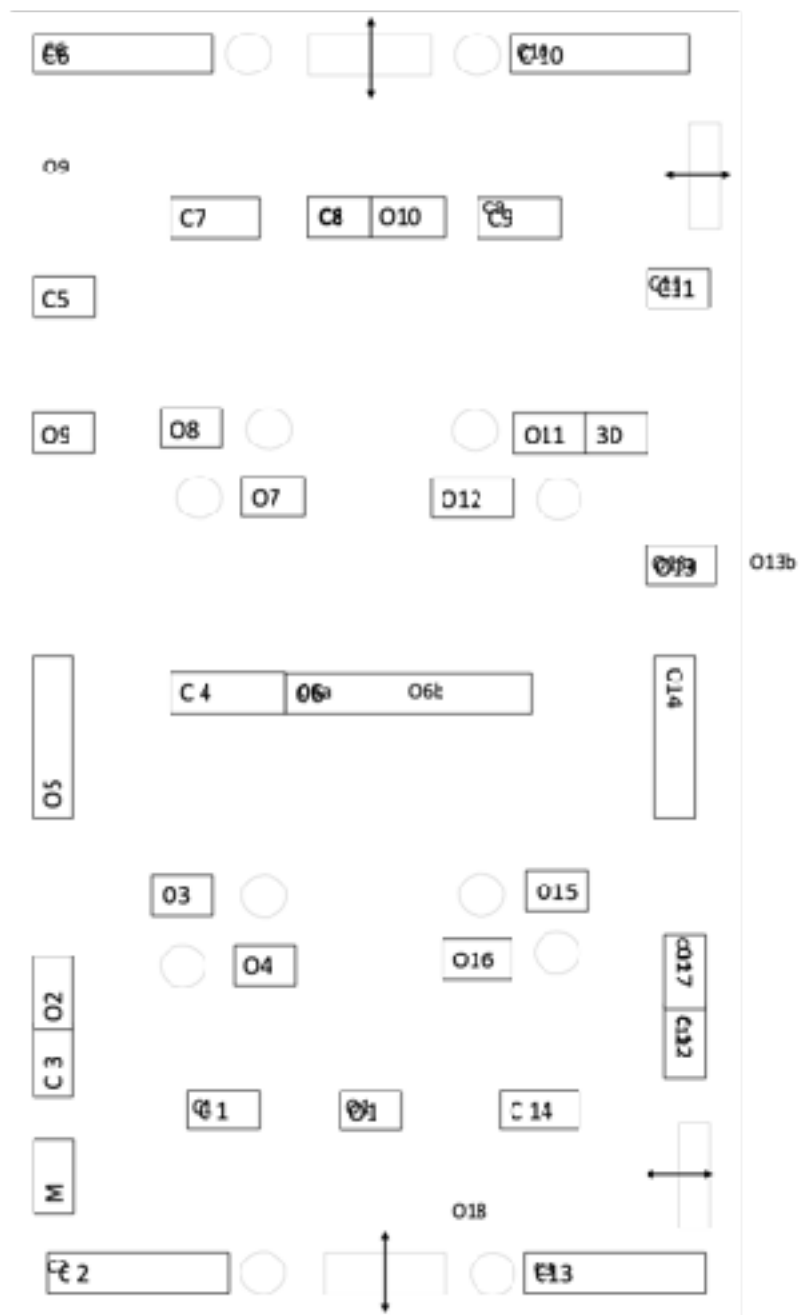
	0-1%
	2-3%
	9-25%
	60+%

Figure 9. Room 21: heat map showing first stop (colour blocks) and direction of second stop of the tracked visitors (arrows).

3.5 Attractiveness

The attractiveness of a display element is defined here as the percentage of visitors who stopped to interact with it.
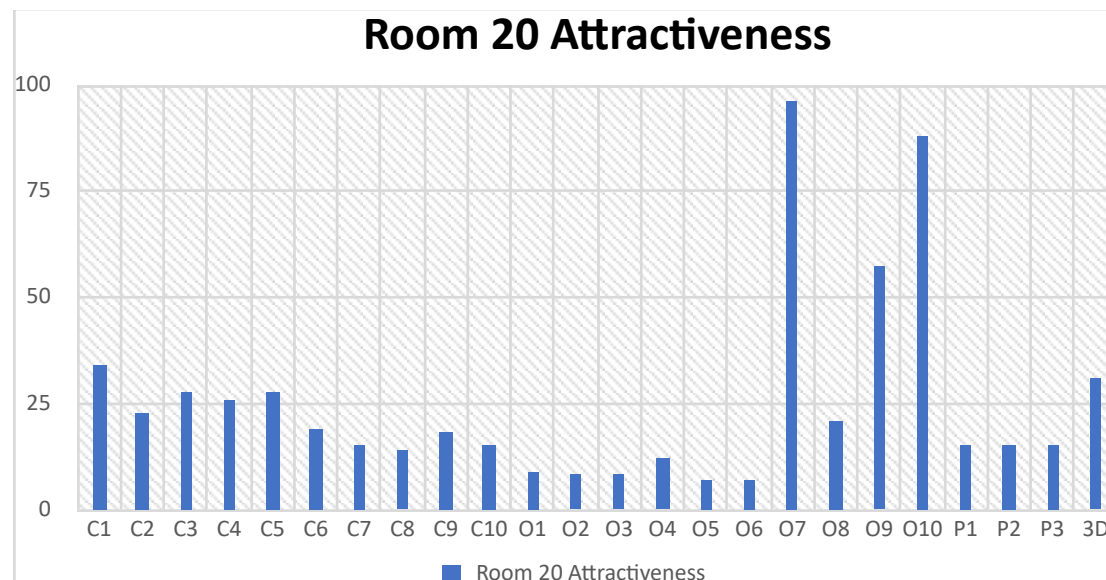
Figure 10. Room 20: attractiveness of each element of the display, measured as a percentage.
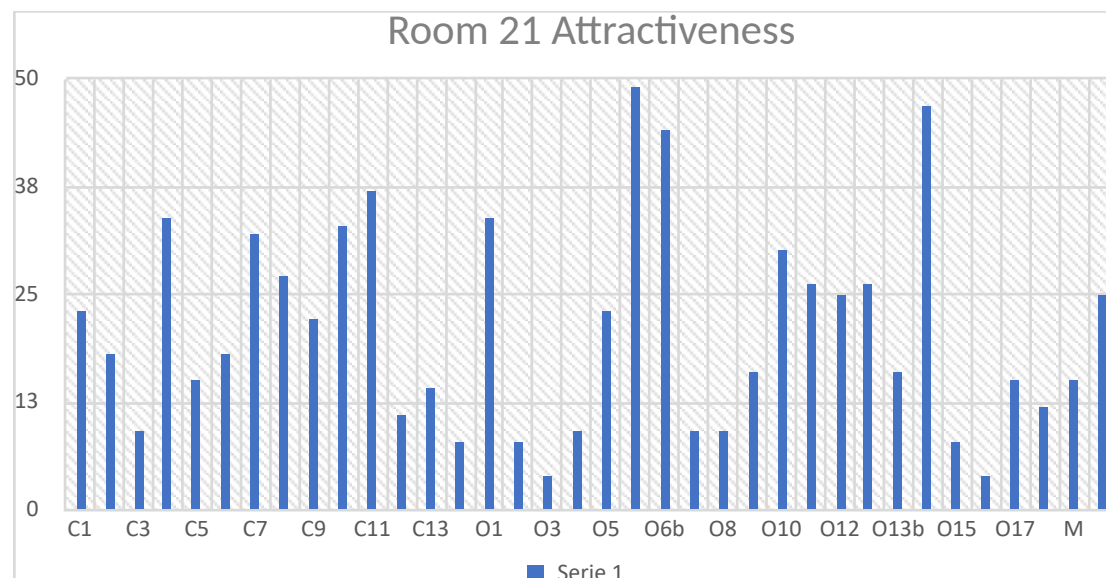
Figure 11. Room 21: attractiveness of each element of the display, measured as a percentage.

Unsurprisingly, in Room 20 the Sarcophagus Lid was the most popular (96%), closely followed by the Sarcophagus (88%), and the Shrine (57%). Comparatively, the other objects proved to have a low attractiveness, with less than 40% of the audience stopping to view them.

In Room 21, all objects had low but consistent attractiveness values, all ranging below 49%. This is not surprising, as the layout of the room and the 4 entry points make it difficult to focus on one or more gateway objects.

3.6 Holding power

A unit's Holding Power is defined here as the mean time spent by visitors interacting with it.

Room 20
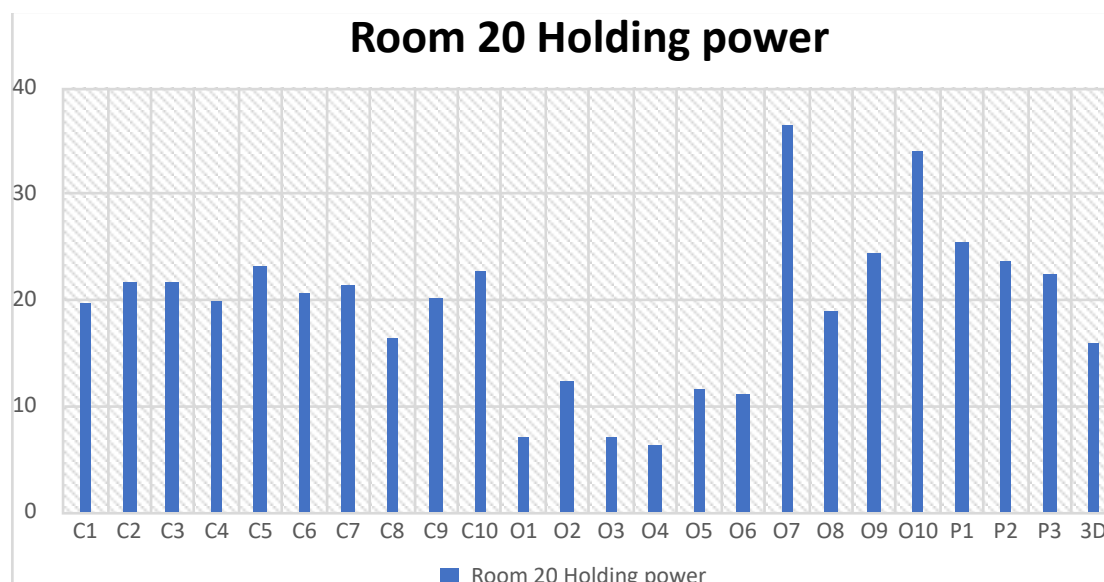
Figure 12. Room 20: holding Power of each display unit, measured as the mean time spent by visitors engaging with it.

Room 21
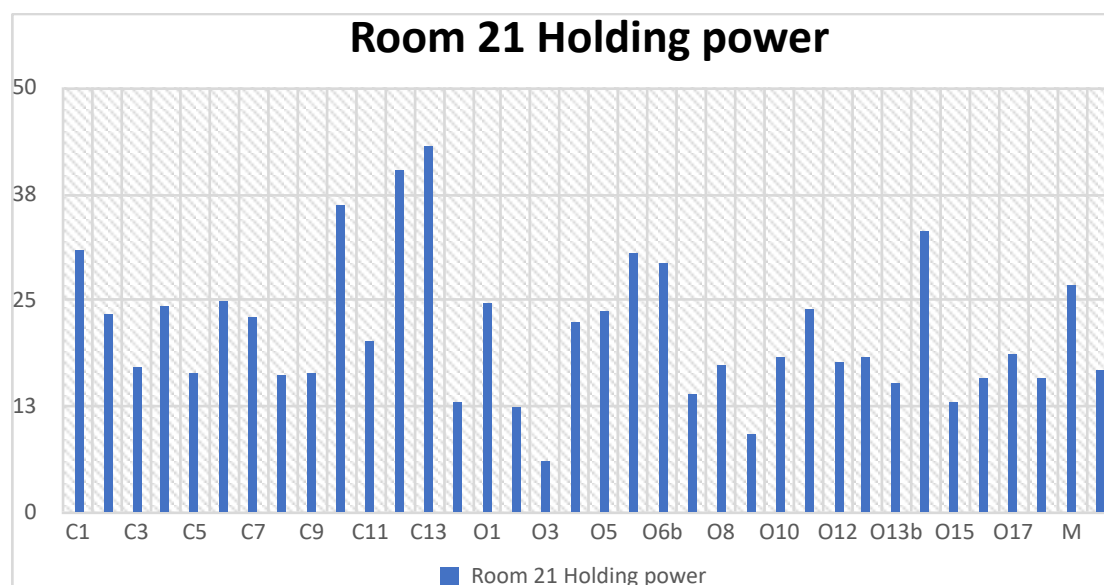
Figure 13. Room 21: holding Power of each display unit, measured as the mean time spent by visitors engaging with it.

Holding power values are consistent with attractiveness values (section 3.5). In Room 20, the sarcophagus lid (37s), the sarcophagus (34s) had the highest holding power. All elements of Room 21 had similar holding powers. Variations are mainly due to the content of cases and the length of interpretation panels.

4. Interview results

50 visitors agreed to be interviewed. 25 were interviewed in Room 20, and 25 in Room 21. 30 visitors (15 in each room) were selected as they touched with the 3D prints. 20 visitors (10 in each room) were selected as they saw but did not touch the 3D prints.

4.1 Visitors' profile

4.1.1 Gender
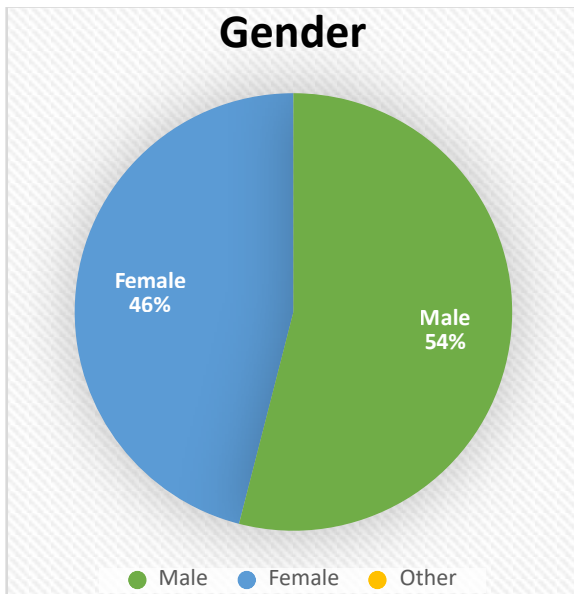
Figure 14. Gender of interviewees.

4.1.2 Age Group

Age Group
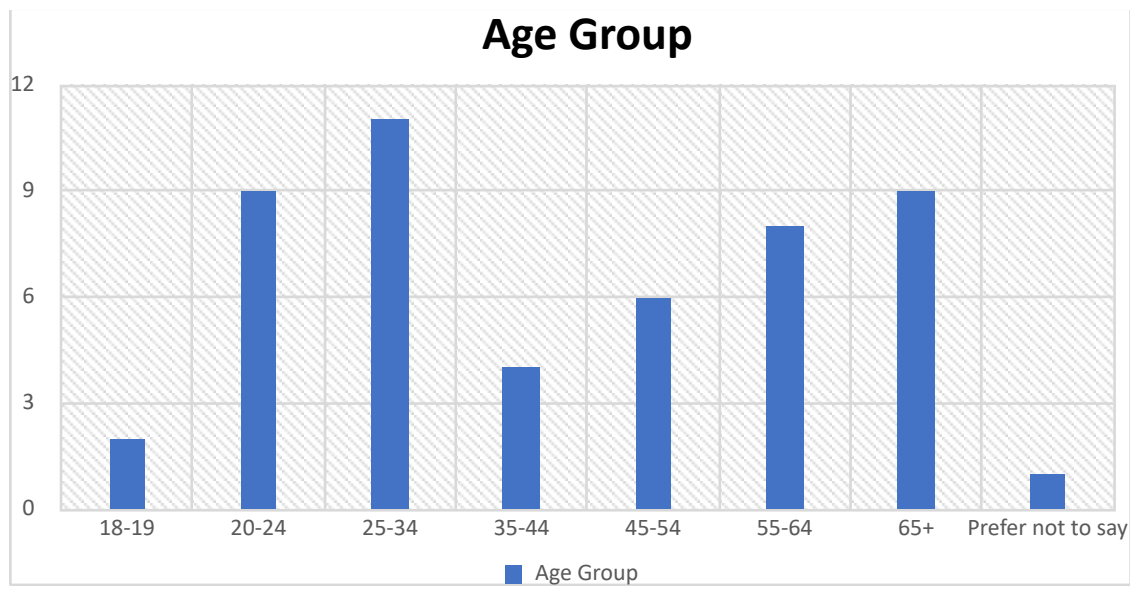
Figure 15. Age range of the interviewees.

