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Swathi Sri Vishnu Priya Rayala for the degree of Master of Science in Computer Science presented on June 16, 2017.

Title: User Perceptions on Security and Usability of Mobile "Tap-and-Pay"

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Rakesh Bobba

Apple launched their first "tap-and-pay" mobile payment solution called "Apple Pay" in October 2014 in the United States. Quickly catching up with the popularity of Apple Pay, Google launched their own mobile "tap-and-pay" payment solution called "Android Pay". Both the companies claim that their tap-and-pay solutions are more convenient and more secure than swipe-and-pay with traditional debit or credit cards. In this work, we investigated security, privacy and usability aspects of why people use and do not use mobile tap-and-pay in stores. We used both qualitative and quantitative approaches for cross validation and methodological triangulation.

The results of our online survey with 860 participants (349 for Apple Pay and 511 for Android Pay) suggest that the top reason for *not using* mobile tap-and-pay is security. However, Apple Pay *users* did not feel insecure using it in stores. A common security misconception we found among the *non-users* was that they felt

storing card information on their phones is less secure than physically carrying cards inside their wallets. Our security knowledge questions revealed that such participants lack knowledge about the security mechanisms being used to protect card information. This suggests the possibility that technology adoption rates may improve with increased awareness of security protections, given that our study results show usability was the most important reason for using tap-and-pay over traditional swipe-and-pay.

We also found a positive correlation between the participants gender and adoption rate, suggesting that males are more likely to prefer and use tap-and-pay than females.

User Perceptions on Security and Usability of Mobile "Tap-and-Pay"

by

Swathi Sri Vishnu Priya Rayala

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Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Swathi Sri Vishnu Priya Rayala, Author

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Chapter 1: Introduction

Smart phone usage has been increasing over years [9]. About 77% of American population own a smart phone with majority of the users belonging to age group 18-29 (92%) and an educational attainment of college graduates (89%). Consumer time spent on mobile is increasing while time spent with all other media is decreasing further reflecting the need for marketers to prioritize mobile as the first screen that it has truly become [10]. Figure 1.1 shows the usage statistics of different media by US adults from 2013 to 2018.

In particular, web-capable mobile phones have changed the way the worlds five billion mobile users search, shop and buy. As a result, the stakes in providing payments solutions for the rapidly expanding mobile commerce world are also high. Thus, mobile payment solutions have received a significant amount of attention recently. Yet, despite the attention, they have not been widely adopted in the US [16]. Therefore it is worth analyzing the reasons for why people use or not use mobile payment solutions in the US.

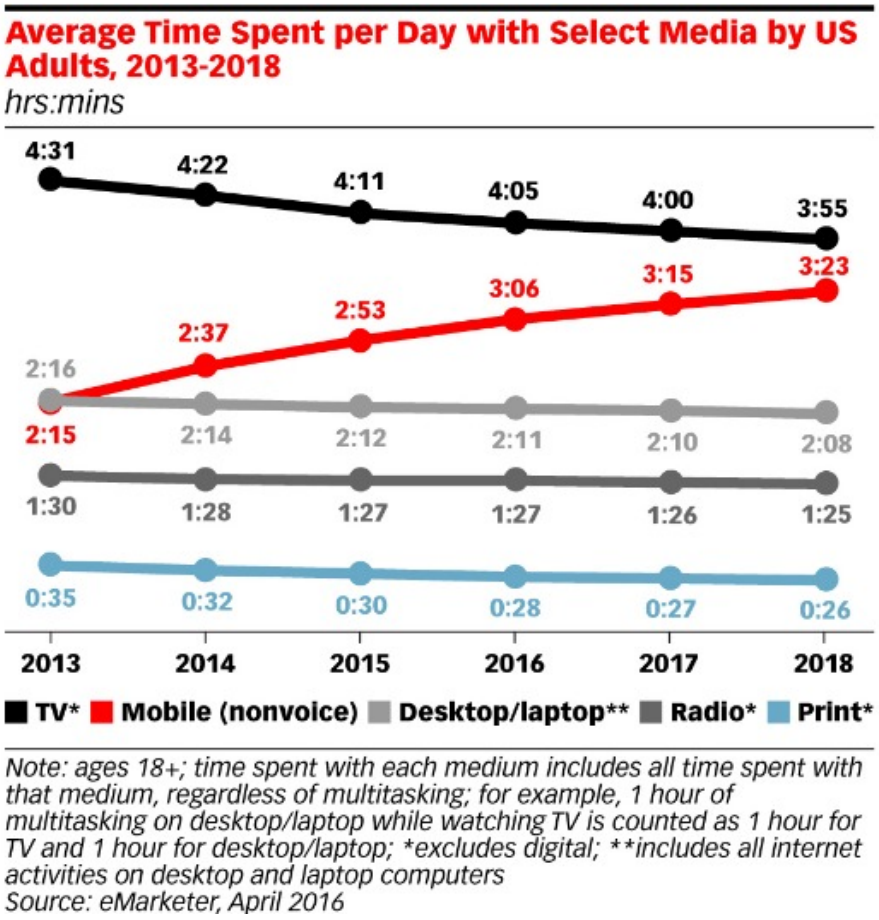


Figure 1.1: Usage statistics of different media

1.1 Motivation

Mobile payments encompass many different solutions, ranging from near field communication (NFC) contactless solutions to e-wallets, and digital currency. NFC has attracted considerable attention, but its impact as a payment technology remains unclear [1]. This work mainly focuses on the two NFC capable mobile payment solutions, Apple Pay and Android Pay, to understand the various factors for using and not using tap-and-pay solution. In October 2014, Apple launched iPhone 6 (and 6 Plus) and their first mobile payment solution called "Apple Pay in the United States. Their marketing pitch was: tap-and-pay with iPhones in stores is faster and more secure than swipe-and-pay with traditional debit or credit cards. It quickly became the biggest tap-and-pay mobile payment solution, accounting for two out of every three dollars processed through contact-less payment systems in the United States [6]. Quickly catching up with the popularity of Apple Pay, Google launched their own mobile payment solution called "Android Pay around September 2015 [2]. Both companies claim that their tap-and-pay solutions are more convenient and more secure than swipe-and-pay with traditional debit or credit cards. However, the adoption rates for both the payment methods are low as of October 2016 (23.6% for Apple Pay and 9.3% for Android Pay) [8], [7]. Therefore, it is interesting to investigate the factors that impact the adoption of these technologies.

