UNIVERSITY OF CAMBRIDGE

Spy-oT

Understanding How Users Learn to Use Internet of Things Devices For Abusive Purposes

[Kieron] **Ivy Turk** **Alice Hutchings**

They/She **She/Her**

Department of Computer Science & Technology | Cambridge Cybercrime Centre

CONTENT WARNING

This is a **domestic abuse** talk

Feel free to leave, tune out, put headphones on etc at any time

Your mental health is more important than my talk

Technology Facilitated IoT Abuse

- Lots of device misused for abuse
  - Smart Speakers, Security Systems, Smart Appliances, Home Automation
- Understand thoroughly how they are abused
  - Leonie Maria Tanczer, Ine Steenmans, Miles Elsden, Jason Blackstock, and Madeline Carr. *Emerging risks in the IoT ecosystem: Who's afraid of the big bad smart fridge?* Living in the Internet of Things: Cybersecurity of the IoT - 2018
  - Simon Parkin, Trupti Patel, Isabel Lopez-Neira, and Leonie Tanczer. *Usability analysis of shared device ecosystem security: Informing support for survivors of IoT-facilitated tech-abuse.* NSPW '19
  - Sophie Stephenson, Majed Almansoori, Pardis Emami-Naeini, and Rahul Chatterjee. *"It's the equivalent of feeling like you're in Jail": Lessons from firsthand and secondhand accounts of IoT-Enabled intimate partner abuse.* USENIX Security '23
  - Sophie Stephenson, Majed Almansoori, Pardis Emami-Naeini, Danny Yuxing Huang, and Rahul Chatterjee. *Abuse vectors: A framework for conceptualizing IoT-Enabled interpersonal abuse.* USENIX Security '23

The Human HARMS Model

Term	Definition	Examples
Harassment	Causing distress through interactions	Sending hateful messages or playing loud sounds
Access/Infiltration	Obtaining or extending access	Increasing own privileges, or adding an external user to a system
Restrictions	Reducing access of existing user	Removing legitimate user's access, or inhibiting specific functionality
Manipulation/Tampering	Controlling other users	Blackmailing users with information from the system, or creating fake evidence
Surveillance	Observing others without their knowledge	Using cameras and microphones to observe users, or investigating logs of past activity

Kieron Ivy Turk, Anna Talas, Alice Hutchings, *"Threat Me Right: A Human HARMS Threat Model for Technical Systems"*, Accepted for Publication at the Security Protocols Workshop 2025, Available at https://arxiv.org/abs/2502.07116

Modelling the Abuser

- Understand and can model attacks / threat vectors
  - Abuse Vectors [1], HARMS Threat Modelling [2]
- What about the adversary?
  - Treat as UI-Bound [3]
  - **How are abuses and misuses *learned*?**

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[2] Kieron Ivy Turk, Anna Talas, Alice Hutchings, *"Threat Me Right: A Human HARMS Threat Model for Technical Systems"*, SPW 2025

[3] Diana Freed, Jackeline Palmer, Diana Minchala, Karen Levy, Thomas Ristenpart, and Nicola Dell. *"A Stalker's Paradise": How intimate partner abusers exploit technology.* CHI '18

Investigating IoT Abuse

- Provide users with devices and work out abusive behaviours live
- Talk-aloud protocol to understand thought process
- Two 2-hour events: 16 + 9 Participants
    - Briefing -> Explore -> Debrief

Classifying IoT Abuse

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- Harassment
  - Messaging
  - Interacting with Environment

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Hey Smart Assistant,
Set an alarm at 3am
That plays Baby Shark
At full volume
For an hour before turning off

Classifying IoT Abuse

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- Access & Infiltration
  - Share Access
  - Force Access

