

Browser Permission Mechanisms Demystified

(Details of User Study)

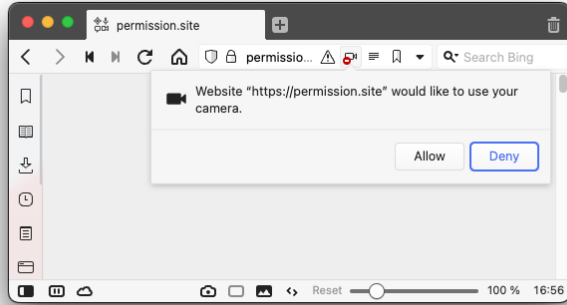


Fig. 1. Screenshot of a web browser requesting the camera permission. (Japanese prompts were used in the survey. The prompts are shown translated into English.)

I. UNDERSTANDING USER EXPECTATIONS

In the following, we present detailed results of the online surveys highlighted in Section V. Recall that surveys U_1 – U_6 correspond to test scenarios T_1 – T_6 defined in Section IV. We conducted the online surveys using Lancers [1], hence our participants are Japanese. The questionnaire used for the online survey is available on the official website of this study [2].

Here is an example of a task that participants in the experiment engage in. In the survey U_1 , we ask participants to assume the following scenario.

You are browsing a website using a web browser. The website requests camera permissions, and the permission request prompt shown in Figure 1 appears on your web browser. Suppose that you have denied or granted the camera permission request.

The participants answer the following questions about the permission granted to the website for each case: (1) whether a website can record camera footage and (2) whether a website can send the recorded camera footage to outside parties. The participants choose the answer from “Yes,” “No,” or “Don’t know.”

U_1 : User Expectations on the Permission Mechanisms. Survey U_1 aims to investigate users’ expectation on the permissions they give to websites when they grant or deny these permissions. Specifically, we investigate users’ expectations of whether a website can (1) record camera footage and (2) send the recorded camera footage to outside parties when users deny or grant camera permissions. Table I shows that the percentage of users who were able to correctly understand the relationship between camera permission status and whether or not the video

can be recorded is 93% for denying permissions and 79% for granting permissions, respectively. The table also shows that the percentage of users who were able to correctly understand the relationship between camera permission status and the ability to send the recorded images to the outside parties was 88% for the denial of permissions and 60% for the grant of permissions. This means that 40% of the users did not have a correct understanding.

U_2 : User Expectations Regarding the Persistence of the Permission State. Survey U_2 aims to investigate how users expect whether the permission state is persistent after setting the permission state to granted or denied. In our experiments, we asked users to assume a situation in which, after allowing or denying permissions on a website, they accessed the same website and received a second request for permissions.

Table II shows the results. Here, all participant groups were defined as Group A ($N = 232$), and Group B ($N = 121$) was defined as the group of participants who knew about and had used the private browsing mode. In the normal browsing mode, when the permission state is denied/granted, 65%/38% of users expect that the permission is not persistent, respectively. This result suggests that, in the normal browsing mode, users expect the permissions they grant to have persistence rather than the permissions they deny. In the private browsing mode, approximately 60% of users in Group A and 75% of users in Group B expect permissions to be non-persistent, regardless of the permission status.

The results shown in Section IV revealed that, in the private browsing mode, all the browsers investigated persist at least one or more permission states. These observations indicate that user expectations and the current web browser implementations differ.

U_3 : User Expectations Regarding Isolation of the Permission State Across Browsing Modes. Survey U_3 aims to identify users’ expectations regarding the isolation of permission states across browsing modes. In our experiments, we asked users to assume a situation in which they grant or deny a camera permission request on one website and then access the same website in a different browsing mode and again receive a camera permission request.

Table III shows the results. As in the U_2 experiment, we divided the users into two groups, A and B. Specifically, 63–73% of all users (Group A) expect that the permission state is not inherited across browsing modes. In Group B, where users are more familiar with the private browsing mode, the trend is more significant, with 72–80% of users expecting the permission state not to be shared across browsing modes, especially for denied permissions. The results presented in Section IV revealed that, for all the web browsers investigated,

TABLE I. RESULTS OF U1: USER EXPECTATIONS ON THE CAMERA PERMISSION STATUS.

User expectations (recording images)	Denied	Granted
The website can record camera footage.	3 (1.3%)	183 (78.9%)
The website cannot record camera footage.	216 (93.1%)	10 (4.3%)
Other	13 (5.6%)	39 (16.8%)
User expectations (sending iamges)	Denied	Granted
The website can send camera footage to an external source.	4 (1.7%)	140 (60.3%)
The website cannot send camera footage to an external source.	203 (87.5%)	19 (8.2%)
Other	25 (10.8%)	73 (31.5%)

TABLE II. RESULTS OF U2: USER EXPECTATIONS ON THE PERSISTENCE OF PERMISSION STATUS.