1.2 Objectives

In this work, we investigate why people use or not use mobile tap-and-pay solutions, which are highly security-critical technologies that store and access users' credit card information using mobile devices. In addition to the reasons for using or not using, we would like to know their corresponding security and usability concerns. It is important to note that this work only focuses on the *physical tap-and-pay* feature of mobile payment solutions, and compares them with the traditional, *physical swipe-and-pay* transactions made using debit or credit cards in stores. In the United States, swipe-and-pay is still the most common payment method (chip-and-PIN readers are slowly being adopted)

1.3 Contributions

The primary objective of this research is to understand what factors would impact the adoption rates of mobile tap-and-pay - particularly, Apple Pay and Android Pay. It illustrates the reasons for using, not using and stopped using. The research findings show that usability is the most important reason for using mobile tap-and-pay. However, there are security/usability concerns and misconceptions quoted by non-users for not using this payment mode. These findings suggest that technology adoption rates (only about 36% for Apple Pay and 21% for Android Pay) could improve with increased awareness of security protections and convenience offered by tap-and-pay solutions over traditional swipe-and-pay.

Chapter 2: Background

"Tap-and-pay" payment solutions by Apple Pay and Android Pay, allow users to pay through their mobile devices at point-of-sale (POS) terminals. Apple Pay works on iPhone 6 and later versions, however this research was conducted prior to the release of iPhone 7. Android Pay is supported on multiple Android devices that are running version 4.4 or later and support near field communication (NFC). 2.1 shows the step-by-step procedure of how Apple Pay or Android Pay works.

2.1 Apple Pay

In October 2014, Apple launched iPhone 6 (and 6 Plus) and their first mobile payment solution called "Apple Pay". Apple Pay works on iPhone 6, 6 Plus, 6S, and 6S Plus. In the United States, it was claimed that, Apple Pay accounted for two out of every three dollars processed through contact-less payment systems [6].

Setup and use

To set up Apple Pay, users simply add a debit or credit card on the Wallet app. The card information can be imported from iTunes, entered manually, or added by taking a picture of a card. Users can start using Apple Pay after the card verification process. To tap-and-pay in stores, users need to hold their iPhone

Figure 2.1: Working of Apple Pay and Android Pay

close to a near field communication (NFC) reader. A default payment card can be pre-selected on the Wallet app. Users then place a finger on Touch ID (finger print scanner) to authenticate themselves, and complete the payment process. The Wallet app immediately notifies users about confirmed transactions.

Security

According to the iOS security guide [5], the card information entered by a user is sent over to the Apple server and the bank for card number and expiration date verification. This communication is protected through SSL. After this check, Apple Pay performs link and provision, sending the cards CVV information to the bank and asking the banks approval to add the card. After adding the card, the payment network or bank creates a device account number, which is a random 16-

digit number that is unique to the users device and card; it is also referred to as the token. The device account number is encrypted, and sent over to the users iPhone. A cryptographic token key is also encrypted and sent; this key is used to generate dynamic security codes that are unique to each Apple Pay transaction. The encrypted device account number and token key cannot be decrypted by Apple, and are added to the "secure element" of the users iPhone. All payment related information are stored in the secure element, which is a hardware chip that is designed to securely store and protect confidential information of hosting applications [21]. Apple Pay uses NFC to interact with payment terminals. A single touch on Touch ID authenticates the user, ensuring that only the owner of the iPhone is allowed to make payments. After authentication, the secure element provides the device account number, one-time unique number, and transaction-specific dynamic security code. All of this information is sent over to the payment terminal. The users credit card number is never shared with the merchant. Before approving the payment, the bank or payment service verifies the payment information by checking that the dynamic security code is tied to the users iPhone.

2.2 Android Pay

In September 2015, Android pay was launched. The technologies used and the functionalities of Android Pay are much similar to that of Apple Pay. However, it is supported on multiple Android devices that are running 4.4 (KitKat) and have NFC support.

Setup and use

Android Pay can be activated by entering the debit or credit card information through the Android Pay app. The overall tap-and-pay procedures are similar to that of Apple Pay, except that Android Pay users are required to first unlock their device (e.g., by drawing a screen lock pattern or password), and then place their device near a terminal.

Security

Any official document on Android Pay security was not found, and therefore contents from the I/O Google talk 2015 are used to summarize the key security concepts. Android Pay also uses tokenization [20], and never sends debit or credit card information to merchants. Instead, it uses a virtual account number (like the device account numbers used in Apple Pay). The difference between the two is that Android Pay primarily uses a card emulation method called host-based card emulation (HCE) compared to Apple Pays card emulation processed through the secure element. Due to the insecure nature of host CPUs, Android Pay moves all the card data to remote secure cloud servers (instead of routing them to the local phone CPU) where most of the card processing (including tokenization) and storage takes place. During a transaction, transaction-specific tokens are generated in the cloud, or fetched from spare token payloads locally available on the device if server connections are not available, and forwarded to a users device along with the virtual account number. Android Pay requires users to first unlock their device,

ensuring that only the owner of a device can use the tap-and-pay feature.

