

Rubber Hand

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THIS IS NOT A DEFINITIVE FINAL REPORT

FORMATIVE evaluation studies like this one often:

- **are conducted quickly**, which may mean
 - small sample sizes
 - expedited analyses
 - brief reports

- **look at an earlier version** of the exhibit/program, which may mean
 - a focus on problems and solutions, rather than successes
 - a change in form or title of the final exhibit/program

Mind - Formative Rubber Hand

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PURPOSE

Rubber Hand is an exhibit prototype that allows visitors to experiment with mixing visual and tactile information to experience the sensory illusion the combination can create. The exhibit requires 2 visitors, a subject and an experimenter. The subject places his/her hand underneath the exhibit's rubber hand so that s/he can only see the fake hand. The experimenter, sitting on the opposite side facing the subject, can touch the subject's real hand and the rubber hand and effect a sensory illusion wherein the subject feels that the dummy hand has become a part of his/her own body. See Figure 1, Figure 2 and Figure 3.

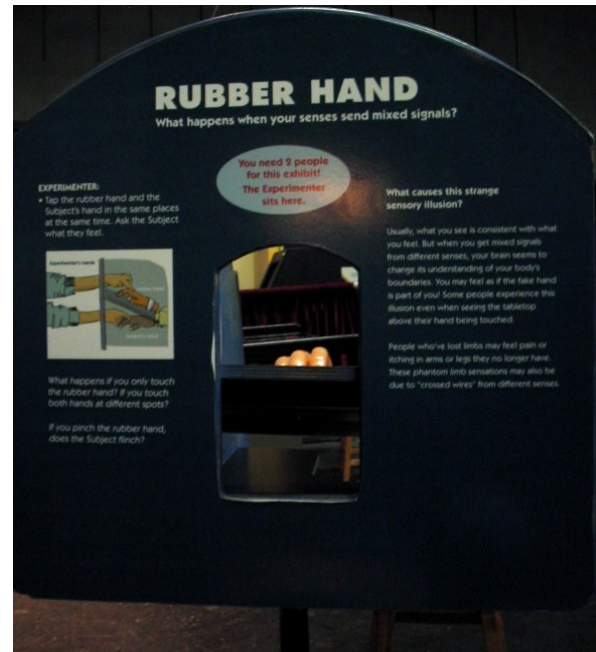
Figure 1. Rubber Hand Prototype in the Mind in Progress Section



Figure 2. Rubber Hand - Subject's Side



Figure 3. Rubber Hand - Experimenter's Side



This formative evaluation looks at

- What did visitors do at the Rubber Hand prototype? In particular, did visitors experience the intended effect, in which the dummy hand seems to be a part of their own bodies?
- What was and was not interesting about their exhibit experience?
- Did visitors discover anything about themselves and how their minds work at the current exhibit?
- What suggestions did visitors have for improving the exhibit? In particular, did any visitors feel that the color of the rubber hand should change to accommodate people of color?

METHOD

A chair was placed on the subject's side and on the experimenter's side of the prototype during the evaluation period.

An evaluator stood close to the Rubber Hand prototype and observed every visitor who was 8 years old or older and who sat down on the subject's side for at least 5 seconds. She made note of what the visitor did, paying particular attention to: whether s/he was alone or with another person at the exhibit and whether the subject and her/his experimenter did any of the suggested activities (i.e. tapping both the rubber and the real hand, tapping just the rubber hand, pinching the rubber hand). The evaluator also noted demographic information for each visitor pair she observed.

The evaluator approached the visitor whom she had just observed for an interview after that person had stepped away from the exhibit. This was provided that that visitor at some point during her/his experience was the subject of any experiment at the exhibit. That is, we only interviewed people who used the exhibit with another person who sat on the experimenter's side, while s/he sat on the subject's side. This subgroup represents people who went through some of the activities that can create the sensory illusion that is at the heart of this exhibit experience.

DATA COLLECTED

We collected data on 2 days: Friday, June 30 and Saturday, July 1, 2006.

Observations

We collected 27 observations and 15 interviews.