4.1.3 Nationality and country of residence

Interviews were carried out in English, Spanish, and Italian.
12 nationalities were recorded:
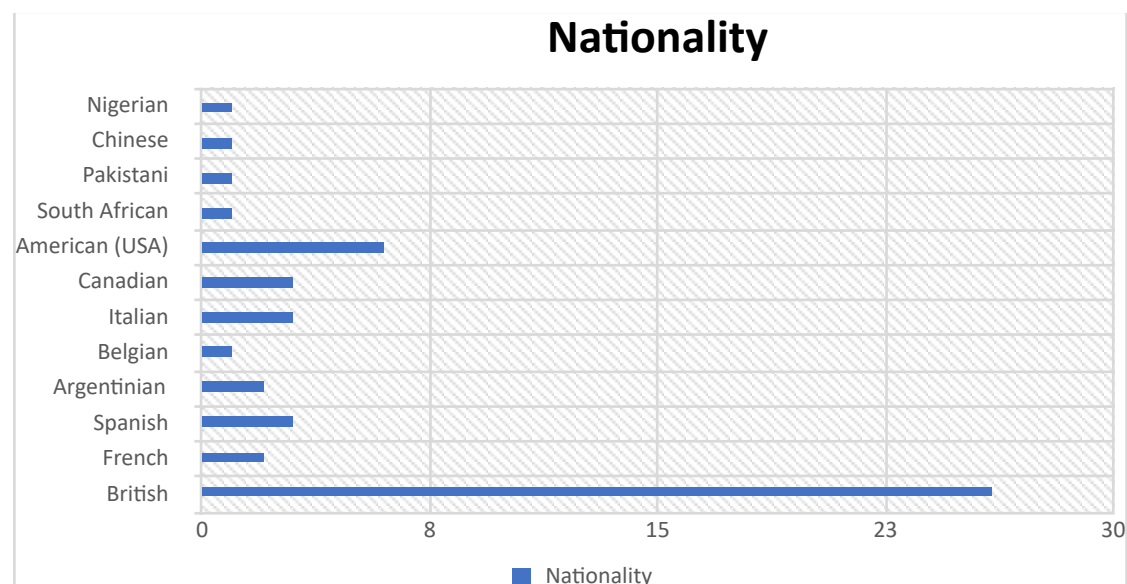
Figure 16. Nationality of interviewees.

8 countries of residence were recorded:
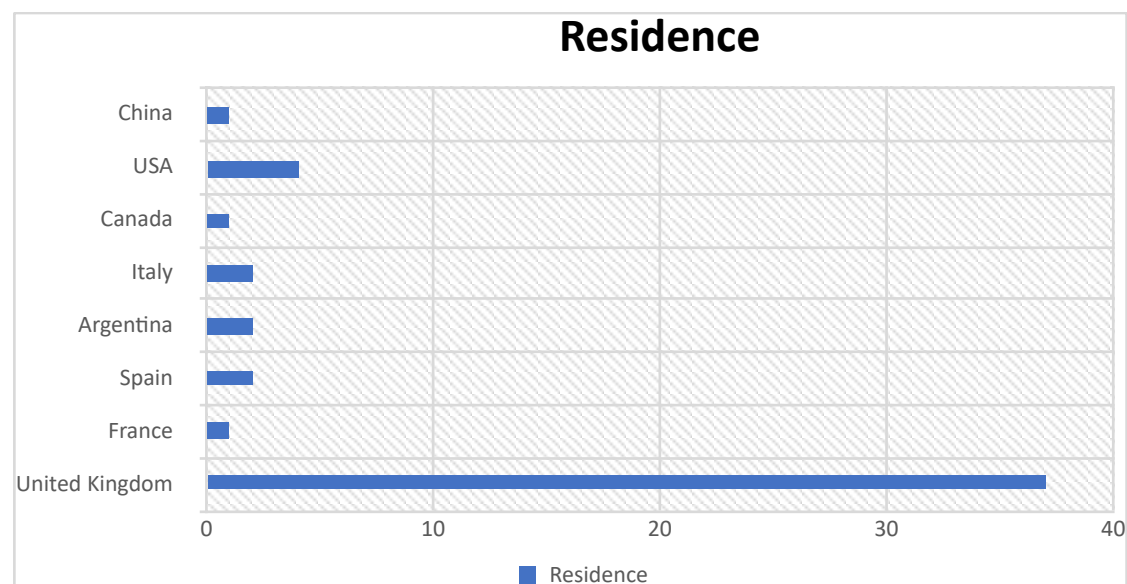
Figure 17. Country of residence of interviewees.

6 first languages were recorded:
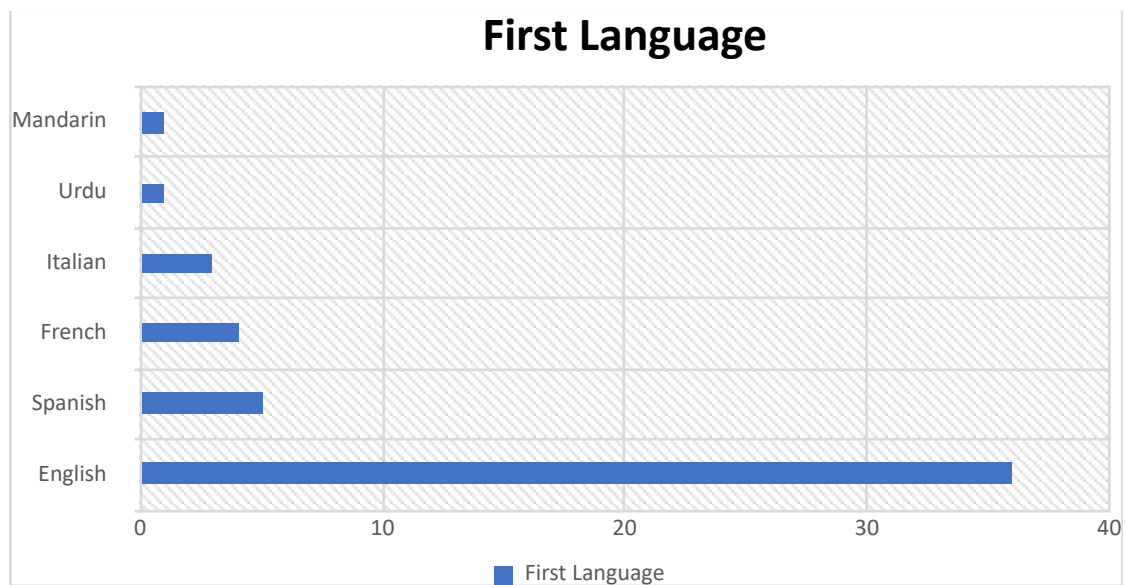
Figure 18. First languages of interviewees.

4.1.4 Group composition

Group composition

- 36% Alone
- 4% Organised group
- 20% Family
- 18% Partner
- 22% Friends

Legend: ● Alone ● Organised group ● Family ● Partner ● Friends ● Other
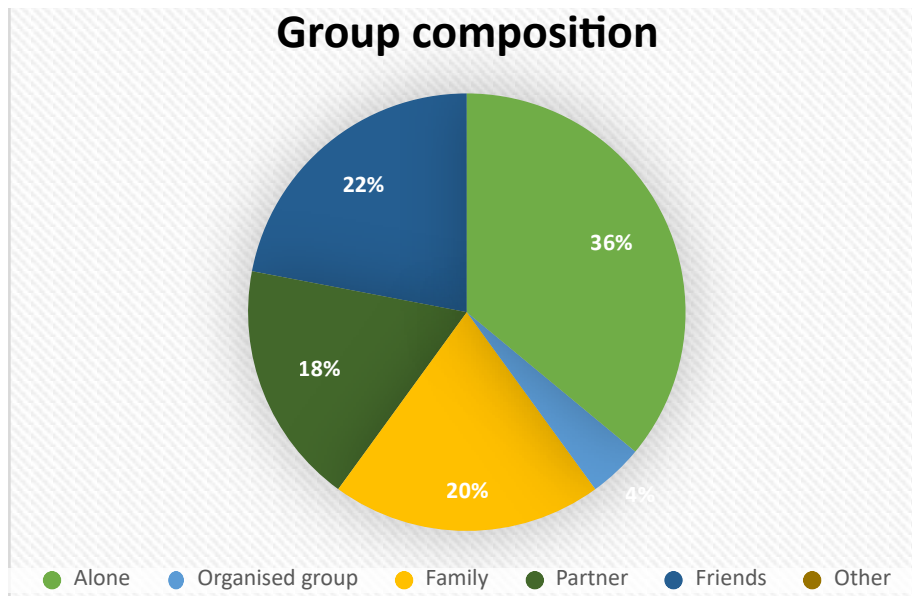
Figure 19. Group composition of interviewees.

The majority of visitors that agreed to be interviewed was visiting on their own (18 out of 25). Interviewees that visited with friends and family were 11 and 10 respectively. 8 interviewees visited with their partners, and 2 were part of an organised group.

4.1.5 Visiting habits

Interviewees were asked if they had visited the Fitzwilliam museum before and, if so, on how many occasions.
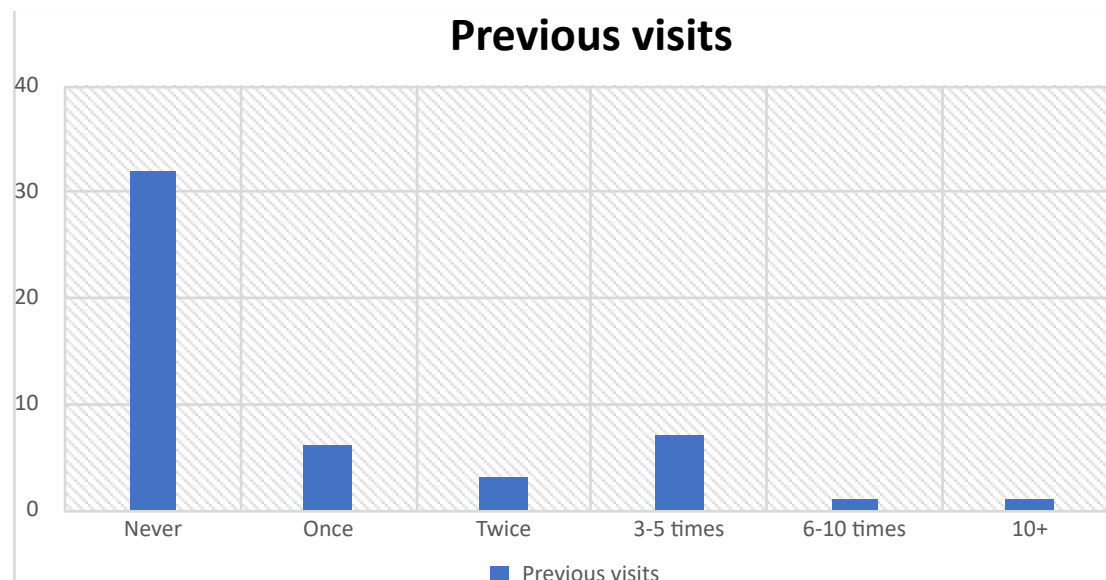
Figure 20. Visit frequency of interviewees.
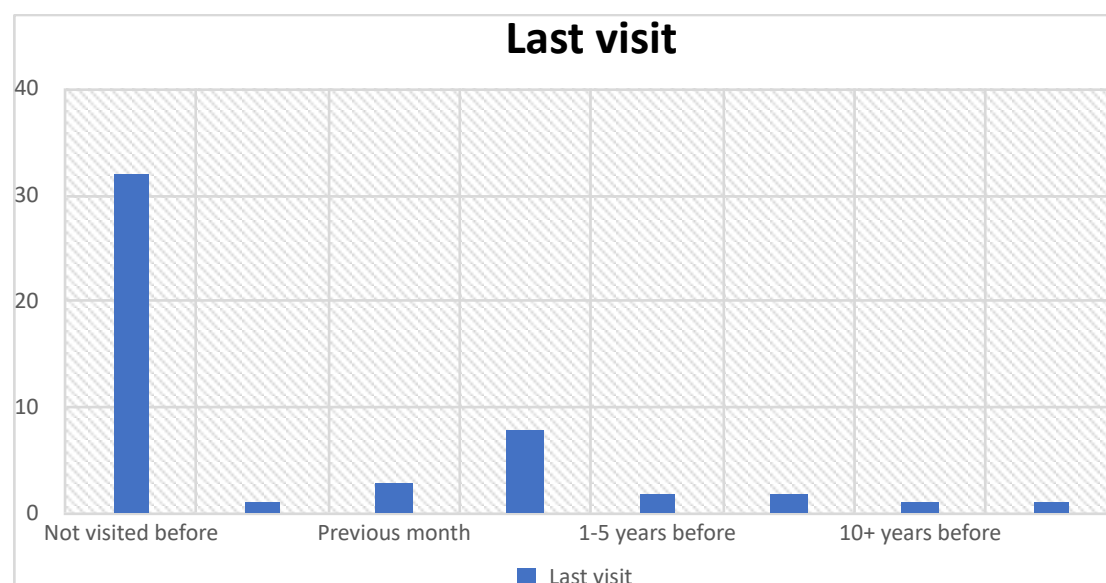
Figure 21. Time since interviewees' last visited the museum.