2.3 Related Work

As mobile tap-and-pay is a fairly new technology, there is not much work done to date on investigating people's perception on its usability and security. Much of the previous research has focused on developing a variety of models based on the "theory of reasoned action" and "theory of planned behavior" to examine mobile payment user behaviors. Among them, the most popular one is the "technology acceptance model" [11, 13, 24]. Linck et al. [18] examine security issues in mobile payment from the customer's perspective, concluding that simple, secure, and inexpensive payment services are preferred. Schierz et al. [23] conclude that the most important drivers for consumer's acceptance of mobile payment services are perceived compatibility (the degree to which mobile payment is reconcilable with existing values), individual mobility (the degree to which an individual pursues a mobile lifestyle), and subjective norms (the degree to which the social environment perceives mobile payment as desirable). Dahlberg et al. [12] identified the factors relevant to acceptance of mobile payment as ease of use, usefulness, and trust. However, most of the research in mobile payment was done before tap-and-pay became part of its services. In contrast, our work explicitly focuses on the tap-and-pay payment method.

Luca et al. [14] showed that usability is the top argument for both using and not using Touch ID, which is a fingerprint-based authentication mechanism used

on iPhones. For Face Unlock, which is a face recognition-based authentication mechanism for Android devices, usability (22%) was again the more important factor than security (8%) for not using it. This contrasts with our findings for Apple Pay where the top factor for not using it was security – we surmise that the higher security risks associated with using mobile tap-and-pay may have impacted this. Egelman et al. [15] provide insight on the strong correlation that exists between users' risk perceptions and their willingness to use the locking feature (i.e., a security feature) on their phone. We found a positive correlation between the participants' knowledge about the security mechanisms being used and their likelihood of using mobile tap-and-pay.

Some recent online (non-academic) surveys studied Apple Pay adoption rates and reasons. An Apple Pay adoption study [8] was conducted in a collaborative effort between "PYMNTS" and "InfoScout" to determine the degree to which consumers use Apple Pay (the population statistics are unknown though). Based on the responses collected through a single quarter (July to October, 2015), their results show that 16.6 % people have tried Apple Pay ever since owning an iPhone 6 or 6s. As the three major reasons for not using Apple Pay, they identified "satisfied with my current payment method" (38.4 %), "not familiar with how Apple Pay works" (33.5 %), and "security concerns about Apple Pay" (18.7%). Another survey was conducted by 451 Research [3], focusing on consumers' (including Apple Pay, Google Wallet, and Paypal users) sentiment towards mobile payment security, and asked participants whether they consider mobile payment to be more or less secure than traditional credit cards. Their results show that 24% believe mobile

payments are more secure than traditional credit cards, while 27% believe it is less secure. A survey conducted by Phoenix Marketing on 3,000 people [4] found that after Apple Pay launched in 2014, it was adopted by 11% of card-holding households in February 2015, but did not offer any usage reasons. The adoption rates mentioned in those studies are lower than our rates mainly because we only recruited those who had some level of familiarity with Apple Pay or Android Pay.

Wang et al. [25] presented a broad view of online mobile payment security, threats, and challenges. Possible attacks for mobile tap-and-pay and NFC payment system, and mitigation strategies have been discussed in [19, 22].

Chapter 3: Qualitative Study

Our aim is to (1) understand what factors have affected user's decision to use or not use a mobile tap-and-pay, and (2) analyze specific usability, security and privacy concerns and misconceptions that people have. For this, we first conducted in-person interviews with 36 participants and performed a qualitative data analysis to define our hypothesis and develop questionnaire for our follow-up large-scale (quantitative) study. Both of our studies were approved by Oregon State University Institutional Review Board (IRB).

3.1 In-person interviews

The main research question of our study was *"Why do people use, not use, or stop using mobile tap-and-pay to pay in stores?"*. To answer this question we first conducted an in-person, semi-structured interview that allowed us to identify hypotheses, clarify areas where we lacked intuition and understanding, and design a questionnaire for a follow up large-scale study.

Participant Recruitment

To achieve strong diversity and richness in participants' responses, we recruited participants from two separate pools. The first group was recruited from a uni-

versity through university mailing lists, university Facebook group, and advertisements posted on public notice boards; the second group was recruited through online advertisements that were posted on Craigslist, Backpage, Adoos, and Oodle. Our inclusion criteria were participants of age 18 years or older who own a phone that supports Apple Pay or Android Pay, and has some familiarity with Apple Pay or Android Pay. In particular, for Apple Pay, the criteria was ownership of iPhone 6, 6 Plus, 6s, or 6s Plus; for Android Pay, we checked that a participant's phone supports NFC, and is HCE-enabled with 4.4 KitKat or higher running. With the responses collected from the university pool, we did not identify any new code after the 18th interview, and stopped scheduling new interviews. We ended up recruiting 21 participants. With the responses collected from the online advertisements, we did not identify any new code after the 13th interview, and ended up recruiting 15 participants. On average, the interviews took about 35 minutes, and every participant was compensated with a $24 Amazon gift card.

Procedures

After agreeing to be interviewed, the participants were asked to show us their phone (we checked whether their phone supports Apple Pay or Android Pay), and read and sign a consent form. Next, the purpose of the interview was explained as an effort to better understand why people use or not use mobile tap-and-pay. To avoid priming, the security and usability focus of the interview was revealed after asking why they use, not use, or stopped using mobile tap-and-pay. The interview

consisted of the following parts:

1. **Smartphone proficiency:** In the first part of the interview, we asked the participants about the model of their smartphone, how many minutes they spend on their phone each day, how frequently they unlock their phone, and how long they have been using their phone.
2. **Mobile tap-and-pay usage:** Next, we asked the participants about their familiarity with Apple Pay and Android Pay, whether they have set it up, how frequently they use it, how long they have been using it, and common places where they use it.
3. **Why use or not use mobile tap-and-pay on phone:** Next, we asked the participants why they use, not use, or stopped using Apple Pay or Android Pay on phone. We then asked how they feel about its security and usability.
4. **Familiarity with mobile tap-and-pay security:** Next, we asked if they understand (1) how Apple Pay or Android Pay protect their tap-and-pay transaction privacy and security, (2) how it protects debit or credit card details, and (3) how it ensures that only they can pay in stores with their phone.
5. **Why use or not use mobile tap-and-pay on Apple watch:** Next, we asked the participants (who own Apple Watch) why they use, not use, or stopped using Apple Pay or Android Pay on Apple watch. We then asked how they feel about its security and usability.
6. **Comparing mobile tap-and-pay against traditional credit cards:** In

the last part of the interview, we asked the participants about their preference for mobile tap-and-pay over traditional credit cards. We then asked the reasons for their preference.