Group Type	Count (out of 27 Observations)	Count (out of 15 Interviews)
Individual adult	1	0
Individual child	2	0
Individual teen	2	0
Multi-generational	8	6
Peer - adult	10	7
Peer - teen	3	2

Gender Pairing¹	Count (out of 27 Observations)	Count (out of 15 Interviews)
Female Alone	2	0
Female-Female	5	3
Female-Male	6	4
Male Alone	3	0
Male-Female	4	2
Male-Male	6	6

¹ The first in the pair denotes the gender that was interviewed.

RESULTS

What visitors tried to do

The exhibit label recommends a set of activities to try. Table 1 gives the tally of the number of visitors who tried each activity.

Table 1. Suggested activities that visitors tried

Activity	Count (out of 27)
Tap both the rubber and real hand	16
Tap one hand only	11
Pinch the rubber hand	6
At least one suggested activity	17

12/27 visitors switched sides, or roles, while they were at the exhibit.

In addition we observed some less conventional behavior:

- An individual visitor was at the exhibit alone (5/27), but the exhibit requires two people for the phenomenon to work. In one such case, the solo visitor spent his time touching the rubber hand. In another case, the visitor looked under the table as if searching for a switch or mechanism. Another solo visitor tried to use the exhibit on himself by reaching one arm around to the experimenter's side.
- The subject was not sure where to place his/her hand (3/27). Two of the visitors we observed placed their hand on top of the rubber hand.
- The subject spent the entire time touching the rubber hand (2/27).
- Visitors came in a group, read the instructions but for unknown reasons did not try anything (2/27).
- The experimenter only used one hand, alternating between tapping the rubber hand and the real hand (1/27).
- The subject, while sitting on the subject's side, tapped the experimenter's hands (1/27).

We asked our visitors what, if anything, was confusing about the instructions. Over half (8/15) of the visitors we interviewed found the instructions clear. The others thought they could be improved. More specifically,

- Visitors wanted more information about what to expect (2/15).
- People misread rubber *hand* as rubber *band* and were confused by the misread (2/15).
- Visitors couldn't see the instructions clearly (2/15). One person said that it was too dark for her to read.
- People wanted more detailed directions about how to touch the hands (1/15).

Visitor3Fri: It should say to touch them in the same place -- on the same part of the hand.

- The instructions on the subject's side detracted from the experience (1/15).

Did visitors feel the effect

In many cases, we found that people had a very difficult time describing what they felt. Therefore, to determine if visitors experienced the intended sensory illusion, we asked visitors a set of questions from general to increasingly specific (and necessarily leading). We then looked across each person's responses to that set of questions to gauge if they felt the effect.

The following gives examples of visitors' responses to this line of questions. In this report, comments made by visitors who experienced the sensory illusion are noted in green, and those made by visitors who did not experience the illusion appear in red.

Examples from visitors who experienced the illusion

Interviewer: Was there anything that surprised you at the exhibit? [Probe: anything else?]

Visitor4Fri: It was kinda weird how it felt. I thought it would hurt when he hit the rubber hand.

Interviewer: So, when you were sitting on that side [*point to subject side*], can you describe what you felt if anything?]

Visitor4Fri: I thought--it's hard to describe! -- I expected it to feel like my hand but it didn't.

Interviewer: ... [*ask only if you observed this activity*] especially when the other person touched the rubber hand differently from how s/he touched your hand

Visitor4Fri: Slightly, yeah. I kinda expected that the actual hand wouldn't react but it did.

Interviewer: ... [*ask only if you observed this activity*] So, did it feel like s/he was touching your hand even when s/he wasn't?

Visitor4Fri: Yeah.

Interviewer: Was there anything that surprised you at the exhibit? [Probe: anything else?]

Visitor5Fri: I didn't realize he was reaching through and touching my hand for real. But as soon as he did it I knew he was doing it. At first, I just didn't see him, so it was a surprise.

Interviewer: So, when you were sitting on that side [*point to subject side*], can you describe what you felt if anything?]

Visitor5Fri: Just for the briefest moment, I thought I could feel him touching the rubber hand.