4.2 Visitors' experience

4.2.1 Previous visits to Room 20 & 21

- Room 20: 7 out of 25 interviewees had been to Room 20 before (28%).
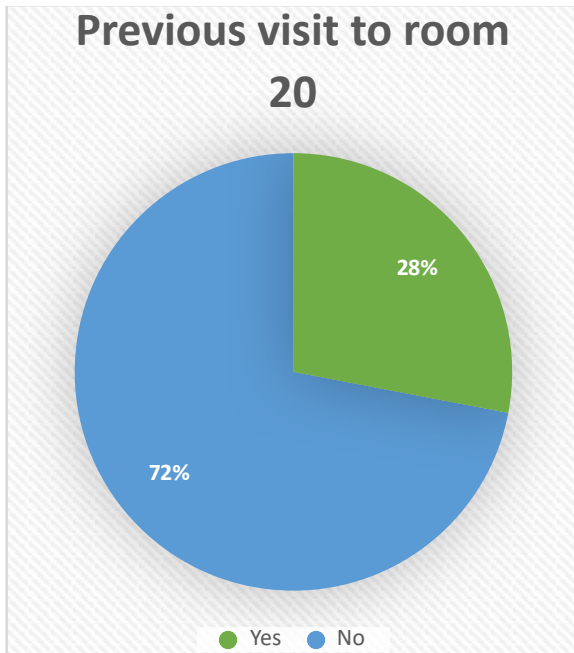
Figure 22. Interviewees that have visited Room 20 before.

- Room 21: 4 out of 25 interviewees had been to Room 21 before (16%).
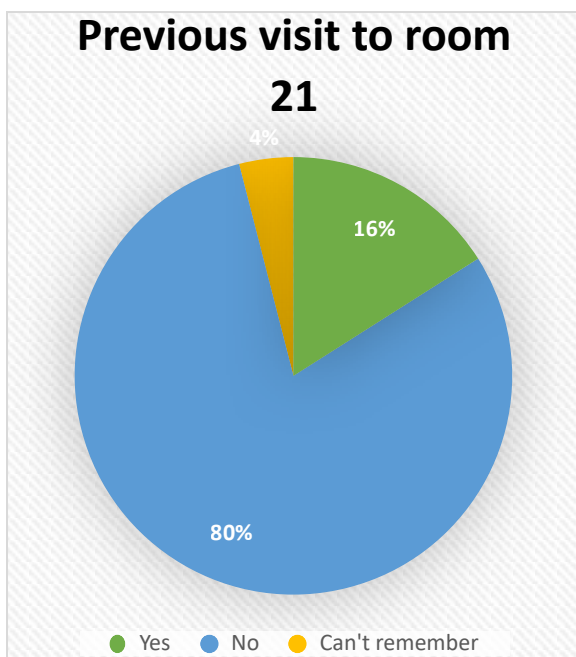
Figure 23. Interviewees that have visited Room 21 before.

- Room 20: 4 interviewees that had visited before clearly remembered the room and the sarcophagus. 2 explained that they regularly visit the museum as they live in the area. 1 explained that he visited several times as he is a student of Egyptian archaeology.

- Room 21: 2 interviewees remembered the content of the room vividly. 1 explained that she is a member and that she regularly takes her grandchildren to the museum (she was with them in this occasion). The other explained that he had already visited the room many years before with his family.

4.2.2 Planning of the visit

Interviewees were asked whether they had intended to visit the display or not.

- Room 20: 18 out of 25 interviewees intended to visit Room 20
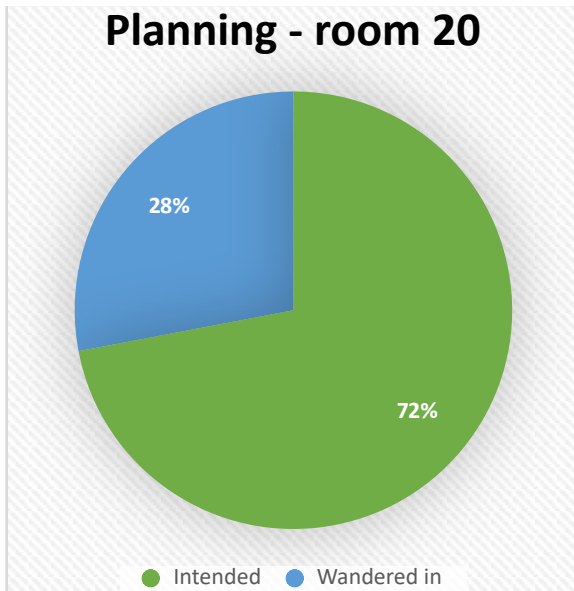
Figure 24. Intended visits to room 20 vs those who had wondered in.

- Room 21: 13 out of 25 interviewees intended to visit Room 21
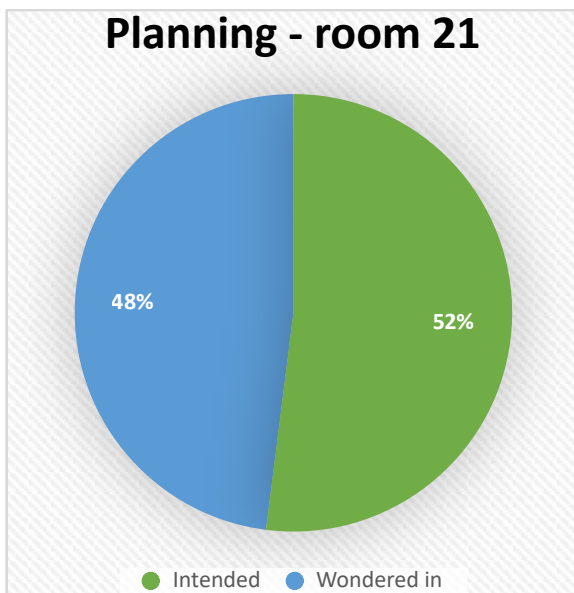
Figure 25. Intended visits to Room 21 vs those who had wondered in.

- Room 20: 18 interviewees clearly stated that they visited the museum primarily to see the Egyptian rooms, and in 5 cases specifically "the mummies". Visitors in general seemed aware of the Egyptian collection in the museum.

As expected, no one was aware of the possibility to touch the 3D print before they entered room.

- Room 21: slightly less interviewees (13) compared to Room 20 said that they visited Room 21 on purpose. Visitors in general seemed less aware of the Greek and Roman collection of the museum compared to the Egyptian one.
One interviewees was aware of the possibility to touch the 3D print before she entered room, as the visitor service told her in Room 20.

4.2.3 Motivation

Interviewees were asked why they decided to visit the museum. While in most cases a predominant motivation was identified, usually more than one motivation co-existed. It is clear that visitors had multiple motivations for visiting. Findings were coded through the following categories[2]:
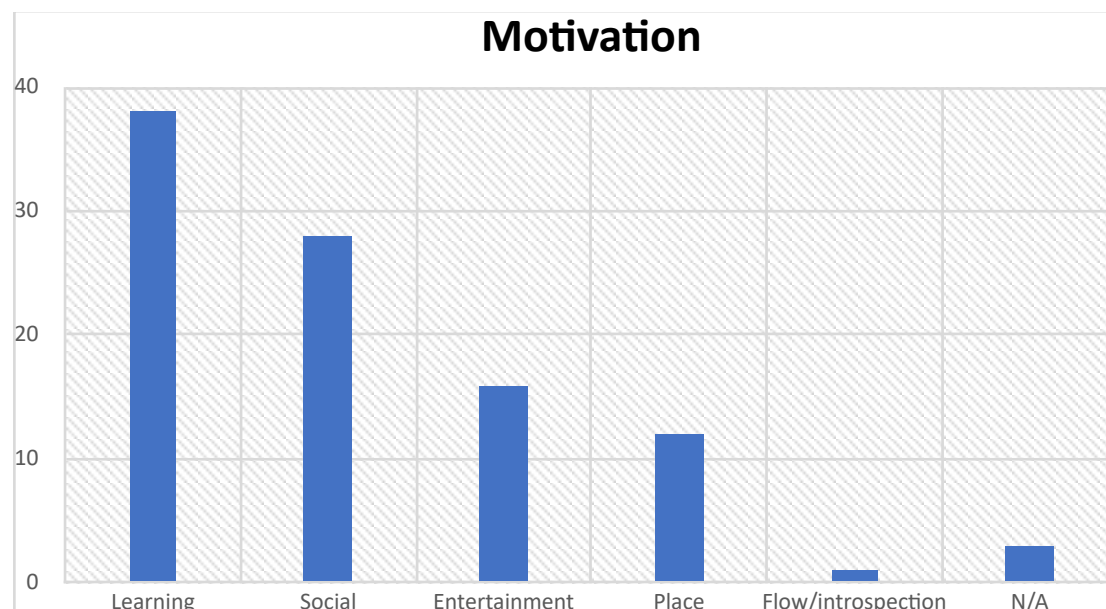
Figure 26. Self-reported pre-visit motivations.

a) Learning (38)

Learning in general (and more specifically about a certain period of time), as well as exposing children to the informational and cultural content of the museum was the predominant motivation among visitors. Groups of adults with children in particular seemed to value the educational side of the experience. Most visitors that reported a desire to learn tended to have a fixed strategy and have clear in mind which galleries they wanted to visit.

Selection of responses:
- We came here to learn about the mummies.
- I like finding out new things.
- I wanted to look at the museum collection.
- It's a great summer activity for the children. They can learn in a different way.
- We decided to come and look at the impressionists' paintings.

b) Social (28)

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[2] Motivations categories here are inspired by Macdonald's (1993) and Moussouri's (2017) cultural itineraries, inspired by Lave's sociocultural framework (1988).

The possibility to share a pleasurable social experience was common between groups of friends, families and couples. In some cases (5) visitors seemed to value the possibility of learning together with their companions. In 6 cases, interviewees were on a date, and they explained how the museum provides an ideal environment for that type of interactions.

Selection of responses:
- It's great to be able to come here and have some family time. It's a way to spend more time together and do something useful for them (the children)
- We're on our second date and we spoke about the museum during our first date. So here we are.
- (two friends) We come here all the time.

c) Entertainment (16)

Entertainment was often mentioned in conjunction with education and social motivations. Visitors seemed to seek fun and something enjoyable to do. The possibility of having fun while learning was particularly valued by families.

Selection of responses:
- We (adult and child) come here and we draw what we see. It's important for her (child) as she can learn but at the same time she has fun and expresses her creativity.
- I decided to come here because we want to do something different together, something fun.
- Oh well, coming here is extremely fun for the kids. They're very into the Egyptians at the moment.

d) Place (12)

Several interviewees highlighted how the Fitzwilliam museum is a 'must-do' attraction in Cambridge. Rather than being specifically interested in the content of the two galleries, they expressed the desire to visit the museum as an emblematic institution. 'Place' was a common motivation expressed by visitors on holiday, organised groups, and those on day trips.

Selection of responses:
- It's an important place to visit
- We checked on Google for things to do in Cambridge
- I'm part of an organised tour
- We're visiting Cambridge, and this was a suggestion.

e) Flow and introspection (1)

One interviewee explained how she desired to take time off her routine and how she identified the museum as the ideal place to be immersed in the activity, to clear her head and to take a break.

Selection of responses
- Today I needed to be on my own. Somewhere quiet. I needed some time to take a break from everything. This is the ideal place. You can look at things and clear your head. You get… transported? You get lost, but in a good way.

Findings above show that interviewees did not perceive different motivations (like wanting to learn and having fun) as conflicting. They all valued the museum as cultural, social and leisure places. The following section (4.2.4) traces links between self-reported pre-visit motivations and findings about what emerged during the visit.

4.2.4 Favourite aspect of the exhibition

Visitors were asked what they liked best about the exhibition. It should be noted that visitors sometimes gave more than one answer to the question.
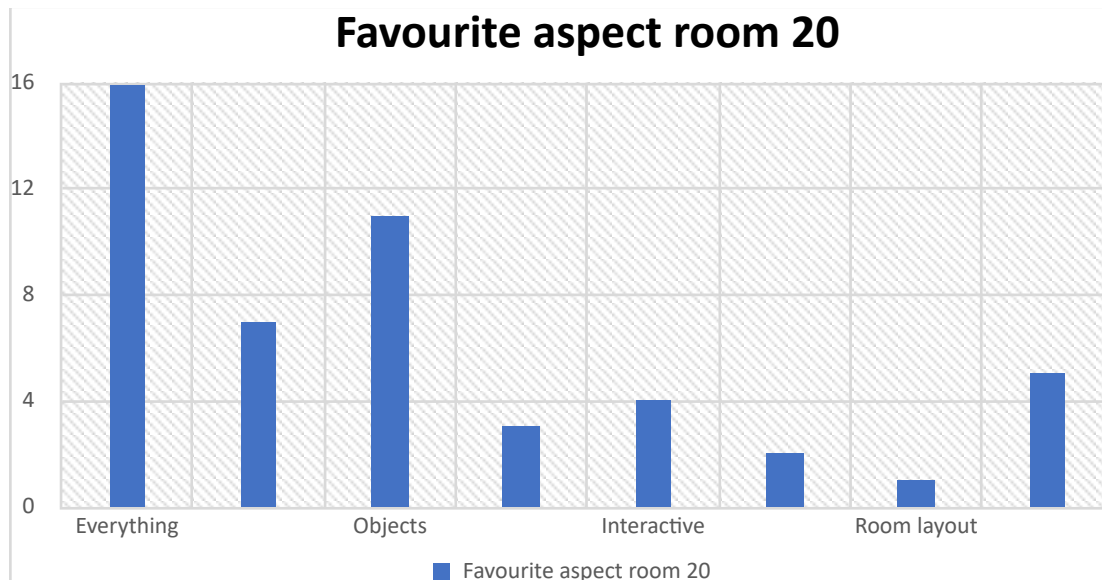
Figure 27. Interviewees' favourite aspect of the exhibition, Room 20.
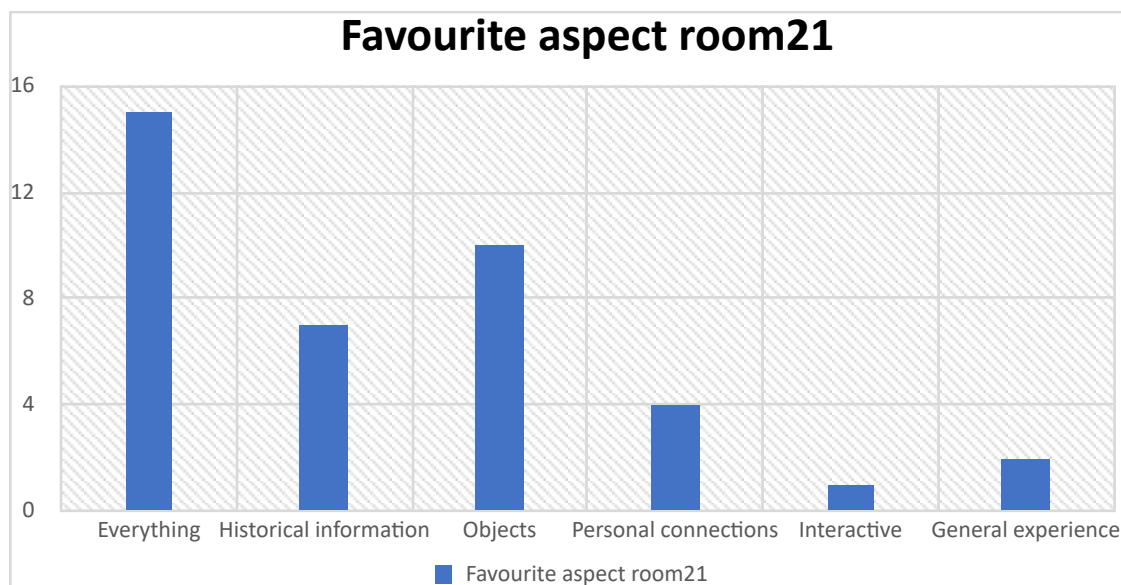
Figure 28. Interviewees' favourite aspect of the exhibition, Room 21.

