The Privacy Generation: A Historical, Multileveled Analysis on the Sociotechnical Factors Responsible for American Belief in Camera Covers

A Research Paper Submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Jared Conway

Fall 2024

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Kathryn A. Neeley, Associate Professor of STS, Department of Engineering and Society

## I.	Introduction

From as recent as 2015, children are growing up in a new technological age which has caused a disconnect in families (Hayman, 2016, 11). Specifically, between the years 2011 to 2013, the amount of children under the age of 2 years that have used a smart device has gone from around 11% to 38% (Gold, 2015, Growing Up Digital). Although not all children have disconnected, some "children melt down every day when it is time to unplug" (Gold, 2015, One Size Does Not Fit All). Parents have over time been losing influence over their children as families continue to disconnect (Hayman, 2016, 17). Children are becoming a more prominent actor in the sociotechnical system, meaning engineers must go beyond accounting for the "expert views" of parents, to also accounting for the "user views" of children (Pacey, 1983, 154-155).

For example, about 33.3% of notebook users younger than 18 in a study conducted in Germany were not comfortable with their own notebook cameras potentially recording them, even when there was no real threat involved (Machuletz et al., 2016, 4). Unfortunately, as around "seventy-seven percent of public schools reported moving classes to online distance-learning formats," failing to resolve this friction may lead to an underdeveloped generation - a third of children would never learn how to communicate nonverbally from either schools or their own disconnected households (Berger et al., 2022, 3). To better understand the sociotechnical factors which contribute to this behavior, Geels' historical, multi-leveled analysis in "Transformations of Large Technical Systems" is used in this paper. With it, a trend analysis is employed to see how camera privacy concerns have shifted over time, hinting towards potential actors. By using Geels' approach, it is found that government corruption is not a strong indicator for camera covering behavior, prevalence of cameras in daily activities is a stronger indicator, and survey data does not always reflect people's beliefs.

II.   Problem Definition: Identified Factors are Unknown to be Real or Believed Real

Camera covers were designed to help protect users from spyware attacks by providing a physical barrier between the user and the camera (Machuletz, 2018, 1). Shown below in Figure 1 are the percentages of various demographics which have camera covers. As seen under the Age category, about 32% of children and young adults will cover their web camera in the event they believe they are being watched (Machuletz, 2018, 4). Some may believe this is due to people being more "tech savvy," in which younger generations understand more about privacy than older ones. However, activities that actually disclose sensitive information, such as accepting the terms and conditions of sites such as Facebook, are done without a second thought by this very same generation (Machuletz, 2018, 2). It is found this behavior comes from the perception of risks rather than actual consequences (Machuletz, 2018, 3).

	Frequency (#)	Of all (%)	With cover (%)
Total	113	100.0	31.9
Gender			
Male	69	61.1	26.1
Female	42	37.2	42.9
Unknown	1	0.9	0.00
Age			
< 18	6	5.3	33.3
$18 - 29$	92	81.4	31.5
$30 - 39$	4	3.5	50.0
$40 - 49$	2	1.8	50.0
$50 - 59$	9	8.0	22.2
> 59	0	0.0	0.0
Notebook usage per day (hours)			
< 1	17	15.0	11.8
$1 - 2$	24	21.2	29.2
$3 - 4$	27	23.9	44.4
$5 - 6$	13	11.5	38.5
> 6	31	27.4	32.3
Webcam usage during last month (times)			
0	63	55.8	31.8
$1 - 4$	38	33.6	26.3
$5 - 8$	5	4.4	80.0
> 8	7	6.2	28.6
Antivirus installed			
Yes	98	86.7	31.6
No	15	13.3	33.3
Mobile phone front camera covered			
Yes	3	2.7	66.7
No	103	91.2	28.2
Use of mobile phone privacy filter			
Yes	7	6.2	57.1
No	103	91.2	31.1

Some variables have missing values.

Figure 1. Survey Demographics. The survey mostly included ages 29 and under, in which 33.3% under 18 had a cover, while 31.5% between 18 and 29 had a cover (Machuletz, 2018, 4).