Interviewer: ... [*ask only if you observed this activity*] especially when the other person touched the rubber hand differently from how s/he touched your hand

Visitor5Fri: Just touching a different finger? No

Interviewer: ... *[ask only if you observed this activity]* So, did it feel like s/he was touching your hand even when s/he wasn't?

Visitor5Fri: I don't think so.

Interviewer: Was there anything that surprised you at the exhibit? [Probe: anything else?]

Visitor1Sat: How strange it would feel to have the hands touched in the same spot and in different spots.

Interviewer: So, when you were sitting on that side *[point to subject side]*, can you describe what you felt if anything?]

Visitor1Sat: I felt like when he touched the rubber hand, I really felt like the rubber hand was the hand I was supposed to feel.

Interviewer: ... *[ask only if you observed this activity]* especially when the other person touched the rubber hand differently from how s/he touched your hand

Visitor1Sat: It didn't seem right. It should have been the same touch.

Interviewer: ... *[ask only if you observed this activity]* So, did it feel like s/he was touching your hand even when s/he wasn't?

Visitor1Sat: Yes.

Examples from visitors who did NOT experienced the illusion

Interviewer: Was there anything that surprised you at the exhibit? [Probe: anything else?]

Visitor4Sat: I thought the reaction that I did with my wife would be stronger.

Interviewer: So, when you were sitting on that side *[point to subject side]*, can you describe what you felt if anything?]

Visitor4Sat: I didn't really feel what I thought I was supposed to feel.

Interviewer: ... *[ask only if you observed this activity]* especially when the other person touched the rubber hand differently from how s/he touched your hand

Visitor4Sat: No, I told him to do it at the same time.

Interviewer: ... *[ask only if you observed this activity]* So, did it feel like s/he was touching your hand even when s/he wasn't?

Visitor4Sat: no

Interviewer: Was there anything that surprised you at the exhibit? [Probe: anything else?]

Visitor14Sat: Not really, 'cause I didn't do it right.

Interviewer: So, when you were sitting on that side *[point to subject side]*, can you describe what you felt if anything?]

Visitor14Sat: I didn't feel anything.

Overall, 8/15 visitors seemed to have experienced the sensory illusion. For completeness, Table 2 and Table 3 give the tallies of visitors who did and who did not experience the illusion

according to group type and gender pairing, respectively. We have very small numbers and, therefore, cannot comment on whether or not one demographic in particular is having problems with this effect.

Table 2. Tally of visitors who felt and who did NOT feel the illusion according to group type

Group Type	Felt Illusion (out of 8)	Did NOT Feel Illusion (out of 7)
Multi-Generational	4	2
Peer - Adult	2	5
Peer - Teen	2	0

Table 3. Tally of visitors who felt and who did NOT feel the illusion according to gender pairing

Gender Pairing	Felt Illusion (out of 8)	Did NOT Feel Illusion (out of 7)
Female-Female	1	2
Female-Male	2	2
Male-Female	1	1
Male-Male	4	2

Visitors' Interest

On average, visitors thought the exhibit was *Neutral*, neither interesting nor not interesting.

Interest Rating	Count (out of 27)
Interesting	2
Somewhat Interesting	4
Neutral	6
Somewhat Uninteresting	3
Uninteresting	1

Visitors found the exhibit interesting for the following reasons:

- It felt strange (5/15)

Visitor2Fri: Because I wouldn't call it bad because it feels weird and stuff. It feels weird.

Visitor3Fri: The unexpected nature of it.

Visitor8Fri :It felt weird.

Visitor9Fri: Because whenever someone touched the rubber hand, I could feel it too.

Visitor15Sat: Because the feeling was strange and interesting.

- The interaction between the mental and the physical is interesting (1/15)
 - Visitor 10Fri:'Cause it's interesting to see the mental-physiological effect in action.
- It was interactive (1/15)
 - Visitor 14Sat: Because you get to be interactive.