In both rooms, visitors predominantly appreciated the objects, the historical information, and in general, the experience that the gallery offered. 3 interviewees in Room 20 and 4 in Room 21 mentioned how they felt connected to the objects on a personal level, because of their heritage or because of places that they had visited. 4 visitors in Room 20 and 1 in Room

21 explained that they particularly enjoy interacting with the 3D prints. 1 visitor mentioned the family activity that she used with her child.

Below are some of the responses to this question (for the full transcripts see Appendix d):

Room 20:

- It's fun to be able to learn about all these new things together. I didn't know most of the things we looked at, but he's a bit of an expert. He explained things to me most of the time.
- I think it's a great space for children. We can come here, and have a look at things and learn something new. We draw them together. Today we learnt how they were writing. And then we drew all the hieroglyphics we could find.
- It reminded us of our trip to Egypt. We went two years ago along the Nile. It was really beautiful. And we saw a lot of these things, and all the places like Thebes, Cairo. So good!
- She liked the object over there, the one you can touch. We tried to find together which part of the original thing it was. I think it's very nice to have that sort of resources for kids. We got them at the entrance (family activity).
- I thought that the panel that explains that Egypt is traditionally part of Africa was the most interesting. I don't think people realise it. Because now it's mainly part of the middle east. It's important.
- Absolutely the sarcophagus (points at the sarcophagus lid). It's crazy how big it is. And it shows the Pharaoh it's so perfect. So well preserved. I liked that they had pictures of the colours of the tomb.
- Everything was interesting. I really liked the information about the conservation of these objects. The pictures are great and it gives an idea of what the scientists of the museum do. I didn't know a lot of things. I had no idea that there are techniques that let you see the colours. Or things like X-rays on mummies. It's quite incredible

Room 21:

- I liked seeing all the statues of the Romans. You have the head of Plato and all the emperors. It's very interesting
- The head with the double face (two headed herm of Dionysia and Silenus). It reminded me of a couple of people I know (and she laughed)
- I thought the timeline was very good. I never realised that Romans and Greeks overlapped
- He (the child) liked very much touching that thing, the replica (points at it). The rest can be quite boring for him. It's great that there are things he can engage with. We also saw another replica in the other gallery (20). Do you have them everywhere in the museum?
- I liked everything. I'm Italian and it's my culture. I grew up with it. You really feel a connection, you know?

- The jewellery over there (she pointed at case). It's incredible that the rings and the earrings are so well made. They look so fine and perfect. Something you could buy in a shop today and it would be very expensive

Visitors seemed to appreciate the possibility to learn about new things, as well as sharing a meaningful social experience with their companions and families. Adults visiting with children valued that they could use the space as an education resource to combine learning with interaction and enjoyment for their children.

It is interesting to compare these findings to self-reported pre-visit motivations (4.2.3). Despite learning was the most mentioned pre-visit motivation, the language they used in their responses as well as the observed visit seem to suggest that visitors valued the holistic experience the museum and its collection have to offer. Social and cultural enjoyment seemed at the core of their experience.

4.2.5 Least favourite aspect of the exhibition

Visitors were then asked what their least favourite aspect of the display was and if they encountered any difficult.

The majority (37) of respondents did not name a least favourite element of the exhibition. Frequent answers in both rooms were that the lighting in the gallery was poor, and the lack of translations. In Room 20, 2 visitors expressed their desire for more tactile interactive elements. In Room 21, it was also pointed out that there are too many objects in the room, and it is difficult to follow the narrative.

Room 20
- The resources for children are not enough. It would be nice to have something more interactive.
- The light is a bit low?
- It would be great to have larger text. The text is small and very difficult to read with the light so low.
- I wish they had translations (Italian speaker)
- More interactive! It would be great to be able to touch a replica of the sarcophagus as well.
- The information is good but I'd like more. I'd like to know more about the objects
- There definitely need to be more pictures and more explanations
- The labels were quite basic
- I did not understand the labels. The language is very complicated (Chinese speaker)

Room 21

- (The room is) a bit cramped. There's a lot of stuff and you really don't know where to start.
- There are a lot of things. You kind of get lost at some point.
- It was really difficult to read some of the writings. You know, those very low (she points at labels at the bottom of a case)
- It's not that I didn't like it, but the text is very difficult. My English is not good, and I tried but it was difficult to understand (Spanish speaker)

5. 3D prints

This section presents findings from tracking, interviews, and observations about the interaction with 3D prints. Section 5.4 presents findings from the ethnographic observations carried out in the Museum of Cambridge on the third 3D print produced. This section ends with the analysis of findings in section 5.5.

5.1 Tracking results

5.1.1 Visitors' interaction

A sizeable number of tracked visitors interacted with the 3D prints:
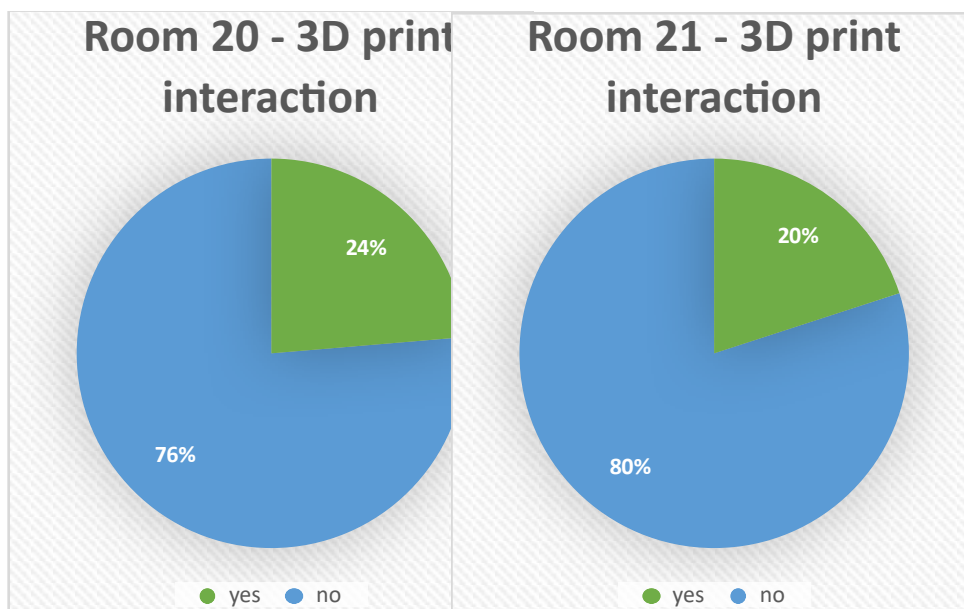
Figure 29. 3D prints introduction.
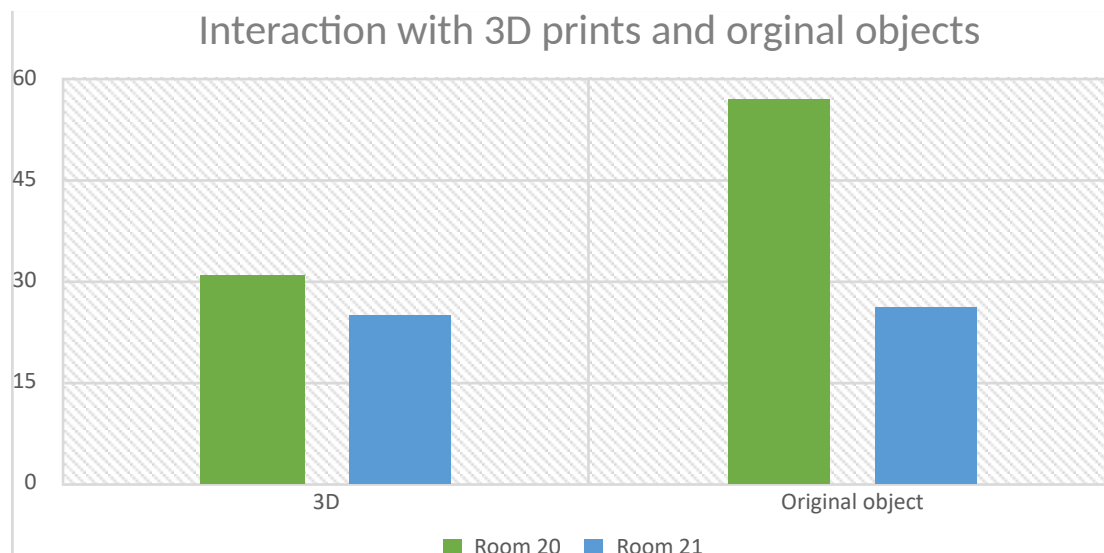
Figure 30. Comparison of the interaction between the 3D prints and the original objects.

Every tracked visitor but one (25), that stopped to look at the Honours for Antiochos I in Room 21 also interacted with the 3D print, either touching it or just looking at it. On the other hand, in Room 20, 57 tracked visitors stopped to look at the Shrine, but only 31 visitors interacted with the 3D print. This is due to the position of the 3D prints: visitors that observed the Shrine from the frontal, the right, or the rear side could not see the 3D print (positioned on the left side).

5.1.2 Mean and median dwell times

The mean dwell times of tracked visitors were:
- Room 20: 3D print 16 seconds, original object 24 seconds.
- Room 21: 3D print 17 seconds, original object 25 seconds.
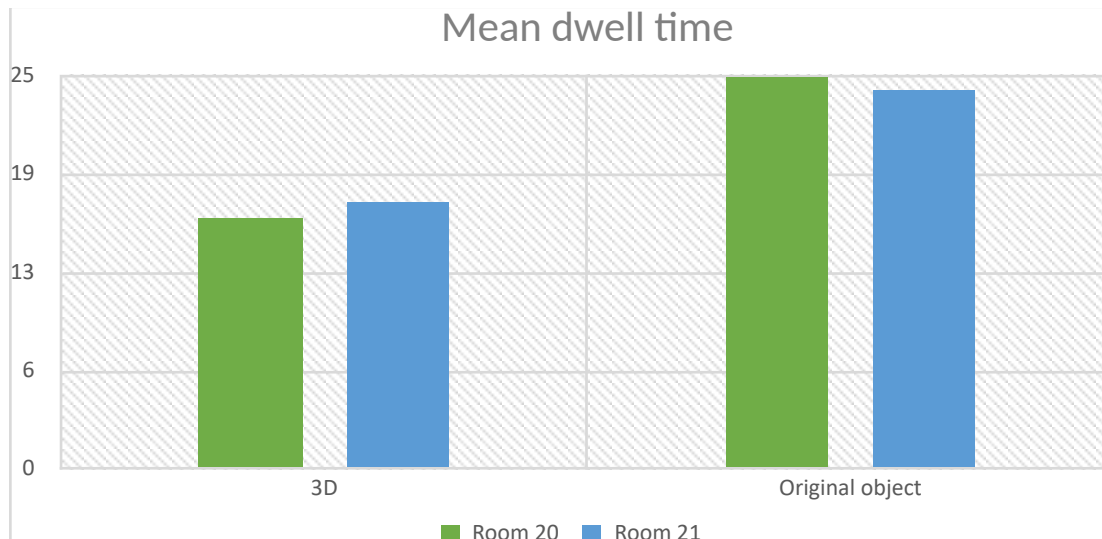
Figure 31. Mean dwell time for 3D prints and original objects.

The median dwell times of tracked visitors were:
- Room 20: 3D print 12 seconds, original object 21 seconds.
- Room 21: 3D print 16 seconds, original object 17 seconds.
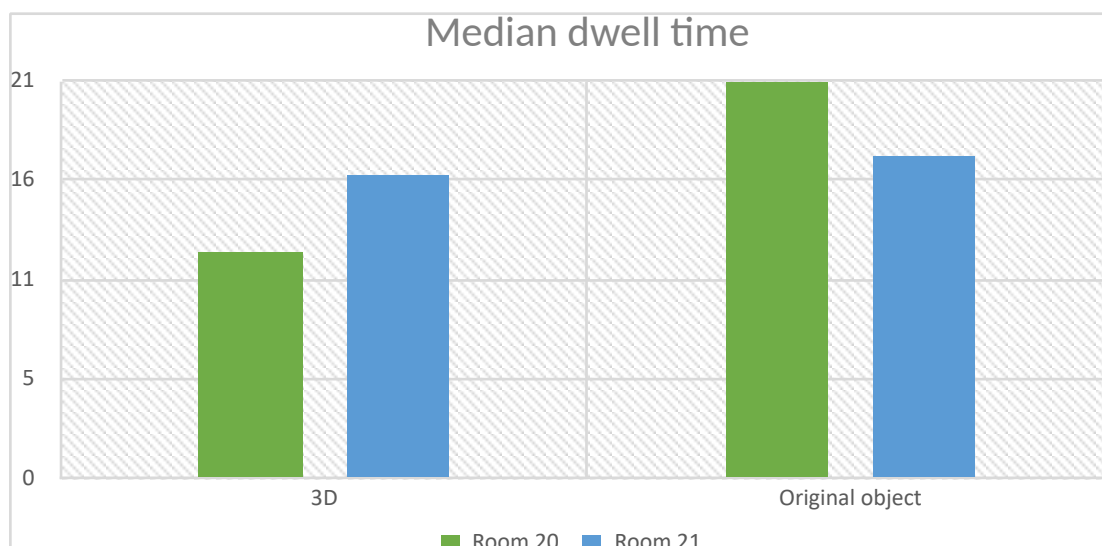
Figure 32. Median dwell time for 3D prints and original objects.