As shown in Figure 2 below, certain factors which contribute to the perceived risk of web cameras have been identified by the German study. For example, the two largest factors hypothesized to influence this behavior are the attitudes of how needed and useful a webcam cover is, as well as how protected people feel under their government privacy-wise (Machuletz, 2018, 5). Unfortunately, not much is known about what leads to the belief that web cameras are "necessary" or "practical." A possible contributor towards these attitudes may be that children care more about body image and are more self conscious than previous generations due to their early consumption of social media (Hayman, 2016). Specifically, about 38% of 2 year olds in 2013 were exposed to smartphones, making up 38% of 12 to 13 year olds today (Gold, 2015, Growing Up Digital).

Item code	Item description	Estimate	Exp. Estimate	Std. error	z value	Pr(>|z|)
(Intercept)		−5.76	0.00	3.89	−1.48	0.138
Attitudes towards webcam covers						
AW1	Fear of unauthorized webcam access	1.52	4.57	2.29	0.66	0.507
AW2	Opinion that one should protect from unauthorized webcam access	−2.45	0.09	2.33	−1.05	0.294
↔AW3	Perception that webcam covering is excessively cautious	0.12	1.12	2.28	0.05	0.960
AW4	**Perception that webcam covers are practical**	**5.32**	**204.24**	**2.12**	**2.51**	**0.012***
AW5	Perception that webcam covers are useful	−0.82	0.44	3.23	−0.25	0.800
AW6	**Perception that webcam covers are necessary**	**7.18**	**1311.15**	**2.30**	**3.13**	**0.002****
AW7	Perception that webcam covers are secure	1.04	2.82	2.24	0.46	0.643
Attitudes towards privacy						
↔AP1	Opinion that video cameras should be used at public places to increase security	−0.28	0.75	2.14	−0.13	0.895
↔AP2	Perception that the disclosure of own personal information in social networks is harmless	−3.25	0.04	2.91	−1.12	0.264
↔AP3	Willingness to upload a personal video on a public website	−0.85	0.43	2.52	−0.34	0.737
↔AP4	**Belief that the government sufficiently protects personal privacy on the Internet**	**−6.31**	**0.00**	**3.18**	**−1.99**	**0.047***
↔AP5	**Belief that firms respect personal privacy**	**4.91**	**135.80**	**2.31**	**2.12**	**0.034***
Subjective norms towards webcam covers						
SW1	**People in the social environment use a webcam cover**	**−7.63**	**0.00**	**3.24**	**−2.35**	**0.019***
SW2	**People in the social environment argue for webcam covering**	**10.23**	**27758.95**	**3.90**	**2.62**	**0.009****
SW3	Expectation of others to use a webcam cover in the work environment	2.70	14.89	2.12	1.27	0.203
↔SW4	Fear that others rate webcam covering overly cautious	−0.83	0.43	2.42	−0.34	0.731
Subjective norms towards privacy						
SP1	Perception that society expects Internet privacy self-protection	−3.45	0.03	1.87	−1.84	0.065
SP2	Privacy protection is an important topic in the social environment	1.01	2.76	2.02	0.50	0.614
↔SP3	Fear of social rejection for not being active in social networks	1.73	5.65	2.42	0.72	0.474
↔SP4	Fear of social rejection for not sharing pictures in social networks	−6.26	0.00	4.08	−1.54	0.125

Scales of items indicated by "↔" were reversed before conducting the analyses in Section 5.2 and Section 5.3
Significance level codes: 1% '**', 5% '*'
Nagelkerkes' pseudo-$R^2 = 0.74$

Figure 2. Regression Analysis of Different Factors. Bolded terms have a higher correlation with camera covering behavior. Positive estimate values, such as the 5.32 for AW4, denote a direct correlation, while negative values, such as the -6.31 for AP4, denote an inverse correlation (Machuletz, 2018, 5).

Unfortunately, we do not know for sure if this regression analysis is true as it is based on what people think they believe, but not necessarily what they actually believe. Basing a solution off of what people believe is the problem rather than what the problem actually is would solve nothing and waste time. Harkening back to the introduction, failure to identify the sociotechnical factors which lead to camera covering behavior may cause the privacy generation to deteriorate into the underdeveloped generation. Therefore, to better understand how these factors emerged, Geels' historical analysis of multileveled systems is applied.