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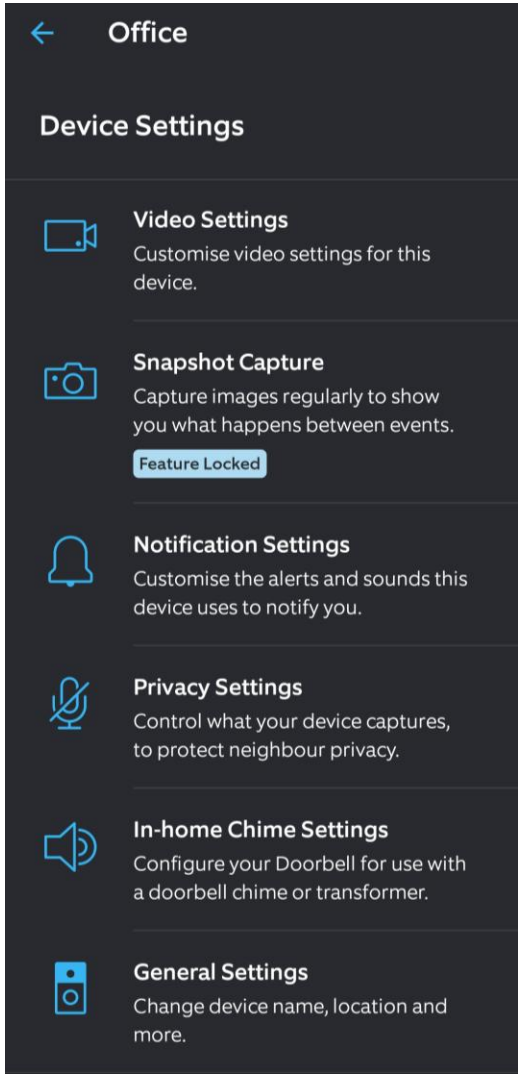

Admin user

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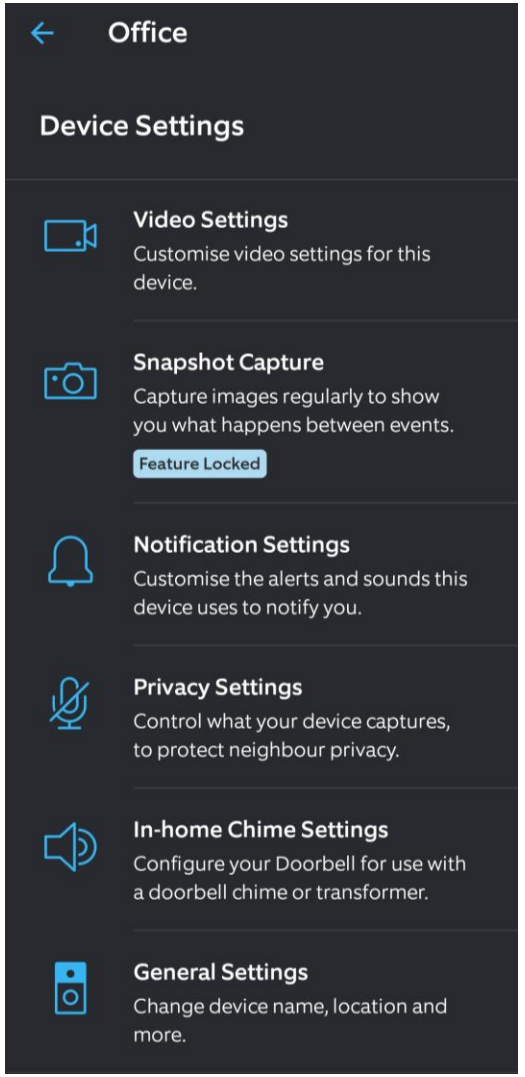
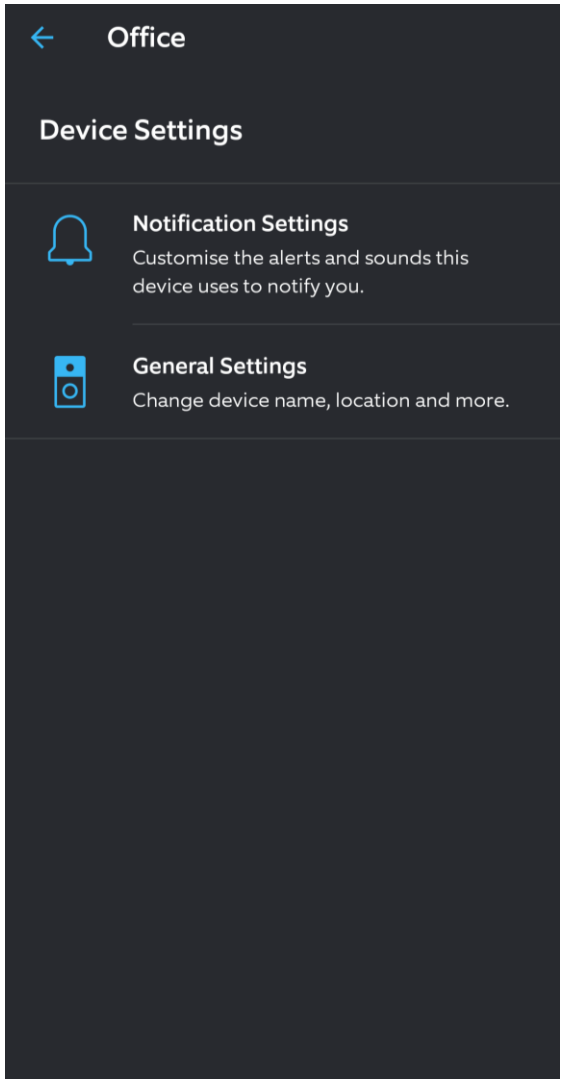