After completing these parts, we collected the demographic information and concluded our interview process by informing them how they will receive their compensation.

The interview questionnaires for Apple Pay and Android Pay used for the qualitative study are shown in Appendix A and Appendix B respectively.

3.2 Results

All of the interviews were conducted by two researchers together to ensure that all of the questions were asked and consistently understood by the participants. We audio recorded all the interviews with the participants' consent. Later, we have transcribed each of the audio recording into word documents. Thus, we have a textual data source of ideas and thoughts (of 36 participants) for our research question "Why do people use, not use, or stop using mobile tap-and-pay to pay in stores?" We need to build concepts from this textual content in order to expose the meaning, define and analyze the ideas. Open coding is one such process of analyzing textual content and is a part of many Qualitative Data Analysis methodologies like Grounded Theory. Figure 3.1 shows the workflow of Qualitative Data Analysis. It includes labeling concepts, defining and developing categories based on their

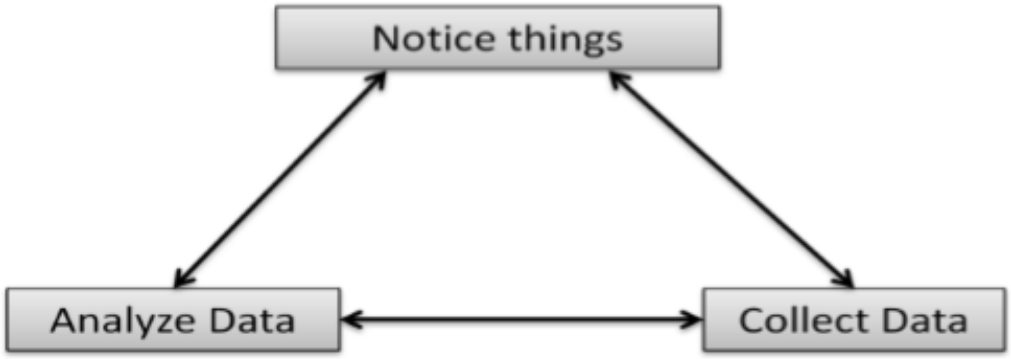


Figure 3.1: Workflow of Qualitative Data Analysis

properties and dimensions. We have used Atlas.ti, a commercial qualitative data analysis tool, to do open coding and analyze qualitative data [17].

Generating Codes

We have separately performed thematic analysis of each interview, independently reading the responses to create lists of themes observed in the responses to each question. Such themes are referred to as "codes" in grounded theory. After every few coding sessions, we got together to discuss the identified codes until we reached a consensus. As a result, after coding 36 responses (21 from the university group, and 15 from the online advertisement group), we were able to create two unified codebooks. The codebook for the university group consisted of 40 unique codes, and the codebook for the online advertisement group consisted of 38 unique codes. There were 28 common codes between the two codebooks. Figure 3.2 and figure

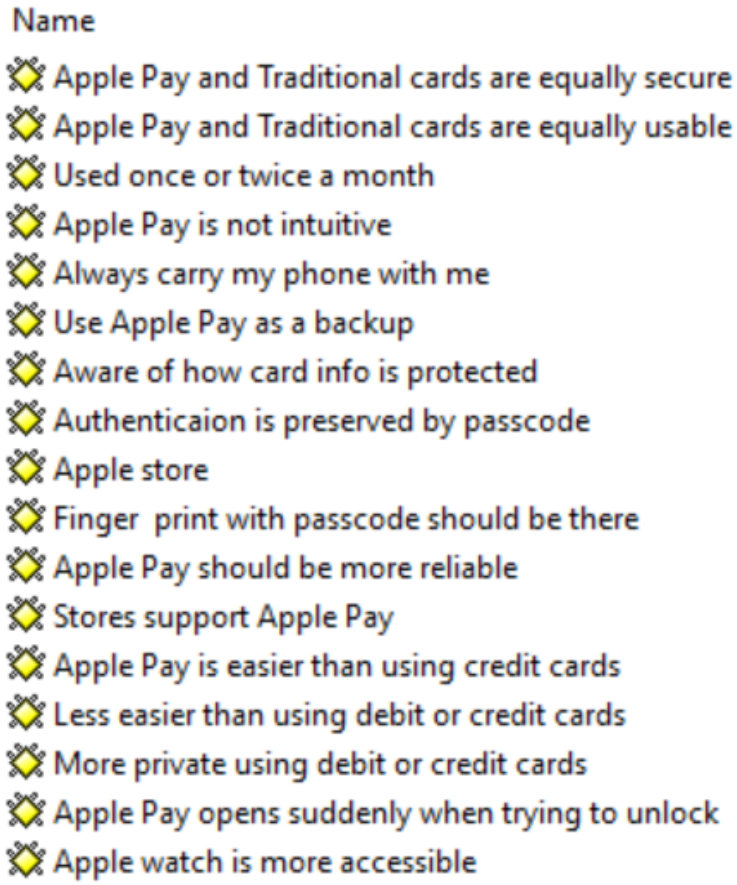


Figure 3.2: A snapshot of codes for Apple Pay

3.3 shows a snapshot of codes created for Apple Pay and Android Pay respectively. The researchers disagreed on three responses, achieving an inter-rater agreement of 91.67%.