III. Research Approach: A Historical, Multileveled Analysis on Privacy Trends

I wish to improve our understanding of why web camera covers are used as about 33.3% of notebook users younger than 18 in a study conducted in Germany covered their notebook web cameras (Machuletz et al., 2016, 4). As mentioned in the introduction, with the move to online learning, these kids would learn nothing about nonverbal communication. As mentioned in the Problem Definition section, we do not know if governmental corruption is a strong indicator of camera covering behavior in the United States. We do not know if there is some other factor that Machuletz did not ask participants that is not being considered, nor if there is any correlation between the belief in covers and political mistrust. If we do not find the difference between the beliefs and believed beliefs which contribute to camera covering behavior, we could instead find ourselves with an underdeveloped generation. To answer these questions and find the difference, I will be using Geels' "Transformations of large technical systems" as I believe a historical analysis is the best approach to understanding why the belief that web camera covers are useful came to be. Potential known sources of this behavior, such as mistrust in the government, can be used as a seed for this approach to recursively branch out into other unknown contributing niches, as well as identify the factors which contribute to this behavior.

Technological momentum describes how once a system is set up, it is oftentimes hard to remove or change. Momentum also applies to large technical systems, and many sociologists and economists agree on the existence of momentum in these systems. Unfortunately, it was unknown how major changes to existing systems occur due to momentum (Geels, 124). To resolve this matter, a multilevel perspective was used on the Dutch Highway system to observe how existing systems change over time (Geels, 143). Using this approach, Geels found that major change occurred when both "promising niche innovation" and "outside pressures" on the regime were present (Geels, 146).

A multilevel analysis is where a sociotechnical system is broken up and described by three layers: the niche, regime, and landscape (Geels, 143). This, in turn, helps to understand the technological change of a system, or how each of the three layers changes across time. Geels used trends of the amount of cars and length of highways developed in the Netherlands, as well as various case studies within different time periods, to show how the system evolved over time. Similarly, my project will use a Google trend analysis on the term "camera privacy," which has risen over the span of 2004 to today, spiking noticeably in April of 2020.

To effectively use Geels' framework, a four step iterative plan is used, as seen in the diagram below. First, a trend analysis of currently known relevant topics is done - in this case, "camera privacy" and "government corruption." Next, the trends are analyzed to find key dates and time periods where something changed within the trends - 2020 is one such date. Then, case studies of each time period-of-interest are researched in order to analyze the landscape during each period. Lastly, the niches are identified and examined to see how they contribute and interact with the regimes.
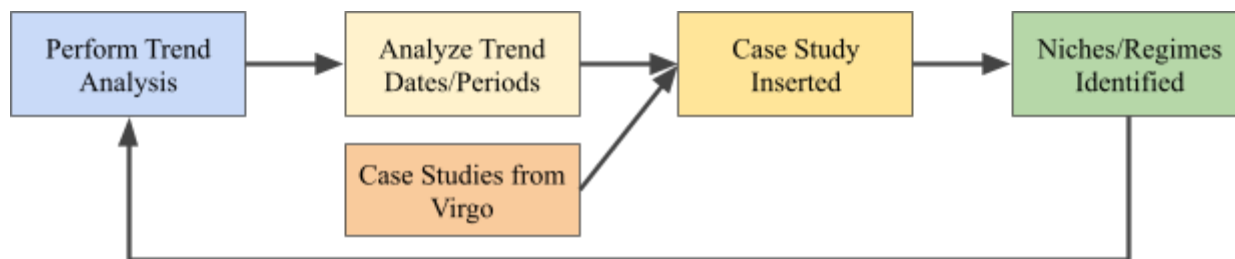
Figure 3. Four Step Iterative Plan. Case studies are siphoned into research after trends are analyzed and used to define the multi-leveled system at that time period (Made by author).

The multi-leveled analysis could help determine if any aspects of the system are related in some way. For example, I am interested to see if governmental and political factors contribute to the belief in cover necessity as Machuletz found in his research. In this case, the regime would be prominent governmental actors at each time period, whereas niche groups would be United States citizens grouped by state. Additionally, the trend analysis has already revealed a potential lead on the emergence of this necessity due to a spike in searches for "camera privacy" in 2020.