5.1.3 Types of interaction

Interactions recorded so far included both touching and looking at the 3D print.
The graph below illustrates the full breakdown of the different types of interactions:
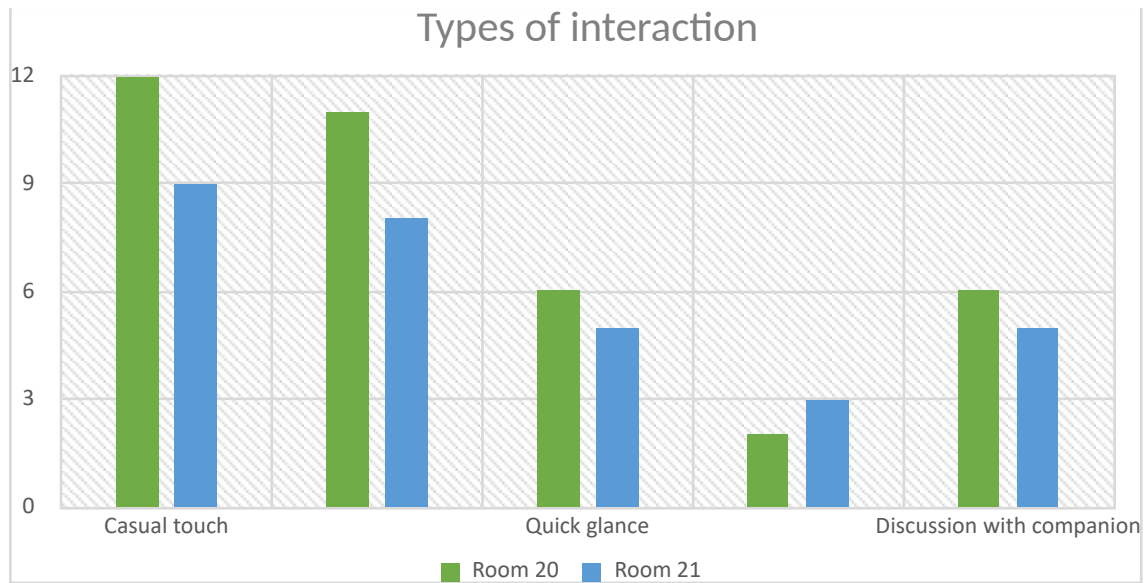
Figure 33. Breakdown and comparison of types of interactions.

5.1.4 Attractiveness

They had medium attractiveness values with 31% (Room 20) and 25% (Room 21) visitors stopping there (see graph from section 3.5).

5.2 Interview results

Interviewees were asked question about the 3D prints in both rooms. In each room, 15 visitors that touched the 3D prints were interviewed. However, data about 3D prints was collected among all the 50 interviewees.

5.2.1 Tactile interaction

30 interviewees (15 in each room) touched the 3D prints. They were approached for the interview specifically for this reason. Nevertheless, during the interview the researcher asked whether they had seen the print and, if so, if they touched them. At this stage of the interview, the researcher called them 'tactile objects'.

Room 20
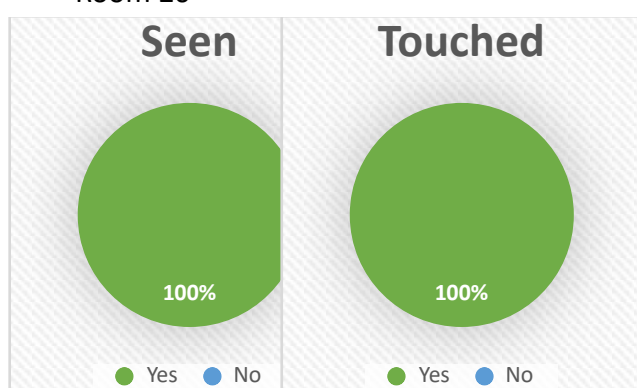
Figure 34. Percentage of visitor that saw and touched the 3D prints in Room 20 (self-reported).
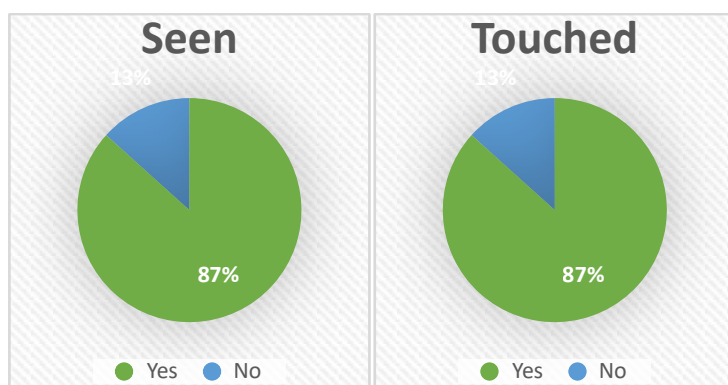
Room 21

Figure 35. Percentage of visitor that saw and touched the 3D prints in Room 21 (self-reported).

It is important to highlight that in Room 21, despite all 15 interviewees being observed touching the 3D print, 2 of them reported that they had not touched it or even seen it. The researcher pointed to the 3D print to ensure that they had understood which object she was referring to, but they both confirmed their initial answer.

One of them was part of a group of adults whose first language was Spanish. During the rest of the interview (carried out in Spanish) he explained that he sometimes struggled to understand the content of the labels, due to the language barrier. He casually touched the 3D print together with other adults in his group. The researcher observed him and two other adults of the same group casually touching several other objects in Room 21: The Roman coffins, the Sandwich marble, and the urns and the grave-altars.

The other interviewee was a woman who visited with two children. One of her children touched the 3D print. However, she did not touch it. When interviewed, the researcher asked her if the children had touched it, but she confirmed her initial answer. This is probably due to the fact that she might have not seen the child touching it. During the interview, the child did not say that he touched it.

5.2.2 Visual interaction

20 interviewees (10 in each room) saw the 3D prints but did not touch them. Nevertheless, during the interview the researcher asked them whether they had seen them.

Room 20
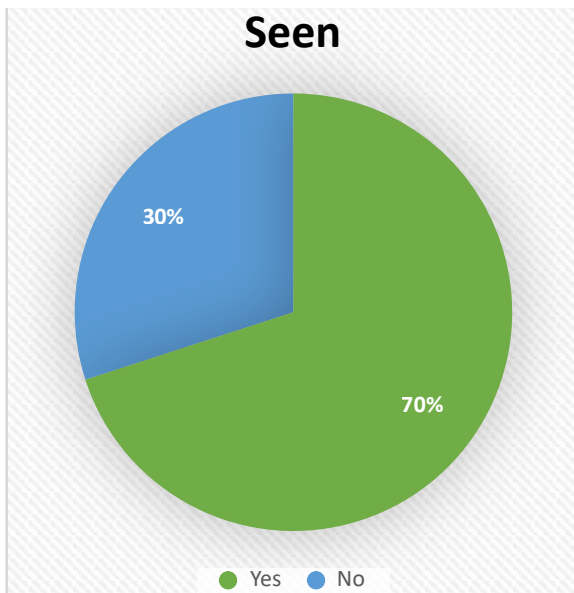
Figure 36. Percentage of visitor that saw the 3D prints in Room 20 (self-reported).
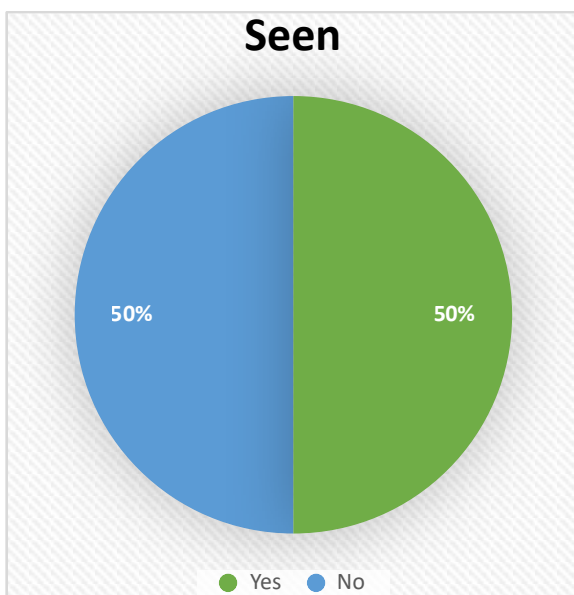
Room 21

Figure 37. Percentage of visitor that saw the 3D prints in Room 21 (self-reported).

3 visitors in Room 20 and 5 visitors in Room 21 did not remember seeing the 3D prints. It has to be noted that 15 out of 20 visitors that saw but did not touch the 3D prints were elderly adults, either in group or on their own.

5.2.3 Expectations for tactile engagement

All interviewees were then asked whether they expect to come across tactile engagement resources when they visit museums.
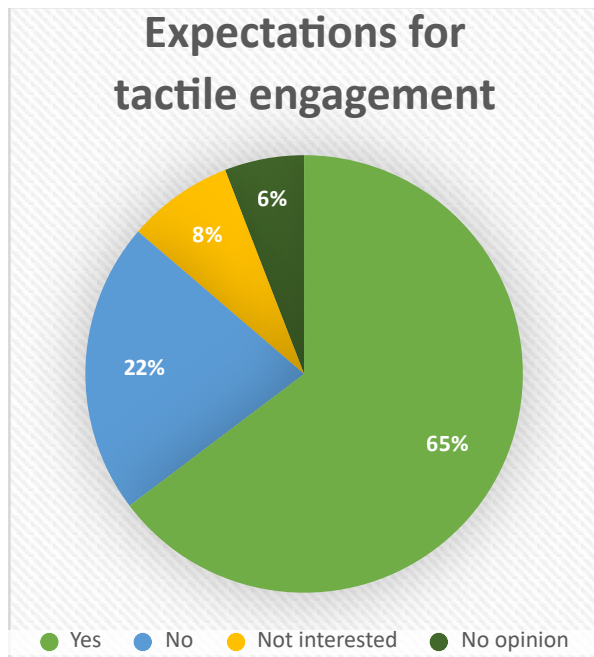
Figure 38. Expectations for tactile engagement.

The majority of interviewees (33) affirmed to expect the presence of tactile engagement resources in museums.

5.2.4 Technology recognition

Interviewees were asked if they knew how the 3D prints were made. At this stage of the interview, the researcher still called them 'tactile objects'.
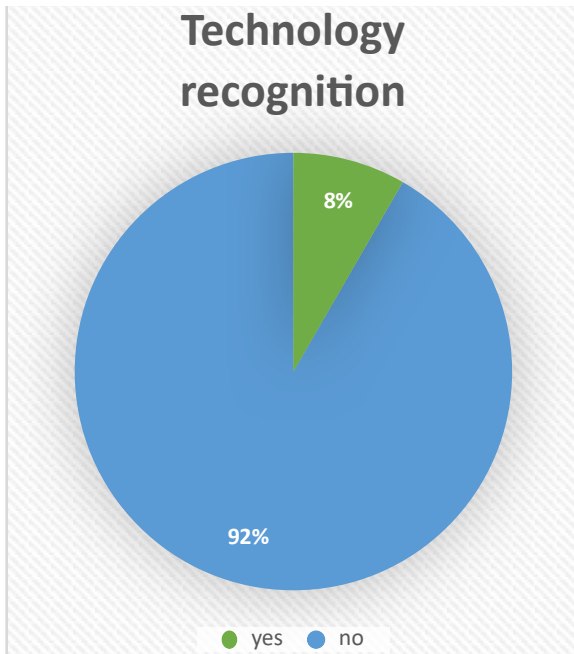
Figure 39. Percentage of visitors that recognised the 3D technology.

Only 4 interviewees recognised the 3D technology. Some interviewees (6) hypothesised that they were made of plastic, while others (7) just generically called them 'replicas'. Other answers included cast, stone, something made with laser, and plastic replicas. One visitor thought it was an original object (Room 20).

5.2.5 Familiarity with the technology

Afterwards, all interviewees were asked if they are familiar with 3D technology, both 3D prints and 3D model.
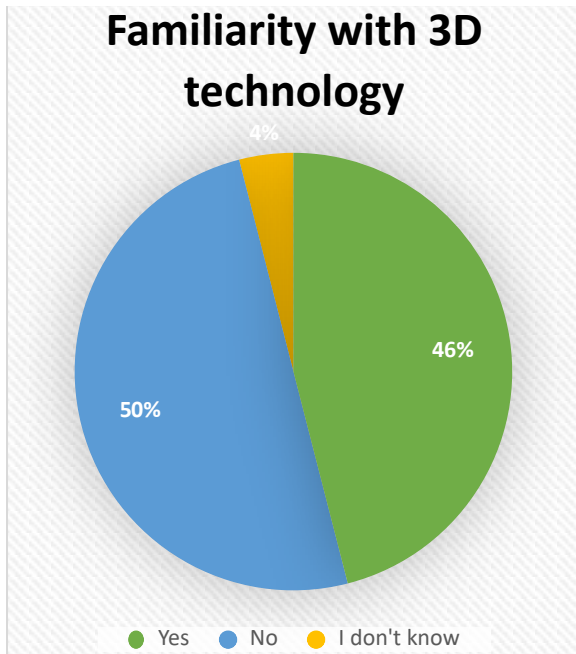
Figure 40. Percentage of visitors that reported to be familiar with 3D technology.

Despite only 4 interviewees recognised the technology (see before), almost half of them (23) stated that they were familiar with it. It has to be noted that the majority of interviewees that claimed to be familiar with the technology were younger adults (presumably <60).

23 interviewees responded positively and explained that they are familiar with the technology. Those were asked whether they had ever seen a 3D model or 3D print of a museum object in another museum or online.
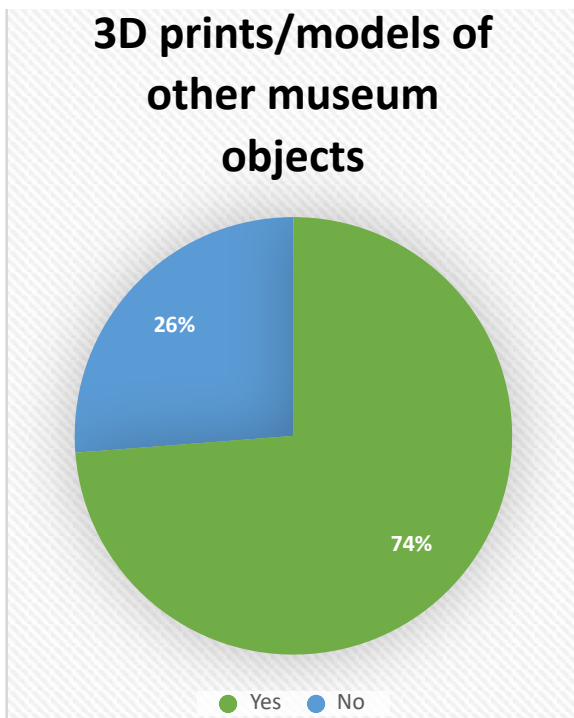
Figure 41. Percentage of visitors that reported to have seen 3D prints or models of other museum objects.

Below is a selection of responses:

- Oh yeah, I've seen the model of the Rosetta Stone, I think. On twitter or something.
- I think they used it to reconstruct those sites destroyed by Isis, right? They're using virtual reconstructions, right?
- I might have seen something in a museum in Germany. In Berlin. I can't remember what. (prompt: was it a model or a print?) I don't remember.
- Of course, they use it for dinosaurs all the time. They reconstruct the missing bones.
- No, I don't think so. But I know that museums use it for preservation. It makes sense.
- I've seen some models on Sketchfab. There's stuff on Pinterest as well.
- There are some artists that use 3D models and machine learning. I've seen it on Instagram. Let me check [check on the phone]. Here: @wannerstedt and @motiondesignschool.
- You can make action figures. Does that count?
- I don't know but it would make sense for restoration?

Finally, interviewees were asked if they expect to come across new kinds of technology like 3D technology in museums, and whether they think museums should experiment more in this field.