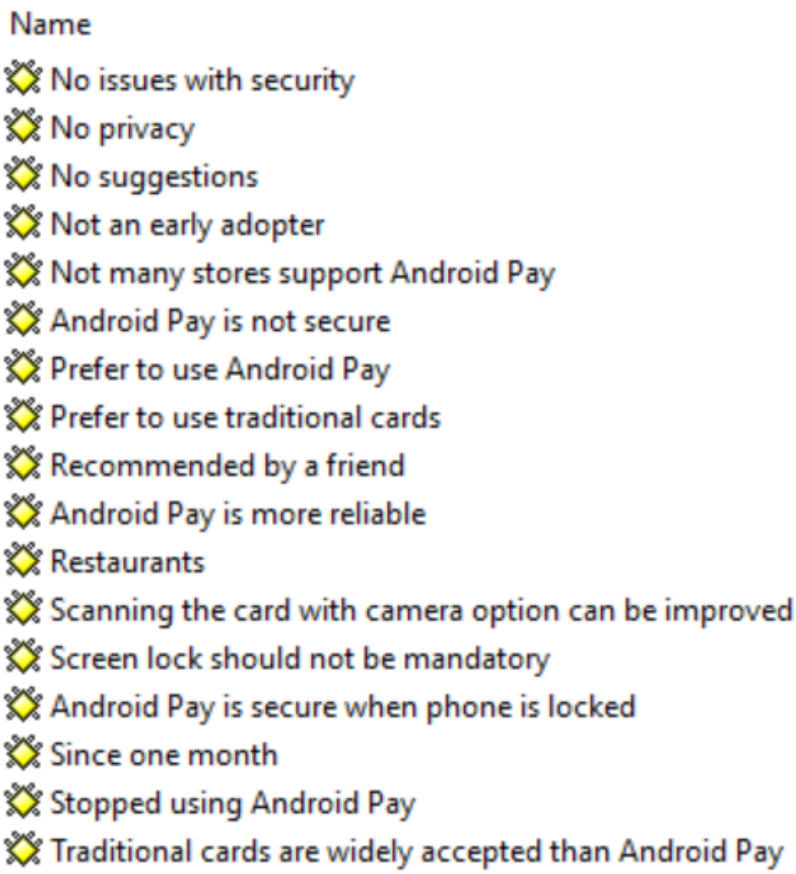


Figure 3.3: A snapshot of codes for Android Pay

Categorizing Codes

As we continued to create codes for the textual content, we ended up having many codes. At that stage, we decided to analyze the codes to find the similarities and group them into categories based on their common properties. The name of the category can be different from the codes to express its scope better. Thus, we created categories like "Why use Apple Pay/Android Pay", "Why not use Apple Pay/Android Pay", "Why stopped using Apple Pay/Android Pay", "Apple Watch", etc. A network diagram of few categories created for Apple Pay and Android Pay are shown in figures 3.4 and 3.5. The counts for each of the reasons for *using, not using and stopped using* Apple Pay and Android Pay are shown in tables 3.1 and 3.2 respectively.

Discussion

Of all the 36 participants we interviewed, 22 were for Apple Pay and 14 were for Android Pay. There were 12, 7 and 3 participants for using, not using and stopped using respectively for Apple Pay and 5, 6 and 3 participants for using, not using and stopped using respectively for Android Pay.

Reasons for not using mobile tap-and-pay

First, we analyzed the responses to the question *"If you are not using Apple (Android) Pay to pay in stores, why do you not use it?"* From the nonusers' responses,