Geels' approach deals with the micro, meso, and macro levels as well as how they relate to each other in a given system; however, political discourse, one of the known contributors to camera cover usage, is mostly on the macro level. Using Mesthene's "Economic and Political Organization" could help further research the political side of privacy as his research deals with specifically larger systems, such as the American political climate. Due to time constraints, this approach is not used in this paper and may be left to be used in a future research topic.

Geels' historical analysis can be used to trace the origin of camera cover usage by observing how various levels of the system evolved over time, as well as how each level interacted with each other during each time period. By this approach, I will not only have a better understanding of how the social dimension evolved for camera cover usage over time, but will also find a new way to reveal the missing dimension through an iterative process.

IV.   Results

Belief in government corruption is not a strong indicator of camera privacy in the United States

As shown below in Figure 4, a Google trend analysis for the terms "government corruption" and "camera privacy" were performed. By observing these trends, it is revealed there is a cyclic pattern for government corruption searches, but not for camera privacy. Upon further analysis, it is noted that corruption searches almost always peak in Autumn, dip in Winter, rise in Spring, and plummet in Summer. A possible explanation to this cycle is likely election cycles, where general elections tend to be held in November, while primary elections are held in June - the same months of the peaks and troughs of each cycle.
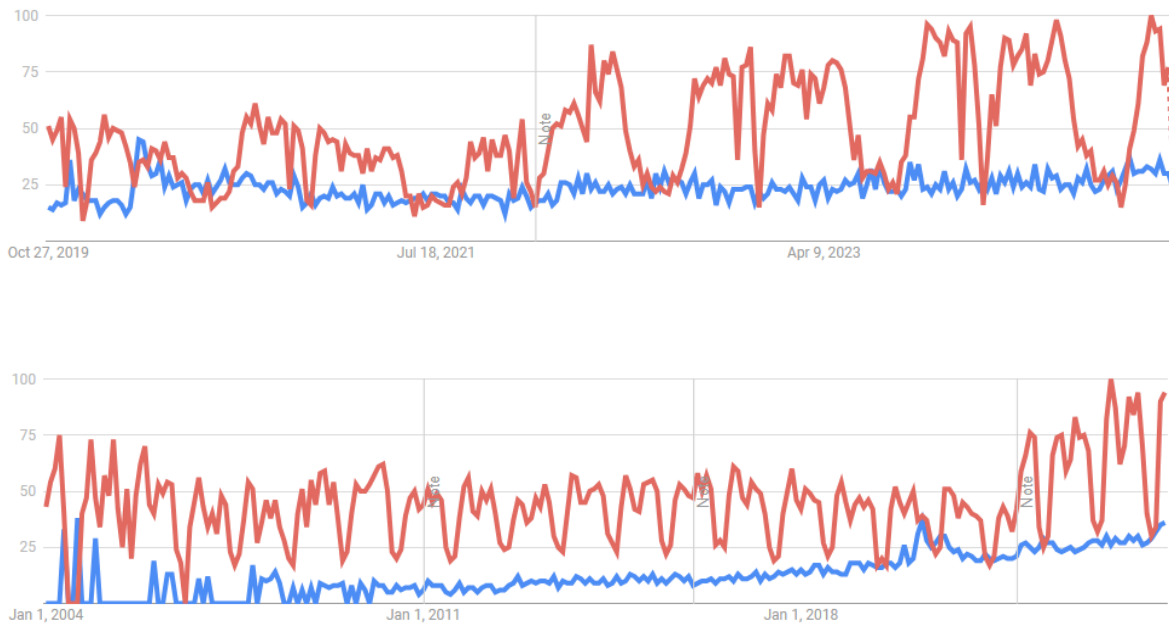

Figure 4. 5 Year and 20 Year Trend Analyses. Red (the more chaotic line) denotes the frequency the term "government corruption" is searched on Google in the United States, whereas blue denotes the same for "camera privacy." The frequency values range from 0 to 100 and are relativistic. (Google Trends, n.d.).