Expectations and opinions on new technology
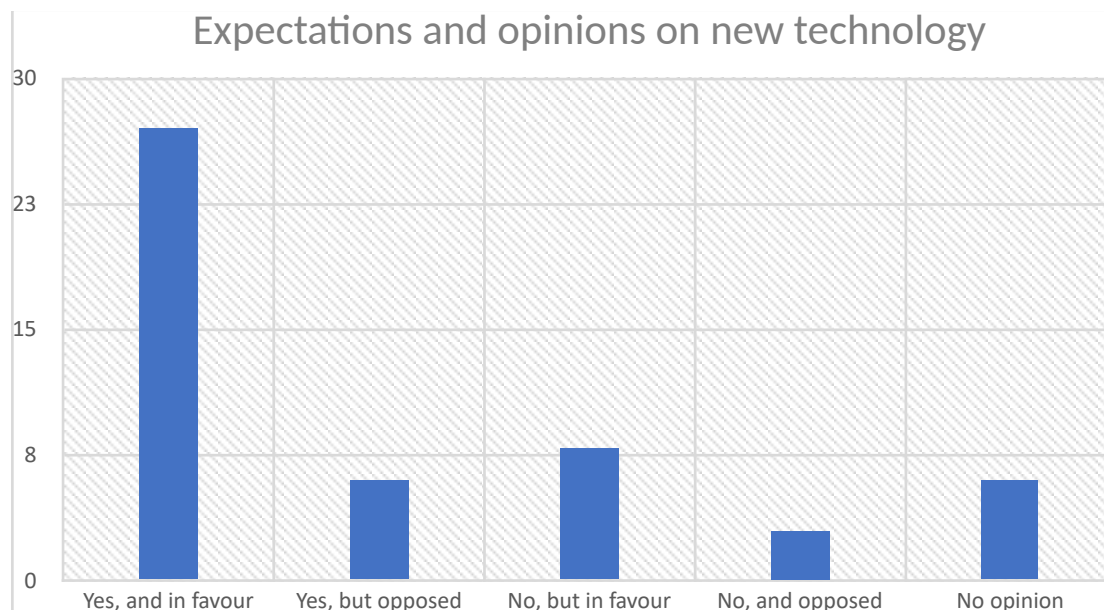
Figure 42. Expectations and opinion on new technology in museums.

The overwhelming majority (27 out of 50) expects to see new technology in museums and is in favour of it. Only 9 interviewees claimed to be opposed to the use of new technology in the galleries.

5.2.6 Response to the 3D prints

The majority of visitors' responses to the 3D prints was positive. Even interviewees that did not touch the 3D prints praised their value. Positive responses can be summarised in the following chart (full responses can be found in Appendix d):
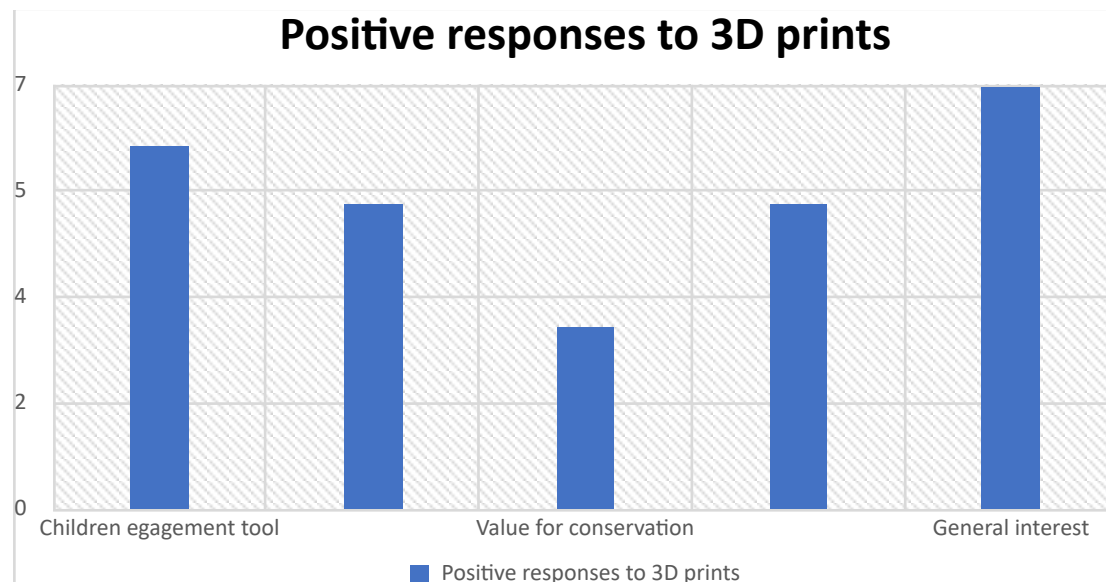
Figure 43. Positive responses to 3D prints.

Below is a selection of responses:

- Room 21: I liked that I could touch it, but I found it a bit confusing at the beginning, because it doesn't look like the actual thing. You see? The text is sort of carved (on the original object) but here (on the 3D print) it's actually raised. But anyway, it was still good
- I think it's an excellent feature to keep the children engaged
- It was really nice because my daughter could touch it and she really enjoyed it. I think it makes the whole exhibition less boring and there should be more in the museum
- It helps understanding the actual thing. With the fact that you can't touch anything else it's good to have a technology that allows you to get a different sense of the things
- (Room 20) I think it helped me. You see, it's difficult to see the symbols here (on the Shrine), because it's faded. And the lights in here don't help. But it's very clear on here (3D print) and you can see it better.
- It has a nice feeling. I was expecting it to feel a bit more like stone but I guess it's normal because it's made of plastic. It's still pleasant to be able to touch it
- I was confused I thought it was real but then I touched it and I thought it was kind of made of plastic. Very nice though.
- It's excellent because you don't want to damage the real object, but you can still touch at the same time.

- It's great that the museum has this resources especially for children
- It's good because with the colour you can't really see all the decorations on the actual object. It's also too high for children (the original object). / But it would be nicer to have some more information. What the symbols mean, you know, the translation
- I would love to be able to touch all these things. But I understand you can't. Too many people would and it's bad for conservation. These replicas are great because at least you can still feel something.

While the general feedback on the 3D prints was overall positive, some visitors also highlighted negative aspects. Some visitors were critical for the lack of information about the 3D prints, and the original objects. Others expressed confusion for the material used, and others complained that the 3D print did not look like the original object (Room 21). One visitor expressed concerns about the value and the function of the 3D print in the gallery.

Below is a list of the negative feedback in the responses:

- I liked that I could touch it, but I found it a bit confusing at the beginning, because it doesn't look like the actual thing. You see? The text is sort of carved (on the original object) but here (on the 3D print) it's actually raised. But anyway, it was still good (Room 21).
- It has a nice feeling. I was expecting it to feel a bit more like stone, but I guess it's normal because it's made of plastic. It's still pleasant to be able to touch it.
- I don't know. I guess it's good to see things better, but personally, I'd like more information. What do the symbols mean? (Room 20).
- I don't really see the point of it. I mean cool you can touch it, but it's not the real thing. I come here to see the real things.
- I just want to touch the real thing.
- I think it's really confusing because you can't touch anything else, but you can touch that one. So, you think you can also touch the other things (French speaker)
- It doesn't say anywhere what the text means. It only says that they wanted to get the favour of the king. So I was like ehm ok why am I touching it? (Room 21).
- It would make sense to have a translation of the text. Otherwise I'm just looking at a bunch of letters (Room 21).
- I would have liked it colourful. Or with images.
- I didn't realise it's a 3D print, (he went back after the interview) need for more clarification for sure.
- What is it made of? It really doesn't look like the actual inscription. You see? It's different. Letters here (on the 3D print) are huge, but here (original object) it's really fine, delicate. Also, there's no information. I don't know what it is and why it's here. What does it represent? What's the point?
- It's good, but it feels very plasticky. I know I can't touch the rest but after touching this (the 3D print) I'm even more curious.

5.2.7 Suggested improvements

During the interview, visitors asked questions about the 3D prints and they suggested potential improvements.

Questions asked can be summarised as follows:

- Why are they here?
- Are there others in the rest of the museum?
- How did you choose which object to print?
- How are they made?
- What materials were used?
- Why is the 3D print in Room 21 raised and not engraved as the original object?

The suggested improvements can be summarised as follows:

- Add more colours.
- Make signage clearer.
- Integrate with family activities/packs.
- Better advertise them outside the room.
- Use more 3D prints in the whole museum.
- Add information about the 3D prints.
- Add a translation of the Greek text and of the hieroglyphics.
- Explain the technology.

5.3 Ethnographic observations

Observations of how visitors interacted with the 3D prints and the original objects were recorded. Observation continued, and it was recorded how visitors interacted with other elements of the exhibit (in particular, whether they touched other artefacts or not).

5.3.1 Organised groups

Organised groups mainly comprised of groups of children who were part of school groups (9), and of young teenagers who visited the museum as part of their language school programmes (3). 6 groups of school children were observed in Room 20, and 3 in Room 21. 3 groups of young teenagers were observed in Room 20, and 1 in Room 21.

School children spent time in the galleries listening to guides and/or teachers, and then were left free to explore the galleries on their own. The 3D prints became one of the focus points for all the groups. In two cases, teachers touched the prints with the children, otherwise children touched primarily on their own.

Four types of interaction were recorded:

- Casual touch: children briefly touched the 3D print without paying attention.
- Thorough exploration of the 3D prints: children spent time touching the 3D print, focusing their attention on it.
- Touching the 3D prints and engaging with the original objects: in Room 20 children started to recognise and match the hieroglyphics on the 3D print and those on the Shrine. In Room 21, children tried to interpret the letters on the 3D print and to find the matching letter on the original object.
- Children touched the 3D prints, the original objects and several other objects in the galleries.

In most cases, children started touching and, as other children approached, they adopted an authority roles and began to explain that it was possible to touch the 3D prints but not the original objects (19 observed children), and to guide their exploration of the 3D print itself (28 observed children). All children expressed joy and enthusiasm at the idea of being allowed to touch something.

In Room 20, in one case, 7 children started to touch the Shrine (they had not noticed the 3D print). As a result, the person from the visitor service guided them to the 3D print and explained to them why they could only touch the 3D print. Several children across the groups were also observed touching the granite sarcophagus, and the back of the sarcophagus' lid.

In Room 21, several children from 2 different groups had a tendency to touch both the original object and the 3D print. They also touched other objects in the gallery. Only in one case, did the teacher intervene.

5.3.2 Groups of adults and children (families)

In both rooms, several groups of adults with children were observed. Families in this research are understood to be every group that comprised one or more adults and one or more children. In both rooms, the majority of families observed (43 out of 46) interacted with the 3D prints.

Three types of interactions were primarily identified: a brief casual touch by a child, a deeper one initiated by child, and a deeper one initiated by an adult.

- Brief casual touch (9): children were mainly left alone by the adults to explore the gallery. They came across the 3D prints, they realised they could touch, and they casually and briefly touched it without paying much attention.

- Interaction initiated by the child (21): children tended to focus primarily on the 3D print. They thoroughly touched it, with two hands, often sitting on the floor. Only in two cases did children visually engage with the original object at the same time.

- Interaction initiated by an adult (13): these interactions happened within families where adults guided the children throughout the visit. They guided the children in the tactile interaction with the 3D print and in the visual one with the original object.

Instances of shifting roles and guidance were observed in 24 interactions. Adults and children took turns in leading the engagement with the 3D print and the original object within the same interaction. In general, children (organised groups and families) touched the 3D prints with two hands. Only 9 of the observed children touched it with one hand.

Significant interactions:

- Room 20: an adult (male) made the child (male) identify every animal on the 3D print and then he introduced the concept of hieroglyphics. They spent a long time trying to identify every symbol on the Shrine, on the 3D print, and then they continued with the sarcophagus.
- Room 20: a child (female) and her mother sat on the floor and together thoroughly touched the 3D print. Intially they tried to recognise the hieroglyphics on the 3D print. The child had a booklet with her to identify the symbols. Then, the mother suggested they should start looking at the original object as well. Finally, the child took her activity board and started drawing. Instead of drawing the 3D print or the original object (as she did for several other objects), she drew herself and her mother while they were touching the 3D print together.
- Room 21: a child (female) noticed the 3D print and started touching it. Then she called her mother ('Mum, come here!') who was on the other side of the room. The mother joined her and together they touched the 3D print. The child explained that

the 3D prints showed a part of the original object and the mother helped her identify which part, as the original object was too high for the child.

- Room 21: a child (male) explained to another two children (one female and one male) within the same group that they could only touch the 3D print, as touching would damage the original object.

Only in 5 observed cases did children touch the original objects (2) and/or other objects in the gallery (4). It has to be noted that anecdotal reports from the visitor service differed from these findings. They reported that children tended to touch both the original object and the 3D print, and they said that the signage was very confusing for them, suggesting that the presence of 3D prints increases the deliberate touching of other objects.

5.3.3 Groups of 2+ adult visit

In both rooms, interactions with 3D prints can be classified according to the age of the observed group of adults:

Elderly adults tended to look at the 3D prints, but they did not touch them. 19 out of 21 elderly visitors did not touch the 3D prints. This mirrors the result from the interviews: 9 out of 12 interviewees in this age range explained that they did not touch the 3D prints.

Significant interactions:

- Room 21: One elderly adult female and one younger adult female (both Asians, presumably mother and daughter) visited Room 21 together. They had lively conversations in front of several objects, and they stopped in front of the 3D print. The younger adult started to touch it, and explained to the mother that it was a replica of the original object. She encouraged the mother to touch, but the mother looked sceptical. They moved on.

Younger couples[3] tended to touch the 3D print together, often having discussions about the replica and the original objects. 9 couples tried to identify which part of the original object corresponded to the replica. 14 couples, presumably under 40 years of age, were observed, and 12 touched the 3D prints together.

Groups of adults presumably between 20 and 60 years of age had the most variegated type of interaction with the 3D prints.

- A minority (6) saw the 3D print but did not touch it, either due to a lack of interest or because their group had already moved on from that area of the room, or because they had already spent time reading the label on the other side of the object and were ready to move on.

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[3] identified because of intimate gestures in the galleries like holding hands and kissing.

- Brief casual touch (11): mainly adults that were part of a group, but came across the 3D print on their own. They briefly touched it without paying much attention and did not have a meaningful interaction with it.

- Tactile interaction with the 3D print and visual interaction with the original object (23): the majority of the observed visitors interacted with the 3D print as well as with the original objects. Some (8) focused on the 3D print, trying to understand the material and to identify key features. 3 visitors had a conversation about the value of replicas for conservation purposes. 7 of the observed visitors tried to identify the hieroglyphics' symbols on the Shrine, while 5 tried to identify and/or translate the text on Honours for Antiochos I.

Two groups of adults (one comprised of 3 English speakers in Room 20 and the other of 6 Spanish speakers in Room 21) did not touch the 3D prints but touched several other objects in the galleries.