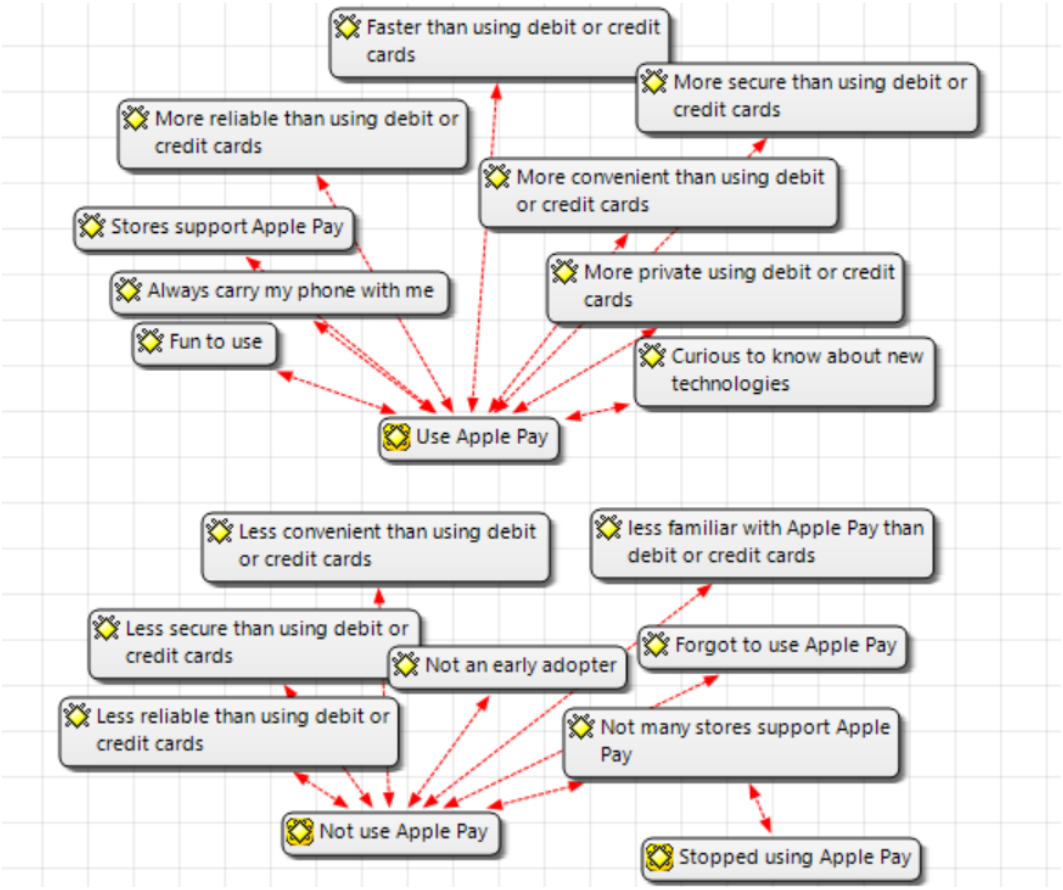


Figure 3.4: Network diagram with categories for Apple Pay

Table 3.1: Top reasons for *using, not using and stopped using* Apple Pay. Some responses contained multiple reasons (codes).

Ranking	Reason (code): Why using?	Count
1	More convenient than using debit or credit cards	12
2	More secure than using debit or credit cards	12
3	Faster than using debit or credit cards	11
4	Fun to use	8
5	Curious about a new technology	7
6	Always carry my phone with me	6
7	More reliable than using debit or credit cards	5
8	More private than using debit or credit cards	3
9	Many stores support Apple Pay	1
Ranking	Reason (code): Why not using?	Count
1	Not many stores support Apple Pay	6
2	Less secure than using debit or credit cards	6
3	Less convenient than using debit or credit cards	3
4	Less private than using debit or credit cards	2
5	Slower than using debit or credit cards	2
6	Forgot to use	2
7	Not an early adopter	2
8	Less reliable than using debit or credit cards	1
9	Less familiar with Apple Pay than debit or credit cards	1
10	My bank does not support Apple Pay	1
Ranking	Reason (code): Why stopped using?	Count
1	Not many stores support Apple Pay	3
2	Less convenient than using debit or credit cards	2
3	Less secure	1
4	Less private	1
5	My bank does not support Apple Pay	1
6	Forgot to use	1
7	Habit of using credit cards	1

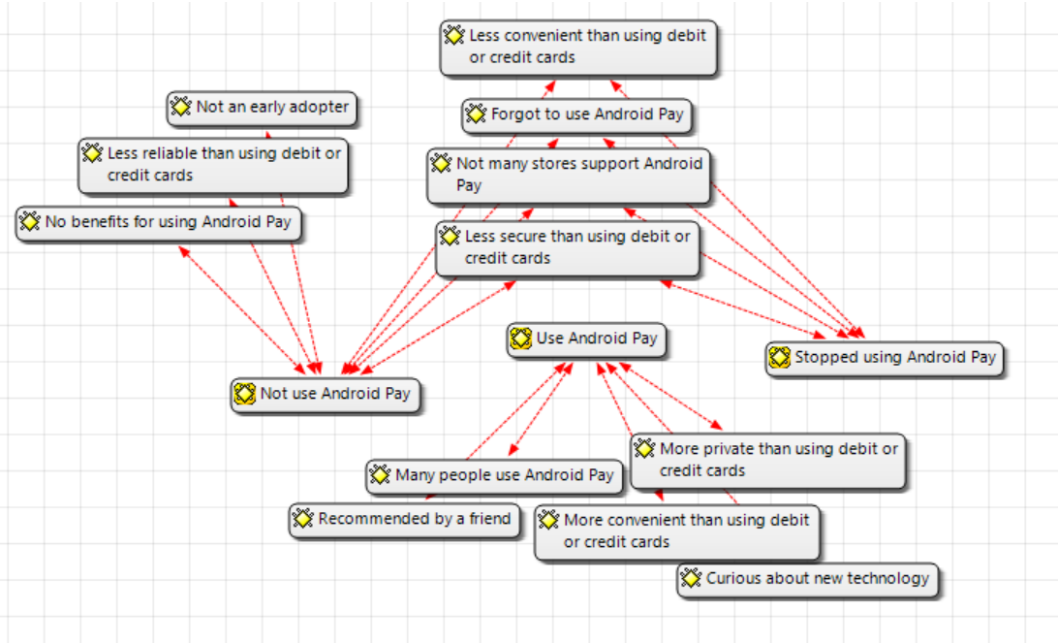


Figure 3.5: Network diagram with categories for Android Pay

Table 3.2: Top reasons for *using, not using and stopped using* Android Pay. Some responses contained multiple reasons (codes).

Ranking	Reason (code): Why using?	Count
1	`More convenient than using debit or credit cards`	4
2	`More private than using debit or credit cards`	4
3	`Curious about a new technology`	3
4	`More secure than using debit or credit cards`	2
5	`Faster than using debit or credit cards`	2
6	`Fun to use`	1
7	`More reliable than using debit or credit cards`	1
8	`Recommended by a friend`	1
9	`Many people use Android Pay`	1
Ranking	Reason (code): Why not using?	Count
1	`Not many stores support Android Pay`	6
2	`Less secure than using debit or credit cards`	5
3	`Less convenient than using debit or credit cards`	5
4	`Less private than using debit or credit cards`	1
5	`Slower than using debit or credit cards`	1
6	`Forgot to use`	1
7	`Not an early adopter`	1
8	`Less reliable than using debit or credit cards`	1
9	`No benefits of using Android Pay`	1
Ranking	Reason (code): Why stopped using?	Count
1	`Less secure than using debit or credit cards`	3
2	`Less convenient than using debit or credit cards`	3
3	`Not many stores support Android Pay`	2
4	`Less private than using debit or credit cards`	1
5	`Slower than using debit or credit cards`	1
6	`Forgot to use`	1
7	`Habit of using credit cards`	1

10 codes emerged from the Apple Pay, and 9 codes emerged from the Android Pay. Note that some participants provided multiple reasons (that were translated into multiple codes).