From the perspective of American politics, political discourse is the landscape of this sociotechnical system. Specifically, as different political parties enter and exit the regime, the landscape changes over time, causing the cycle observed. If camera privacy and the belief in governmental corruption is as interconnected as believed, then camera privacy must be a niche which also changes alongside this landscape. As seen by the 20 year trend, both terms have steadily increased over the years which could denote a positive correlation; however, this is where the correlation ends. For this correlation to be strong, the cyclic pattern observed for "governmental corruption" ought to be observed for the term "camera privacy" as well; however, with a glance at Figure 4 above, this does not appear to be the case.

Further analyzing these trends by comparing these terms by state in Figure 5 below, certain hotspots are found within each map. States such as Oklahoma search more frequently for government corruption than other states, such as Washington. However, states such as Washington search for the term more frequently than other states, such as Oklahoma. Specifically, Washington state has a ratio of 35% for camera privacy to 65% for government corruption, while Oklahoma has a ratio of 17% to 83%. If government corruption and camera privacy were intertwined, the bottom map in Figure 5 should look homogenous, as states which search more for government corruption should also search for camera privacy; however, due to these differences, this cannot be the case.
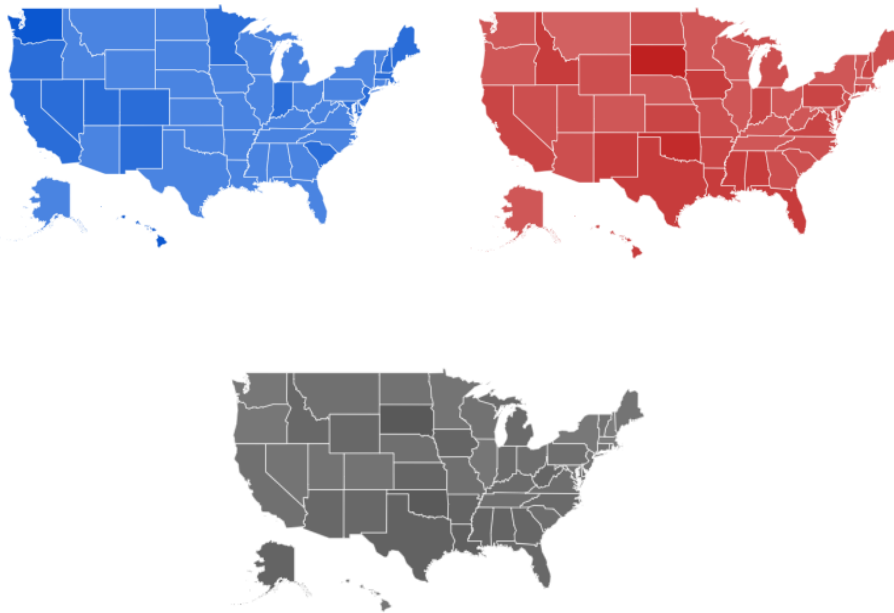
Figure 5. Maps of Searched Terms. Darker areas denote states which search more for each respective term. Note the left map is camera privacy, the right map is government corruption, and the bottom map is the difference between both terms (Google Trends, n.d.).

Although it could certainly be the case that people who believe they are being watched are not searching for camera privacy out of fear of their government, these same people would also not be searching for government corruption for the same reason. At the very least, this insight reveals there must be some other factor at play which causes people in the United States to perceive cameras as a risk as the search for camera privacy has increased over 20 years. Additionally, the fear of government in the United States is not as impactful on camera privacy as observed in Machuletz's study in Germany. If the study is followed and governmental corruption is reduced, nothing would be done about camera covering behavior.

Fear of cameras is caused more by the prevalence of cameras than external factors

Returning to the original trend analysis of camera privacy in Figure 4 above, a noticeable spike in April 2020 is observed. As mentioned in the Introduction, the NCES found 77% of

public schools had switched purely online during this time period (Berger et al., 2022, 3). Given online schooling had required students to use cameras in order to see each other's faces, it stands to reason that this spike which had never been seen before in the history of web camera privacy was caused by this sudden change. In turn, this implies camera privacy is primarily caused by the prevalence of web cameras in daily life as the usage of cameras during this period was much greater.