Significant interactions:

- Room 21: one visually impaired man (a white cane user), visited the room with a woman. She guided him around the gallery, describing the objects that they encountered. She spotted the 3D print and guided him in front of it. She read the label aloud while he touched the 3D print with two hands. He started touching the outline of the 3D print, the back, and then he moved to the front. He followed the lines of letters horizontally, and then traced the outline of each letter of the first row with one finger. He seemed to have residual vision, as he often went closer to the original object to look at it.
- Room 21: a group of 6 adults (4 male and 2 female) interacted with the 3D print and the original object. They were Greek-speakers and, at the beginning, they tried to translate the original object together. Afterwards, two of them touched the 3D print and tried to identify which section of the original object it showed.
- Room 20: One young woman explained to her three companions (two male and one female) that the 3D print is useful because the physical objects cannot be touched for conservation reasons. She explained that hands leave a residue while her companions took turns at touching the 3D print.

5.3.4 Single adult visitors

43 single adult visitors were observed.

None of the <u>elderly single adults</u> observed (16) touched the 3D replica. 8 of them thoroughly read the label on each object, and 6 of them observed both the original object and the 3D print.

<u>Younger adults</u> had mainly three types of interaction: they did not touch (7); they touched casually for a couple of seconds (4); they thoroughly touched the 3D print and engaged with

the original object at the same time (14). Only 2 observed single adults touched the 3D prints but did not engage with the original object.

Significant interactions:

- Room 20: one young woman (in her 20s) read the label at the front of the Shrine. She noticed the 3D print, but she could not get closer as a group of children was touching it. She moved on, and when she was about to leave the room, she went back and thoroughly touched the 3D print, looking at the original object at the same time.
- Room 20: one man (in his 40-50s) noticed the 3D print. He touched it briefly, then he went to the front of the Shrine to read the label. Afterward he returned to touch the 3D print.
- Room 20: one young woman (in her 30s) saw the 3D print. At first, she observed the upper part of the Shrine, and afterwards she bent and squatted on the floor to look at and touch the 3D print.
- Room 21: one man (in his 40s) bent to view the print better, then he tried to touch each letter looking at different portions of the text on the original object.
- Room 21: one woman (in her 50s) looked at the original object for a long time and read the label. Then she casually stroked the print.

5.4. Museum of Cambridge

A third 3D print was installed in the Museum of Cambridge in July 2019. Visitors' interactions with the 3D print were analysed through ethnographic observations on the 30th and 31st July 2019.

The object is a 3D printed replica of the Histon Giant's leather boot. The replica sits on top of a white plinth (figure 44), located to the left of a glass cabinet containing the original boot. Unlike the 3D prints in the Fitzwilliam Museum, the one in the Museum of Cambridge is paired with a detailed label, as well as the 'you can touch this' sign. The label provides a guide on how to interact with the 3D print: it suggests picking it up, thinking about how it feels, and comparing it to visitors' shoes.

Figure 44. The 3D print on the white plinth in the Museum of Cambridge.

30 visitors and groups of visitors were observed. While the researcher observed how each member of the group interacted with the boot, each group was considered as one unit.
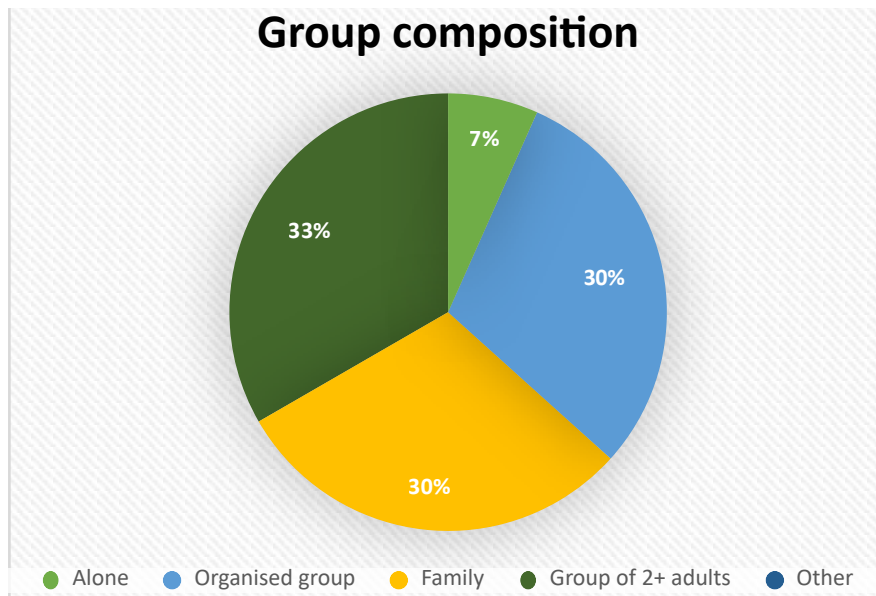
Figure 45. Group composition of observed visitors.

5.4.2 Organised groups

Organised groups mainly comprised of groups of young teenagers who visited the museum as part of their language school programmes. Groups were accompanied by either a guide from the museum or an external guide, or on their own. They all had activity boards, and mainly looked for 'mystery objects' in the room.

The following interactions were recorded:

- Brief casual touch (11)

Primarily by visitors who entered the room without a guide. Most of them were looking for a 'mystery object'. The majority (9) did not see the 'please touch sign', and they just touched it casually, as they touched several other objects in the room.

- Touch without following the label interpretation (5)

5 visitors thoroughly touched the boot without reading the label. They did not pick the boot up, but mainly focused on the consistency of the boot, squishing it and trying to touch the inside.

- Touch following label interpretation (9)

9 visitors read the label and followed the guided interpretation. They picked the boot up and observed how it looked underneath. They squished it and touched the bottom and/or the rim. 7 of them compared it to their own shoes. 6 of them looked for the original object in the glass case. 3 visitors who checked the bottom said that they found it interesting as It is not possible to see bottom of the original object.

- Touch following guide's guidance (3)

It has to be noted that 22 (out of 28) observed members of organised groups touched several other objects in the room, despite the 'do not touch sign'. In one case, a guide made them touch the 3D print, and then made them touch a sheet iron boot as well, despite the 'do not touch' sign (figure 46).

Figure 46. Sheet iron boot.

5.4.3 Families

All the families observed (9) touched the 3D print. Both the adults and the children touched the 3D print. In all 9 cases, either the adults (7) or the children (2) read the label.
7 families followed the guidance on the label: they picked it up, they measured their own shoes against it, and they had conversations about how the boot felt. Children described the 3D print as 'weird', 'jelly', and 'squishy'.

3 families encountered difficulties with translations, as English was not their first language. In 3 other cases, adults pointed to the original boot in the glass case, and they read aloud what it said on the interpretation panel. One woman explained to a child that the leather boot is in a case for conservation reasons, which is why they were only allowed to touch the replica. Neither the mother nor the child touched any other object.

In 6 cases, children touched other objects in the gallery as well as the 3D print. In 4 cases, also the adults touched other objects.

5.4.4 Groups of adults

10 groups of two or more adults were observed. 5 groups did not touch or interact with the 3D print. All 5 groups comprised of elderly adults. Only 1 group of three elderly adults (presumably Mandarin speakers) interacted with the print. Two men touched it. All three members of the group touched several other objects in the room, in particular the sheet iron boot, and another leather boot on display.

2 other observed visitors, part of two groups of adults, casually touched the boot briefly without paying much attention to it. Another 2 groups of visitors, two young couples, casually touched the 3D print (they squeezed it and touched the upper part) and made comments about the technology: 'that's a 3D printed replica' and '3D printed, wow'. One woman, part of another group, saw the boot but did not touch it, and explained to the others that it is a resource for children.

5.4.5 Single adults

2 single adults visited the room. One young woman (presumably in her 30s) thoroughly read every label / panel and looked at each object. She read the label of the 3D print, then she looked at the original boot in its case. She read the panels around the case, and then went back to touch the 3D print. She picked it up, looked underneath, squished it, and tried to touch the inside.

The other single visitor was an elderly woman (presumably 60+ years old). She browsed the room and stopped to read two panels. She briefly looked at the 3D print, but she did not touch it.

5.5 Initial analysis

The multisensory experienced offered by the 3D prints is generally valued by visitors, in particular, younger adults and children. Despite the fact that elderly visitors did not seem interested in tactile interaction, they recognised the value of the 3D prints as tools for engaging children. Visitors responded with enthusiasm and excitement at the possibility of being able 'to touch something'. Several visitors seemed to understand the value of touching the 3D prints rather than risking damaging the collection. These visitors actively praised the museum's effort to create tactile interactive engagement while keeping the collection safe. However, it has to be noted that the lack of interpretation and the non-facilitated engagement resulted in relatively few visitors making the link between conservation and 3D technology.

The findings suggest that placing the 3D prints near the original objects tended to create a dialogue between the two objects that automatically suggests something to visitors. The findings seem to suggest that the fact that 3D prints and the original objects are placed next to each other is enough for more experienced visitors to understand that there is a link between the two. The position alone facilitates meaning-making. Visitors often identified the reproduced sections on the original objects and used the 3D prints as an interpretative media for the original objects. However, for other visitors, less experienced, less familiar with the museum environment, or non-English speakers, proximity does not seem enough to facilitate the interaction. In fact, suggestions for improvements included a request for more information about the original object, the technology, the material, and explanations about why the 3D print is in the gallery. On the other hand, the interaction guidance provided for the 3D print in the Museum of Cambridge led the observed visitors to assume that it was a tool for children.

The low dwell time and holding power of 3D prints in comparison to those of the original objects suggests that the 3D prints did not lessen visitors' interest in the original. The interview responses and observations confirmed that the majority of visitors that engaged with the 3D prints also interacted with the original objects. In the case of the 3D print of the Shrine in Room 20, visitors explained how the presence of the 3D print enhanced their understanding of the Shrine, as it allowed them to detect details that were less visible on the original object. In the case of the 3D print of the Honours for Antiochos I in Room 21, visitors expressed some concern as they explained that they were confused by the differences between the original and the 3D print. In fact, several visitors highlighted how the original inscription is a reverse relief, while the 3D printed one is raised.

Additionally, the 3D prints have the potential to be excellent accessibility resources and engagement tools. The observed episode with the visually impaired visitor in Room 21 shows that the 3D print created a tactile opportunity and facilitated the understanding of the original object for a person with sight loss.

Finally, findings suggest that for children (whether with adults or with other children) understanding the display together includes continuously engaging with each other in scaffolded meaning-making. Findings also suggest how tactile practices include instances of

shifting roles. While the interactions might be initiated by adults, instances of shifting roles occurred, where children positioned themselves as an authority by guiding other children or adults in their tactile investigation, and by explaining why it is not possible to touch original objects in the galleries. These types of interaction show how children are continuously engaged with each other and their family members and with the objects, and how it is precisely that engagement that facilitates meaning-making.

5.5.1 Recommendations

These findings focus on increasing attracting power and holding power as well as making the gallery more friendly to the large number of non-English speaking visitors:

- Increase the number of tactile 3D replicas in the museum
This is supported by the large number of visitors that interacted with the 3D prints

- Add one layer of interpretation (technology description and/or function)
Despite visitors considered the interpretation provided in the Museum of Cambridge as a 'tool for children', in the Fitzwilliam Museum they tended to ask information about the technology, the material, and the function of the 3D prints. This would help to match the gallery narrative to the visitor flow.

- Consider adding translations of English text into other languages, using physical or digital resources.

- Improve the appearance and the likelihood of the 3D prints
Visitors noted the difference between the reversed relief of the Honours for Antiochos I and the raised relief reproduced on the 3D print. They described this discrepancy as 'confusing'. Additionally, it would help to increase the size, the positioning, and the visibility of the 3D prints.

- Use other types of technology to improve the attractiveness 3D prints
Visitors seemed interested in the value and the function of the 3D prints. While the touching deterrent function could be made more explicit on a label, other values of the 3D prints could be highlighted with other types of technology.
Digital re-colourisation and light positioning could be employed to show the faded colours of objects and to increase the visibility of particular features[4]. Digital re-constructions

- Implement evaluation techniques
  - Future analysis could be carried out using cameras (goPro devices or similar) to obtain a detailed and timestamped record of how visitors touched the 3D prints.

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[4] For reference, see the analysis of Li Sou (2015) on re-colourisation of Neo-Assyrian reliefs.

- Using an electronic data input device to record visitor experience in future studies for easier software input.
- Syntax 2D and Qualtrics software could be employed to analyse respectively visitors' paths, and visitors' experience.
- Despite the use of questionnaire produces a limited dataset compared to interviews, it could be taken into account in order to collect a larger sample of data in a shorter framework. Additionally, automated translations of any questionnaire given to visitors increases the demographics reached and decreases refusal rates.
- Consider performing a cyclical analysis (every 6/12 months) of visitors' behaviour in order to create a better understanding of how visitors behave, how they make meaning, and what types of objects affect their behaviour.