Browsing Modes	Normal		Private			
Group	A		A		B	
Permission status	Denied	Granted	Denied	Granted	Denied	Granted
Persistent	49 (21.1%)	107 (46.1%)	44 (19.0%)	32 (13.8%)	18 (14.9%)	12 (9.9%)
Not persistent	150 (64.7%)	88 (37.9%)	146 (62.9%)	141 (60.8%)	92 (76.0%)	91 (75.2%)
I don't know	33 (14.2%)	35 (15.1%)	41 (17.7%)	7 (3.0%)	11 (9.1%)	14 (11.6%)
Other	0 (0%)	2 (0.9%)	1 (0.4%)	52 (22.4%)	0 (0%)	4 (3.3%)

Group A : All participants, Group B : Participants familiar with Private Browsing Modes

the permission state is shared across browsing modes for one or more of the permission types. This result also suggests a gap between user expectations and browser implementation.

U₄: User Expectations for Browsing Data Deletion Mechanisms. Survey U₄ aims to identify users' expectations of the browsing data deletion mechanism. In this experiment, we asked users to assume the following scenario. The user applies the data deletion feature provided by the browser after denying or granting a camera permission request for a certain website. The user then accesses the same website again, and camera permission is requested.

The results are shown in Table IV. Here, Group A consists of all participants ($N = 232$), Group B consists of participants who know and have used the data deletion mechanism ($N = 177$), and Group C consists of participants who know and have used both the private browsing mode and the data deletion mechanism ($N = 106$). Among all users (Group A), approximately 70% or more expect that the data deletion mechanism will erase the permission state, regardless of the browsing mode or permission state. Approximately, 80% of Group C users expect the data deletion mechanism to erase their permission state in the private browsing mode.

As shown in Section IV, all web browsers, except for Safari, retain their permission state even after the data deletion mechanism is applied. Thus, a gap between user expectation and implementation with respect to the data deletion mechanism of web browsers for permission states is noticeable.

U₅: User Expectations of Browser Behavior when Permission Requests Are Ignored. The objective of survey U₅ is to understand the user's expectations of the permission state when the user ignores permission request prompts multiple times. In this experiment, we asked participants to assume the following scenario. A user accesses a website that requires camera permission. The user ignores the permission request prompt several times.

As shown in Section IV, all browsers, except for Firefox, have introduced a mechanism to automatically deny the permission and not display the permission request prompt if the permission request is ignored several times. Table V shows the results of examining the relationship between the number of times a permission request is ignored m and the

browser's behavior regarding the permission status expected by the user. Regardless of the number of times a request was ignored, about 25% of users gave answers that were either different from the actual browser behavior or were unsure. Table VI examines users' expectations of browser behavior when permissions are repeatedly requested. Approximately, 68% of users believe that an implementation that displays a permission request prompt each time is appropriate, even if the request is ignored multiple times. Another 38% of users believe that permissions should not be denied automatically. These results clearly indicate a gap between user expectations and current browser implementations.

U₆: User Expectations for the Overlaid Prompt Display. The purpose of survey U₆ is to determine users' expectations of browser behavior when a permission request prompt pops up from a different website than the one displayed on the screen. In this study, we asked participants to assume the following scenario. While the user is browsing website A displayed on the screen, website B, which is open in a background tab, displays a camera permission request prompt overlaid on top of website A. The user selects to deny or grant the displayed permission request. In the above scenario, we surveyed what permission status the user expects to be given to each website.

Table VII shows the results of asking the user what permissions were granted to websites A and B when the user chose to deny or grant the camera permission request sent by website B, which was hidden from the screen. If the user grants the permission request sent by website B, then the correct specification is that no permissions are granted to website A. If the user grants the permission request sent by website B, then the correct specification is that permissions are granted to website B. However, 44% of the users either did not know or said that website A could use the camera. This result suggests that it is not easy for users to make the right decision when the permission request prompt is overlaid.

Table VIII asks users' opinions about the implementation of the overlay of the permission request prompt. 19% of the users answered that it was rather inappropriate, and 54% answered that it was not appropriate. As indicated in Section VI-B, implementations in which permission request prompts are overlaid can be exploited by attackers.

TABLE III. RESULTS OF U3: USER EXPECTATIONS ON THE ISOLATION OF THE PERMISSION STATUS ACROSS BROWSING MODES.