What visitors found uninteresting

On the other hand, visitors thought the exhibit was not interesting because:

- Visitors could not feel what they were 'suppose to' (4/15)
 - Visitor 4Sat: 'Cause I did it with my little guy and I don't know if I got the real experience.
 - Visitor311Sat: I didn't feel the result. But the idea is good. The idea is a 4
 - Visitor 15Sat:'Cause it didn't seem to work that well.
 - Visitor 16Sat: If it worked, it would be interesting.
- It was confusing (2/15)
 - Visitor4Fri: It would be cooler if you had the instructions on the subject side, but it's good that the explanation is on the other side
 - Visitor6Fri: It has so many words that it's hard to figure out what to do: You've got to figure it out.
- It wasn't interactive enough (1/15)
 - Visitor 7Fri: I don't know, it wasn't really hands-on. (!!! - said totally straight, no pun or tongue-in-cheek apparent) It didn't really deceive me.

What the exhibit showed visitors

We asked visitors if the exhibit experience showed them anything new about themselves or how their minds work. A minority (3/15) of the visitors said yes. For these visitors, the exhibit showed them:

Visitor3Fri: Your brain expects certain things to be true.

Visitor4Fri: I react before I think it through.

Visitor11Sat: (he thought of this in the middle of the next question) I go for the most convenient explanation; I try to make sense of it even if it doesn't make sense.

However, none of these thoughts occurred to the visitor while s/he was at the exhibit. Instead the interview seemed to have prompted their self-reflection. This suggests that visitors are not connecting their experience with the workings of their own minds while at the exhibit.

We did, however, find that a majority (12/15) of the visitors did know what phantom limb means before they read about it in the label. The following are examples of some visitors' definition of phantom limb:

Visitor3Fri: Yeah. That when you lose a limb you still think it's there. Your brain still thinks you have it.

Visitor4Fri: I guess it's kind of what it feels like when someone who has an amputated limb feels an itch on it but it doesn't.

Visitor7Fri: Yes--when an amputee still feels a sensation in their fingertips.

Visitor15Sat: Means when someone has an amputation. They continue to have a sensation as if that limb is still there.

This suggests that the term does not seem to help visitors connect the exhibit experience to themselves, but instead to another phenomenon they have heard about but have no experience with.

Visitors' suggestions for improvement

Visitors made some suggestions for improving the next version of Rubber Hand:

- Have clearer instructions (2/15)
 - Visitor3Fri: Just to say to touch both hands in the same place.*
 - Visitor14Sat: I'd make the letters bigger and in a more lighted spot, and fewer instructions.*
- Make the rubber hand a more natural extension of the real hand (2/15)
 - Visitor4Fri: It would be good if you had an arm bracket so you could put your arm in it and it would look more like your arm was attached to it.*
 - Visitor16Sat: (boyfriend:) Maybe remove the cuff and have the hand at the same angle.*
- Make the rubber hand more rubbery, perhaps for pinching (1/15)
 - Visitor6Fri: (She touches hand again.) I'd make it more rubber-like.*
- Eliminate the instructions on the subject's side (1/15)
 - Visitor5Fri: Maybe make it so that the person on the [subj.] side doesn't know what's going on.*
- Don't allow people to peek at the real hand (1/15)
 - Visitor7Fri: (reading more) Better directions on the other side where the rubber hand is. No, I guess it's clear. Maybe put your hand in a box so you can't peek.*
- Make the rubber hand more prominent (1/15)

Visitor15Sat: Maybe if the whole exhibit is more covered so that when you look from the top, you can only see the rubber hand. It's flesh-colored--or at least it's some people's flesh color.

We were particularly concerned about the color of the current rubber hand. Previously a visitor commented on the color of the hand as being appropriate for only a certain portion of the audience. The hand is white. In this evaluation, we initially asked people what they thought about a neutral grey hand, instead of the current one. Out of the 7 people we asked, two visitors thought it would make the hand look dead and one person thought the hand would look more weird. Only one person thought that this would better accommodate people of color.

We then changed the question and asked people what they thought about our changing the color of the hand to a neutral color. Four (out of 8) visitors were only concerned that the new hand would still match their hand. The other four thought that this may help accommodate more people. For example:

Visitor11Sat: If it's a neutral color then it would be easier to imagine it's your own hand. (Subj. is South Asian)

Visitor14Sat: No, I'd leave it that color. Because it's more realistic. (Daughter says, 'Unless you're black, or Hispanic.') [Mom is white. Daughter is Hispanic.]