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APPENDIX

a) Tracking maps

Room 20
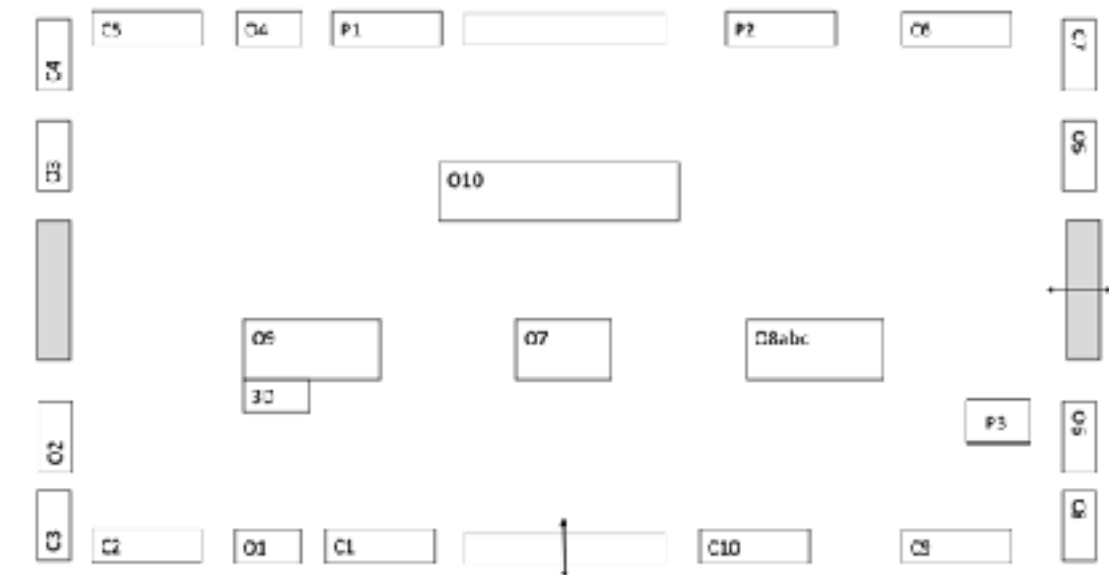
Room 20
Date:
Time: Dwell time: Notes
                               In/Out:
Group composition:
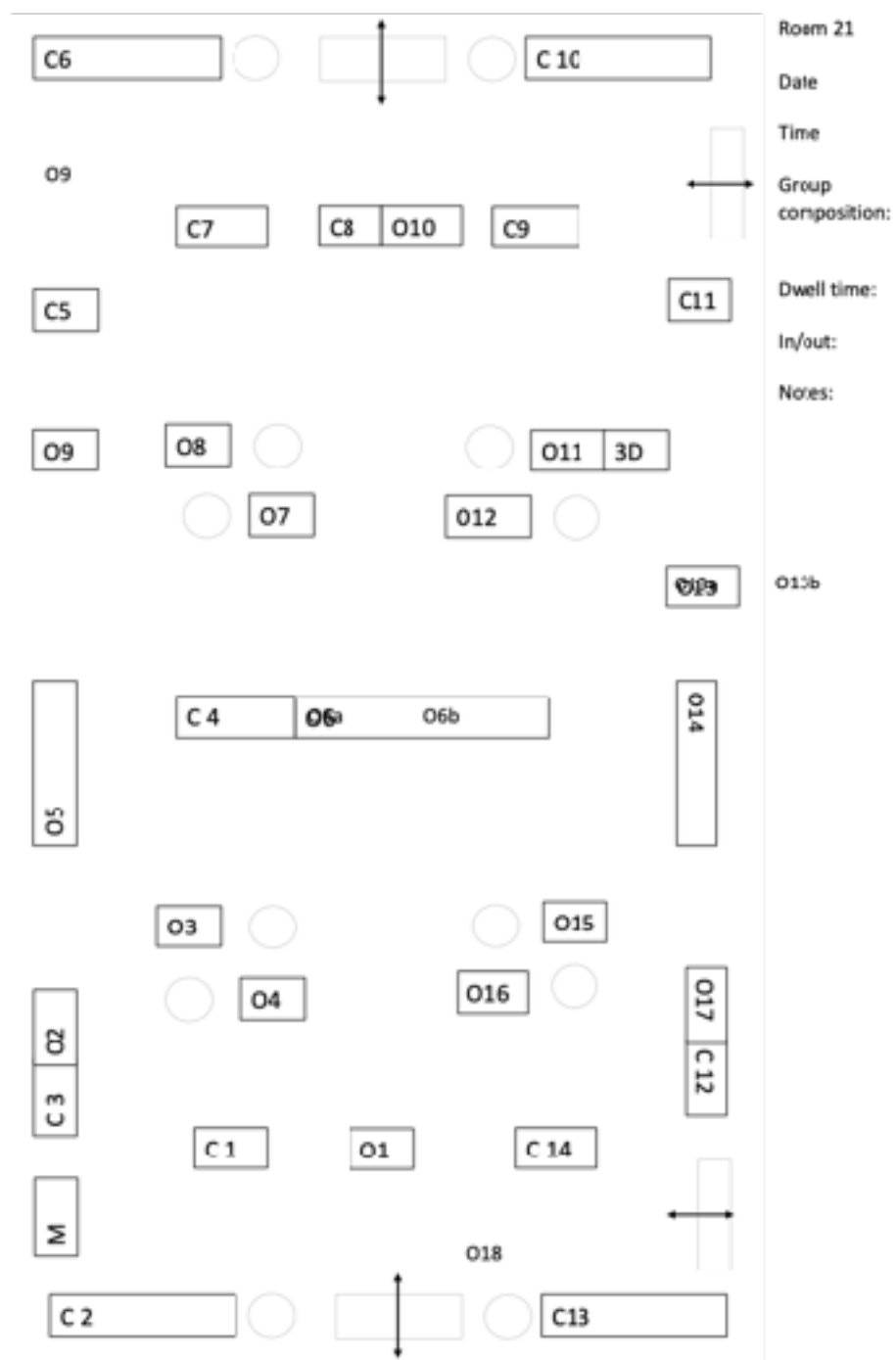
Room 21

b) Description of tracking map

- Room 20

C1	Hierakonpolis: the main temple deposit
C2	Royal burials at Abydos
C3	Old Kingdom and Middle Kingdom Egypt
C4	Early Dynasty 18
C5	Amarna: the Royal family
C6	Amarna: life in the city of Akhetaten
C7	The Ramesside Period, 1292-1070 BC
C8	The Late Period and the Persians
C9	The last Dynasties of Egypt
C10	Roman and Late Egypt
P1	Conserving Ancient Egypt I
P2	Conserving Ancient Egypt II
P3	Kemet the Black Death
O1	Gabbro hanging jar
O2	Fragment of a granite statue of Senusret
O3	Sandstone statue of Amenhotep III
O4	Quartzite block statue
O5	Basalt statue of Psamtik II
O6	Granite statue of a priest
O7	Granite sarcophagus lid
O8	Basalt statue of a Ptolemaic queen; basalt statue of a priest; limestone statue of Alexander the Great
O9	Sandstone naos (shrine)
3D	3D print of shrine (O9)
O10	Granite sarcophagus

C1	Bronze Age Greece
C2	A new beginning: Geometric Athens 900-700 BC; inspiration and influence, movement and trade: Greece 700-500 BC
C3	East Greece, 600-450 BC
C4	Athens 540-400 BC
C5	Greek Sanctuaries
C6	Greek Vases
C7	The Etruscan and Greek myths; Gods in Greece; Greek vases and the Etruscans
C8	Two Herakles figures; two Aphrodite figures
C9	Young satyr or Pan playing the flute
C10	The Greek world 400-1 BC
C11	Italy before Rome: 800-200 BC
C12	Rome: empire and wealth
C13	Collecting Antiquity
C14	Cambridge excavations
O1	Antinous as the god Dionysos
O2	'Dolphin' rock
O3	Gravestone sculptures
O4 (T)	Greek and Roman world timeline
O5	The Romans and Greek sculpture
O6a	Roman coffins and their decorations
O6b	Roman imperial portraits
O7	Gravestone sculptures
O8	Apollo
O9	Fragments of two Athenian inscriptions
O10	Two Serapis figures
O11	Honours for Antiochos I
O12	The Newton Hall Athena
O13a	The Sandwich Marble
O13b	Honours for Cassander
O14	Group of sculptures

O15	Dedication to the Emperor Nero
O16	Urns and grave-altars
O17	Group of sculptures
O18	The Emperor Marcus Aurelius
M	Map of the Greek and Roman world

Demographic protocol

Q1. How many times have you visited the Fitzwilliam Museum before?

1. □ Never   2. □ Once   3. □ Twice   4. □ 3-5 times   5. □ 6-10 times   6. □ More often

Q2. When did you last visit?

Q3. Have you visited this room before?   1. □ Yes   2. □ No

Q4. On this occasion, did you intend to visit this room or did you just wander in?

1. □ Intended 2. □ Wandered in

Q5. Which is your nationality and first language? _____

Q6. In which country do you currently live? _____

Q7. Who have you come to the Museum with today?
     1. □ Alone   2. □ Family   3. □ Friends   4. □ Partners/wife or husband/siblings
     5. □ Organised group 6. Others

Q8. What age group do you fall into?

1. □ 18-19   2. □ 20-24   3. □ 25-34   4. □ 35-44   5. □ 45-54   6. □ 55-64
7. □ 65+   8. □ Prefer not to say

Q9. What gender do you identify with?
1. □ Male
2. □ Female
3. □ Other
4. □ Prefer not to say

Thematic protocol

Part 1:
Questions about visitors' general use of the museum, motivations and expectations, planning of their visit.

Part 2:
Questions about the use/understanding of 3D prints and their tangible properties.

Part 3:

Questions about values associated to 3D prints and how they affected the meaning-making.

Favourite aspect of the exhibition

Room 20:

- Absolutely everything
- The history was interesting, and it was eclectic, things from different ages.
- It's fun to be able to learn about all these new things together. I didn't know most of the things we looked at, but he's a bit of an expert. He explained things to me most of the time.
- I think it's a great space for children. We can come here, and have a look at things and learn something new. We draw them together. Today we learnt how they were writing. And then we drew all the hieroglyphics we could find.
- My favourites were the statue and the tomb [points at the sarcophagus and the sarcophagus lid].
- It's all very interesting. I think what I liked best is that it gives information about the history. It's very detailed. A lot of information.
- I loved everything. It's not boring at all and everything is huge. I can't believe how big they are. Stunning.
- Everything very impressive and interesting.
- It's all nicely done. Very nice.
- Brilliant. I liked everything
- It's very nice. My son really liked the sarcophagus and the mummies (refers to different room)
- It reminded us of our trip to Egypt. We went two years ago along the Nile. It was really beautiful. And we saw a lot of these things, and all the places like Thebes, Cairo. So good!
- I think I enjoyed the most the information about how they are conserving things. You don't get many chances to see the behind the scenes, you know? I'd like to see how they clean papyrus.
- Pretty much the whole gallery. I liked that at some point you could touch a replica. It was cool to see which part of the it was on the thing.
- I liked everything really. I went to Egypt on my honeymoon. All these ancient things are stunning! I remembered so many things I've seen.
- I find this room very impressive every time I come. There are these huge objects, and they were a burial! Every time I come, I read something new. And it's my favourite gallery because you can also sit down!
- Everything was really good, very informative.
- She liked the object over there, the one you can touch. We tried to find together which part of the original thing it was. I think it's very nice to have that sort of resources for kids. We got them at the entrance (family activity).
- Everything was great. I think that it's incredible that you can see the colours on some of the stones. All the decorations are so fine. And all the jewellery. I think it's my favourite. all the shades of blue they used to paint.

- My favourite was the shrine. It would have been cool to see the statue inside but I guess it was not found.
- It's fascinating that the things in the coffin were painted red. All the figures would have been very bright. We recognised the jackal and the hawks, some birds.
- I thought that the panel that explains that Egypt is traditionally part of Africa was the most interesting. I don't think people realise it. Because now it's mainly part of the middle east. It's important.
- Absolutely the sarcophagus (points at the sarcophagus lid). It's crazy how big it is. And it shows the Pharaoh it's so perfect. So well preserved. I liked that they had pictures of the colours of the tomb.
- The other room (19) has a lot more impressive things to be honest. But I liked how big things are in here. That lid is huge.
- Everything was interesting. I really liked the information about the conservation of these objects. The pictures are great and it gives an idea of what the scientists of the museum do. I didn't know a lot of things. I had no idea that there are techniques that let you see the colours. Or things like X-rays on mummies. It's quite incredible.

Room 21:

- I liked seeing all the statues of the Romans. You have the head of Plato and all the emperors. It's very interesting
- Definitely the heads of the emperors
- Mmm if I have to choose one, I'll pick the sarcophagus. (Why) oh it was very detailed and decorated.
- The head with the double face (two headed herm of Dionysia and Silenus). It reminded me of a couple of people I know (and she laughed)
- My favourite... well in general all the history is quite interesting. You get a bit of everything
- There's a lot of information. A bit mixed between Roman and Greek, but it's interesting
- I really liked the history
- Everything was very informative.
- I thought the timeline was very good. I never realised that Romans and Greeks overlapped
- He (the child) liked very much touching that thing, the replica (points at it). The rest can be quite boring for him. It's great that there are things he can engage with. We also saw another replica in the other gallery (20). Do you have them everywhere in the museum?
- The mosaic with the peacock is exceptionally pretty
- Oh, I guess I have to choose the vases. We went to Pompeii a month ago and we saw so many. Here there are some nice ones.
- I liked everything. I'm Italian and it's my culture. I grew up with it. You really feel a connection, you know?
- It was very interesting how they decorated all the vases. How they made them.

- The jewellery over there (she pointed at case). It's incredible that the rings and the earrings are so well made. They look so fine and perfect. Something you could buy in a shop today and it would be very expensive
- I can't think of anything specific. But in general I liked everything
- I don't know. It's a very nice room. It's not to big but you have a bit of everything
- Everything
- Everything was interesting
- I liked everything
- Nothing in particular. I liked it
- I found everything quite informative
- The stories - I like the background information given here.
- Interesting, curious, we know the things, we have seen it before, so nice to see everything again.
- Everything was quite lovely!

Responses to the 3D prints

- interesting
- I really liked that I could touch it
- It's cool because you can't touch anything else in the room. I mean, surely you can't touch the other things!
- It's very clever.
- Room 21: I liked that I could touch it, but I found it a bit confusing at the beginning, because it doesn't look like the actual thing. You see? The text is sort of carved (on the original object) but here (on the 3D print) it's actually raised. But anyway, it was still good
- I think it's an excellent feature to keep the children engaged
- Yes, I liked it
- It's the perfect height for the kids.
- It was really nice because my daughter could touch it and she really enjoyed it. I think it makes the whole exhibition less boring and there should be more in the museum
- It helps understanding the actual thing. With the fact that you can't touch anything else it's good to have a technology that allows you to get a different sense of the things
- Sure, it's interesting.
- Touching is enjoyable for adults as much as children
- Very useful. It helps with children.
- (room 20) I think it helped me. You see, it's difficult to see the symbols here (on the Shrine), because it's faded. And the lights in here don't help. But it's very clear on here (3D print) and you can see it better.
- It has a nice feeling. I was expecting it to feel a bit more like stone but I guess it's normal because it's made of plastic. It's still pleasant to be able to touch it
- I was confused I thought it was real but then I touched it and I thought it was kind of made of plastic. Very nice.

- It was fine
- It's excellent because you don't want to damage the real object, but you can still touch at the same time.
- Really cool
- I don't remember
- It's great that the museum has this resources especially for children
- I don't really know. what is it again? (I explained) oh cool yeah it's nice
- I don't know.
- It's good for children.
- It's funny that you can touch. It catches the attention
- Very cool.
- Interesting
- I liked it.
- It's good because with the colour you can't really see all the decorations on the actual object. It's also too high for children (the original object). / But it would be nicer to have some more information. What the symbols mean, you know, the translation
- I would love to be able to touch all these things. But I understand you can't. Too many people would and it's bad for conservation. These replicas are great because at least you can still feel something.
- I liked that I could touch it, but I found it a bit confusing at the beginning, because it doesn't look like the actual thing. You see? The text is sort of carved (on the original object) but here (on the 3D print) it's actually raised. But anyway, it was still good (room 21).
- It has a nice feeling. I was expecting it to feel a bit more like stone, but I guess it's normal because it's made of plastic. It's still pleasant to be able to touch it.
- I don't know. I guess it's good to see things better, but personally, I'd like more information. What do the symbols mean? (room 20).
- I don't really see the point of it. I mean cool you can touch it, but it's not the real thing. I come here to see the real things.
- I just want to touch the real thing.
- I think it's really confusing because you can't touch anything else, but you can touch that one. So, you think you can also touch the other things (French speaker)
- It doesn't say anywhere what the text means. It only says that they wanted to get the favour of the king. So I was like ehm ok why am I touching it? (room 21).
- It would make sense to have a translation of the text. Otherwise I'm just looking at a bunch of letters (room 21).
- I would have liked it colourful. Or with images.
- I didn't realise it's a 3D print, (he went back after the interview) need for more clarification for sure.
- What is it made of? It really doesn't look like the actual inscription. You see? It's different. Letters here (on the 3D print) are huge, but here (original object) it's really fine, delicate. Also, there's no information. I don't know what it is and why it's here. What does it represent? What's the point?
- It's good, but it feels very plasticky. I know I can't touch the rest but after touching this (the 3D print) I'm even more curious.