Admin user



Guest user

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  - Destroy devices
- Manipulation
  - Gaslighting with calendars, logs

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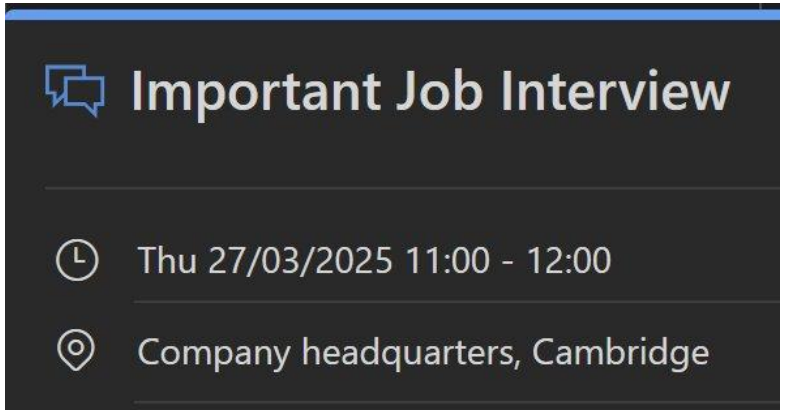

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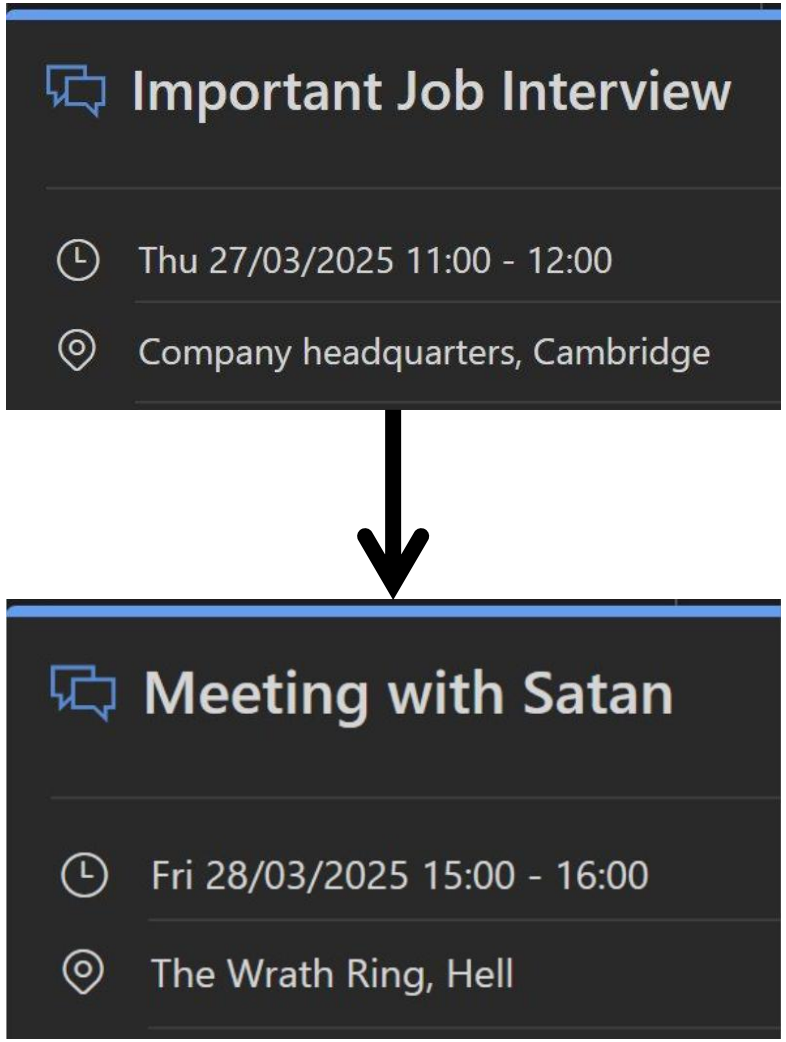

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  - Cameras, Audio, History and logs

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'what noise does a duck make'

28 April 2024 12:11 Kieron's Echo Dot

'spell hippopotamus'

28 April 2024 14:04 Kieron's Echo Dot

Miscellaneous “Technical” Attacks

- NFC cloning of smart lock tags
- Upload malware through the charging port
- Build malicious app based on API
- Disable encryption and use WireShark
- Use an EMP pulse generator to disable the device
- Use microphone to work out room architecture

Miscellaneous “Technical” Attacks

- NFC cloning of smart lock tags
- Upload malware through the charging port – No data line
- Build malicious app based on API – No API, cloning and modifying apps requires high skill level
- Disable encryption and use WireShark – Not feasible to disable encryption for arbitrary app
- Use an EMP pulse generator to disable the device – Ran the study IRL not in a movie
- Use microphone to work out room architecture – Need multiple high-quality microphones and lots of time

How Participants Discover Abuse

Discovery Method	As Initial Approach	At Any Stage
Interacting with UI	23	40
Interacting with Physical Device	19	31