Furthermore, online schooling can help to explain why camera privacy has been trending upwards as unexplained in the previous insight. Specifically, the NCES found that the amount of public schools offering online options went from around 36% to 55% between 2003 and 2010 (NCES, 2011). Although nothing is known about the percentage of schools which offered online schooling between the years 2010 and 2020, the percentage has likely increased given the trajectory of these known years. As seen in the second part of Figure 4 above, the increase had begun around 2008 with some noticeable spikes beforehand.

From Geels' multi-leveled perspective, the landscape in this situation would be the state of online education, the regime would be the public school system offering in-person, or online schooling, and the niche would be camera privacy. As the landscape evolved and the regime started offering more online schooling opportunities, so did the niche as students became more involved with cameras in their daily lives. Since the niche reflects the landscape both between the years 2004 and 2010, as well as during 2020, then it should be logically concluded that the prevalence of cameras has a strong impact on people's interest in camera privacy. Ergo, people believe camera covers are necessary and useful due to the existence of cameras.

V.   Conclusion

As stated in the Problem Definition section, it was unknown if factors relating to camera privacy in Germany also related to the United States, such as the belief in government corruption. Using Geels' historical multi-leveled approach and trend analyses, it was discovered that the belief in corruption has had no noticeable effect on camera privacy concerns in the United States, whereas the prevalence of web cameras is a much stronger indicator. It is found, therefore, that survey data is usable for engineers as a starting point for further research, but cannot and should not be used without further research when creating solutions.

Given the time constraint of this research, only governmental corruption was analyzed as I believed it was best to prioritize just one topic. Further research could be done using the four step iterative plan to also explore the subjective norm categories from Figure 2 as using the survey has already revealed insights discussed in the Results section. Alternative research using Mesthene's approach as mentioned in the Research Approach section could also be applied to investigate the potential geopolitical side of this system as certain states searched more for "camera privacy" than others.

As for the current research, two recommendations can be given for engineers and parents. When collecting project requirements for a new project, it is important to scrutinize survey data and not let it be the be all and end all. Requirements should still be collected, but should only hint towards what stakeholders truly desire. As seen in this paper about government corruption, there is sometimes a dichotomy between what people say they value, and what they actually value. In the case of parents, it is advisable to find some time to spend with your kids for their early development, and look into neighborhood clubs or activities after school. That way, your children can be a part of the developed generation while still accounting for their "user views."

VI.   References

Berger, M., Kuang, M., Jerry, L., and Freund, D. (2022). Impact of the Coronavirus (COVID-19) pandemic on public and private elementary and secondary education in the United States: Results from the 2020–21 National Teacher and Principal Survey (NCES 2022-019). U.S. Department of Education. Washington, DC: National Center for Education Statistics. https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2022019

Geels, F. (2007). Transformations of large technical systems: A multilevel analysis of the Dutch highway system (1959-2000). *Science, Technology, and Human Values 32*(2), 123-149

Gold, J. (2015). *Screen-smart parenting* (1st ed.). New York, NY: The Guilford Press. https://www-r2library-com.proxy1.library.virginia.edu/Resource/Title/1462515533 [Electronic book]

Hayman, S. (2016). *Parents and digital technology: How to raise the connected generation*. London: Routledge, Taylor and Francis Group. https://www.taylorfrancis.com/books/mono/10.4324/9781315678702/parents-digital-technology-suzie-hayman-john-coleman

Machuletz, D., Sendt, H., Laube, S., & Böhme, R. (2016). Users protect their privacy if they can: Determinants of webcam covering behavior. NDSS Symposium. doi: 10.14722/eurousec.2016.23014 [Conference Paper]

Pacey, A. (1983). Excerpts from women and wider values (pp. 154-159). In *The culture of technology*. Cambridge, MA: MIT Press. *With guide*.

U.S. Department of Education (2011), Technology-Based Distance Education Courses for Public Elementary and Secondary Schools: 2002-03 and 2004-05 and "Distance Education Courses for Public Elementary and Secondary School Students: 2009-10," FRSS 98. https://nces.ed.gov/programs/digest/d19/tables/dt19_218.20.asp [Table]