The most frequently cited reasons for not using Apple Pay were `not many stores support it`, and `less secure` (than using debit or credit cards), which were each mentioned by 6 out of 7 nonusers. Responses include:

> *"It is not obvious where you can and cannot use Apple Pay"* (P1)

> *"If my PIN is compromised, I can reset it to another PIN. But my biometric information cannot be reset.."* (P14)

Another frequently cited reason was `less convenient` (than using debit or credit cards), which was mentioned by 3 nonusers.

> *"I mean a debit card is still easier, because you grab it and go there.. It's not [Apple Pay is not] really intuitive.."* (P12)

The codes `not an early adopter`, `forgot to use`, `slower than using debit or credit cards`, `less private than using debit or credit cards` were mentioned 2 times by non users.

For Android Pay nonusers', the most frequently cited reason is `not many stores support it`, which was mentioned 6 out of 6 nonusers and a response for example:

> *".. I don't find many stores to use it in this area."* (P5)

The next frequently cited reasons were `less secure`, and `less convenient`, each of which was mentioned 5 out of 6 nonusers as an important reason for not using it. Responses include:

> *".. it's very easy to get into other people's phone as most of them use [screen] lock patterns."* (P15)

> *"I am not used to unlocking my phone to pay. I feel comfortable paying with my credit card."* (P16)

Android Pay nonusers also considered `less private than using debit or credit cards`, `slower than using debit or credit cards`, `forgot to use Android Pay`, `less reliable than using debit or credit cards`, `No benefits of using Android Pay` and `not an early adopter` as influencing factors, which were mentioned once.

Reasons for using mobile tap-and-pay

We then analyzed the responses to the question *"If you are using Apple (Android) Pay to pay in stores, why do you use it?"* From the users' responses, 9 codes emerged from the both Apple Pay and Android Pay. The most frequently cited reason for using Apple Pay were `more convenient` (than using debit or credit cards), and `more secure` (than using debit or credit cards), which were each mentioned by 12 out of 12 users. Responses include:

> *"It's more convenient.. rather than taking my wallet, finding my card, and swiping it.."* (P7)

> *" .. you have to .. authorize [its use] with the thumb print. So that makes [Apple Pay] very secure."* (P13)

The usability reasons, `faster` (than using debit or credit cards), `fun to use` and `curious about a new technology` were each mentioned by 11, 8 and 7 users respectively. Example responses include:

> *"It's faster as you have to just hold your phone over the machine and that's it, you're done!"* (P3)

> *".. I enjoy using Apple Pay."* (P1)

> *" ...because I liked the technology, and I wanted to see if I could go without a wallet"* (P5)

Other reasons include, `Always carry my phone with me`, `more reliable than using debit or credit cards`, and `more private than using debit or credit cards`, mentioned by few Apple Pay users. Examples include:

> *"I always carry my phone rather than my wallet"* (P30)

> *"I use Apple Pay because I trust Apple."* (P12)

> *"Apple Pay does not store or share transaction history with third parties"* (P7)

For Android Pay, the most frequently cited reasons were `more convenient`, and `more private`, which were mentioned by 4 out of 5 Android Pay users. Example responses include:

> *"Initially I used it to try a new technology. But now, I use it for convenience.'* (P12)

> *"You are not using your actual debit or credit card, and there's not much information on your phone per say other people cannot see your information ...'* (P12)

Few users mentioned `curious about a new technology`, `More secure than using debit or credit cards` and `Faster than using debit or credit cards` as their popular reasons, being mentioned 3, 3, and 2, times respectively.

> *"Android Pay is more secure than cards"* (P13)

> *"It's quicker to pay than pulling out my wallet. I can use multiple cards, and I don't have to fish for those cards from my wallet."* (P28)

Hypotheses

When we merge the codes from both groups, for using Apple Pay, the three dominant factors were `more secure` (12), `faster` (11), and `more convenient` (12). There were just three counts for `more private`. Thus, we have 13 responses for

security (more secure and more private) and 23 responses for usability (more convenient and faster). Based on those code counts, we defined the first hypothesis:

`H1:` usability (more convenient and faster) is a more important factor than security (more secure and more private) for using Apple Pay;

For not using Apple Pay, `not many stores support it` (6) and `less secure` (6) were the dominant factors. The counts for `less convenient`, `less private` and `slower` are 3, 2 and 2 respectively. Thus, we have 8 responses for security (less secure and less private) and 5 responses for usability (less convenient and slower). Based on those code counts, we defined the second hypotheses:

`H2:` security (less secure and less private) is a more important factor than usability (less convenient and slower) for not using Apple Pay.

For using Android Pay (after merging codes), the dominant factors were `more convenient` (4) and `more private` (4). `Faster` and `more secure` just had two counts each. Thus, we have 6 responses for both security and usability. Hence, we came up with a hypothesis:

`H3:` there is no statistically significant difference between the importance of

usability and security factors for using Android Pay;

For not using Android Pay, `not many stores support it` (6), `less secure` (5), and `less convenient` (5) were the three most important factors. `less private` and `slower` have one count each. Based on those observations, we have 6 responses each for security and usability and defined the following null hypothesis:

`H4:` there is no statistically significant difference between the importance of usability and security factors for not using Android Pay

Chapter 4: Quantitative Study

With the refined questionnaire from our first study, we conducted an online survey through Amazon Mechanical Turk. We collected 860 responses in total and performed a quantitative data analysis over this large dataset. Our large-scale study lead to interesting findings in the areas of security and usability besides supporting some of our initial hypothesis from the in-person interviews.