Browsing Modes	From normal to private				From private to normal			
Group	A		B		A		B	
Permission status	Denied	Granted	Denied	Granted	Denied	Granted	Denied	Granted
Shared	48 (20.7%)	38 (16.4%)	21 (17.4%)	15 (12.4%)	34 (14.7%)	46 (19.8%)	15 (12.4%)	19 (15.7%)
Not shared	152 (65.5%)	147 (63.4%)	87 (71.9%)	88 (72.7%)	171 (73.7%)	145 (62.5%)	97 (80.2%)	85 (70.2%)
I don't know	32 (13.8%)	38 (16.4%)	13 (10.7%)	13 (10.7%)	27 (11.6%)	38 (16.4%)	9 (7.4%)	15 (12.4%)
Other	0 (0%)	9 (3.9%)	0 (0%)	5 (4.1%)	0 (0%)	3 (1.3%)	0 (0%)	2 (1.7%)

Group A : All participants, Group B : Participants familiar with private browsing modes

TABLE IV. RESULTS OF U4: USER EXPECTATIONS ON THE BROWSER DATA DELETION MECHANISM.

Browsing Modes	Normal				Private			
Group	A		B		A		C	
Permission status	Denied	Granted	Denied	Granted	Denied	Granted	Denied	Granted
Erased	174 (75.0%)	161 (69.4%)	143 (80.8%)	135 (76.3%)	159 (68.5%)	161 (69.4%)	88 (83.0%)	84 (79.2%)
Not erased	35 (15.1%)	45 (19.4%)	23 (13.0%)	28 (15.8%)	37 (15.9%)	29 (12.5%)	11 (10.4%)	10 (9.4%)
I don't know	22 (9.5%)	25 (10.8%)	11 (6.2%)	13 (7.3%)	35 (15.1%)	37 (15.9%)	7 (6.6%)	10 (9.4%)
Other	1 (0.4%)	1 (0.4%)	0 (0%)	1 (0.6%)	1 (0.4%)	5 (2.2%)	0 (0%)	2 (1.9%)

Group A : All participants, Group B : Participants familiar with private browsing modes

TABLE V. RESULTS OF U5: USER EXPECTATIONS OF BROWSER BEHAVIOR WHEN PERMISSION REQUESTS ARE IGNORED.

Expected permission status	$m = 1$	$m = 2$	$m = 3$
The website can use/get the camera footage	12 (5.2%)	9 (3.9%)	9 (3.9%)
The website cannot use/get the camera footage	177 (76.3%)	176 (75.9%)	180 (77.6%)
I don't know	43 (18.5%)	47 (20.3%)	43 (18.5%)

TABLE VI. RESULTS OF U5: USER OPINIONS OF BROWSER BEHAVIOR WHEN PERMISSION REQUESTS ARE IGNORED.

Question	Options	Count(%)
How do user think about the repetitive display of permission request prompts?	Appropriate	61 (26.3%)
	Somewhat appropriate	98 (42.2%)
	Not really appropriate	39 (16.8%)
	Not appropriate	24 (10.3%)
	I don't know	10 (4.3%)
Do you think the mechanism † is implemented?	Yes	92 (39.7%)
	No	140 (60.3%)
The permission status should automatically become denied when permission is repeatedly requested.	Strongly agree.	54 (23.3%)
	Somewhat agree	82 (35.3%)
	Somewhat disagree	61 (26.3%)
	Strongly disagree.	28 (12.1%)
	I don't know	7 (3.0%)

† : Mechanism that prevents web browsers from repeatedly displaying permission request prompts.

TABLE VII. RESULTS OF U6: USER EXPECTATIONS ON THE OVERLAID PROMPT DISPLAY.

Permission status	Denied		Granted	
Website	A	B	A	B
The website can use/get the camera footage.	10 (4.3%)	10 (4.3%)	53 (22.8%)	190 (81.9%)
The website cannot use/get the camera footage.	188 (81.0%)	200 (86.2%)	129 (55.6%)	20 (8.6%)
I don't know	34 (14.7%)	22 (9.5%)	50 (21.6%)	22 (9.5%)

† : The implementation is that permission request prompts are displayed on different websites.

TABLE VIII. RESULTS OF U6: USER OPINIONS ON THE IMPLEMENTATION OF THE OVERLAID DIALOG DISPLAY.

Question	Options	Count(%)
How do users think about the implementation? †	Appropriate	28 (12.1%)
	Somewhat appropriate	27 (11.6%)
	Not really appropriate	43 (18.5%)
	Not appropriate	126 (54.3%)
	I don't know	8 (3.4%)

† : The implementation is that permission request prompts are displayed on different websites.

REFERENCES

- [1] Lancers,inc. Lancers. <https://www.lancers.jp/>, oct 2022.
- [2] Kazuki Nomoto. Permium. <https://permium.seclab.jp/>, oct 2022.