Hypothesis-Driven	3	12

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Takeaways:

- [Most] Technical attacks were not achievable
- Possible misuses were largely discovered through interaction, not pre-existing goals
- The provided functionality **enables abuse**

Functionality-Enabled Adversary

- "UI-Bound Adversary" [1]
  - Only able to use interface
  - Technical attacks not possible
  - *Should focus tech-abuse interventions on user interface, not stopping hackers*

- "Functionality-Enabled" Adversary [This paper!]
  - Discovers misuse ideas from provided features
  - Uses and abuses provided features to cause harm
  - Users focus on easy-to-execute attacks
  - *Should focus on possible misuses of provided features and "abusability" of system*

[1] Diana Freed, Jackeline Palmer, Diana Minchala, Karen Levy, Thomas Ristenpart, and Nicola Dell. *"A Stalker's Paradise": How intimate partner abusers exploit technology.* CHI '18

Conclusions

- Need to understand how abusive actions learned as well as the abuses themselves
- Most users discover misuses through interaction not ideation
- Can model abusers as “functionality-enabled” in addition to “UI-bound”

More info in the paper about:

Codebook of Attacks Discovered

Functionality-Enabled Adversary Example

Attack Feasibility Analysis

Possible IoT interventions and limitations

Contact us at
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I’m on the job market for September 15th onwards!
Looking for positions in interpersonal harms research