No one, however, during their interview suggested changing the color of the current hand until it was suggested to them. And only 4 visitors thought it might help; yet, they did not feel strongly about the change. We note that most of the visitors we interview were not people of color.

SUMMARY

A majority (17/27) of the visitors, whom we observed, tried at least one of the activities suggested at the Rubber Hand prototype (i.e., tap the rubber hand and the real hand, tap only the rubber hand, and/or pinch the rubber hand.). However, we also noticed that some visitors had difficulties using the exhibit:

- Some people (5) tried to use the exhibit alone.
- A few others (3) were not sure where to place their hand.
- And, 2 people sat down at the exhibit and for some unknown reason never tried any of the activities.

Of the people who tried an activity, about half (8/15) experienced the intended effect. They described a strange feeling. As one visitor put it:

Visitor4Fri: [it] feels like my hand but it didn't

The other half (7) of the visitors did not report feeling the sensation even though at some point they tried an activity that could have potentially created the strange sensory effect.² Correspondingly, visitors on average found the exhibit neither interesting nor not interesting. The most frequent reason for finding the exhibit interesting was the strange feeling it created. Alternatively, the most frequent reason for finding the exhibit not interesting was the visitors' inability to experience the intended sensation.

Visitors volunteered some suggestions for improving the odds of feeling an effect. Their recommendations fall into these general categories:

- Clearer and easy-to-see instructions on the experimenter's side.
- A rubber hand that seems more real, though no visitor complained about the color of the current hand until prompted. Even then, only 4 visitors thought the exhibit might improve with a more neutral color hand.
- More focus on the rubber hand, which may involve removing distractions such as the instructions on the subject's side and/or better concealing the subject's real hand.

Finally, few visitors (3) reported discovering anything about themselves or how their minds work. In fact, the 3 visitors, who said they did, made the connection only during their interviews. That is, the interviews were what prompted visitors' self-reflection. This suggests that we should experiment with ways to better encourage people to reflect on the experience the exhibit enables.

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² It is possible that for some people the illusion was so convincing that they never realized the discrepancy.

APPENDIX A**Observations**

Start Time _____ (when visitor sits)

End Time _____ (when visitor leaves the exhibit)

Note the sequence of activities and reactions. In particular, make note of the following:

1. Did they do all the suggested activities? Which ones? In what sequence? Did they do each activity 'right'?
2. Did they switch roles (subject vs. experimenter)?
3. Was the person alone? Did s/he call someone over?
4. Did the subject 'react'?
5. Any snippets of conversation you overhear.
6. Did s/he read the explanation panel and/or the instruction panel

Interview Questions

1. How interesting did you find that experience? Would you say that was ...

Uninteresting	Somewhat Uninteresting	Neutral	Somewhat Interesting	Interesting
1	2	3	4	5

2. What made it _____ for you?

3. Can you describe what you tried to do at the exhibit?

4. Was there anything confusing about the instructions? [If YES] What was confusing?

5. Was there anything that surprised you at the exhibit? [Probe: anything else?]

6. Did the activity show you anything new about yourself or how your mind works?

[If YES]

a. What did it show you?

b. Did you think of that just now as we're talking or before now?

7. So, when you were sitting on that side [*point to subject side*], can you describe what you felt if anything?

... [*ask only if you observed this activity*] especially when the other person touched the rubber hand differently from how s/he touched your hand

... [*ask only if you observed this activity*] So, did it feel like s/he was touching your hand even when s/he wasn't?

8. We're curious: does the phrase 'phantom limb' mean anything to you? It's okay if it doesn't. [*if YES*] What does it mean to you?

9. What if anything would you change about this exhibit? [Pause to give visitor a chance to answer. Then, follow with...] For example, we're thinking of replacing the hand there now with a grey hand. Do you think that's a good or a bad idea?

This version was used in later interviews: What if anything would you change about this exhibit? [Pause to give visitor a chance to answer. Then, follow with...] For example, we're thinking of replacing the hand there now with a more neutral color hand. What do you think?