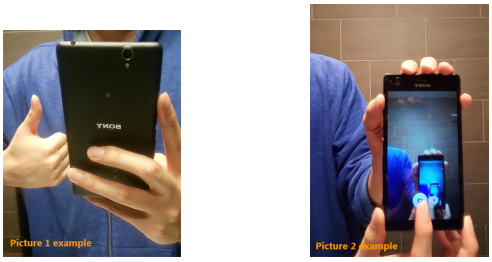
4.1 Online Survey

The first study results showed a number of possible reasons for using, not using, and stopping use of mobile tap-and-pay solution. However, we were not able to compare the relative importance of those reasons in a representative sample of Apple Pay and Android Pay participants. Thus, we conducted a large-scale online survey with 349 Apple Pay and 511 Android Pay participants, and statistically analyzed the relative importance of those reasons.

Participant Recruitment

We recruited participants on Amazon Mechanical Turk (MTurk) between March and April 2016 and collected 860 responses in total. We limited MTurk workers to those in the United States, and asked MTurk workers to participate only if they

have some familiarity with Apple/Android Pay, and own a phone that supports Apple/Android Pay (we provided instructions on how users can check this on their phone). In contrast to the in-person study, the online survey made it difficult to validate whether a participant owns a phone that supports Apple Pay or Android Pay, and has some familiarity with Apple Pay or Android Pay. To address the first concern, the participants were asked during the survey to submit two photos: (1) a photo of the back of their phone taken in front of a mirror while showing their thumbs up, and (2) a photo of the front of their phone taken in front of a mirror with the selfie mode. We asked the participants to take off their phone cases before taking those pictures. The participants were asked to reproduce (to the extent possible) the example pictures shown in Figures 4.1 (a) and (b). We later used those photos to validate the claimed phone model and support for Apple Pay or Android Pay. In addition, we also asked the participants to provide us with the model number, e.g., "D821," which has one-to-one correspondence with the marketed model, e.g., "LG Nexus 5." We excluded responses from those who did not provide us with photos, who did not follow the photo instructions (attention checking), who provided photos that did not match their claimed phone model in the survey, or who provided photos of a device that does not support Apple Pay or Android Pay.



(a) Back of a phone (b) Front of a phone

Figure 4.1: The participants were asked to reproduce those two example photos and submit them during the online survey

Procedures

Before collecting responses, we conducted a pilot study with 8 Apple Pay and 9 Android Pay users to test the survey questions, and data collection processes. Using the feedback obtained from the pilot study, we revised the questions for improved clarity and readability. The following parts are included in our survey questionnaire -

1. Demographics
2. Smartphone proficiency
3. Mobile tap-and-pay usage
4. Why use or not use mobile tap-and-pay
5. Familiarity with mobile tap-and-pay security
6. Feelings toward mobile tap-and-pay
7. Why use or not use mobile tap-and-pay on Apple watch

All the MTurk participants (except for those who did not submit photos) who have successfully completed the study are compensated with $3.00 for their time.

Table 4.1: Percentage of the participants who are using, not using, or stopped using Apple (Android) Pay. Note, all of our participants had *some familiarity* with Apple (Android) Pay.

	Apple Pay		**Android Pay**	
Options	Count		Count	
`No, I have never used it`	189	(54%)	330	(64%)
`Yes, I use it`	124	(36%)	100	(21%)
`I was using it in the past but stopped using it`	36	(10%)	81	(15%)

Online survey questionnaires used for Apple Pay and Android Pay in the quantitative study are shown in Appendix C and Appendix D.

4.2 Results

To address the limitations of the first (qualitative) study, and test the hypotheses we got from the that study, we conducted a large scale online survey and statistically analyzed the relative importance of the reasons for using, not using and stopped using of mobile tap-and-pay solution, and the participants feelings towards security and usability.

4.2.1 Reasons for not using mobile tap-and-pay

We asked the nonusers *"If you are not using Apple (Android) Pay to pay in stores, why do you not use it? Rank the options below in order of importance from 1 to 8, 1 being the most important reason. If there is no* `other` *reason, leave its ranking as blank."* We also asked the participants *"If you had* `other` *reason and ranked*

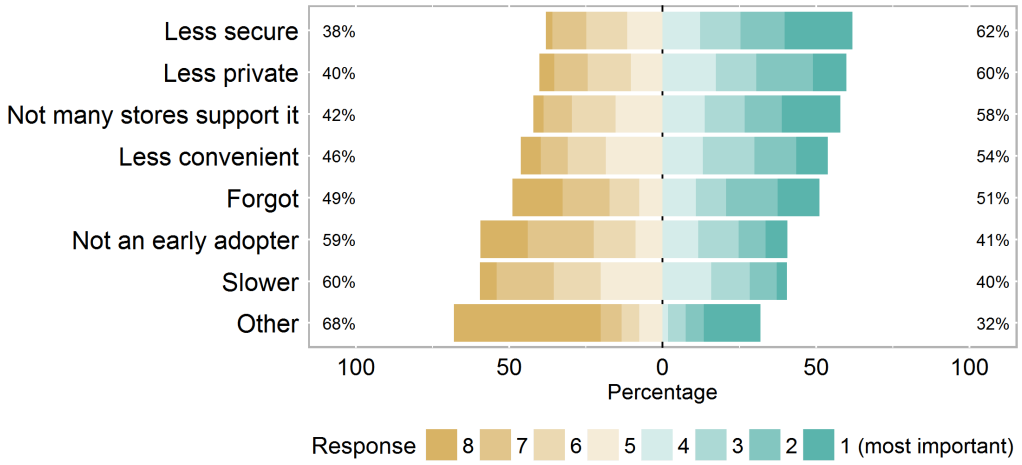


Figure 4.2: Reasons for *not using* Apple Pay, sorted based on the overall distribution of the ranks between 1 and 8, where 1 represents the most important rank.

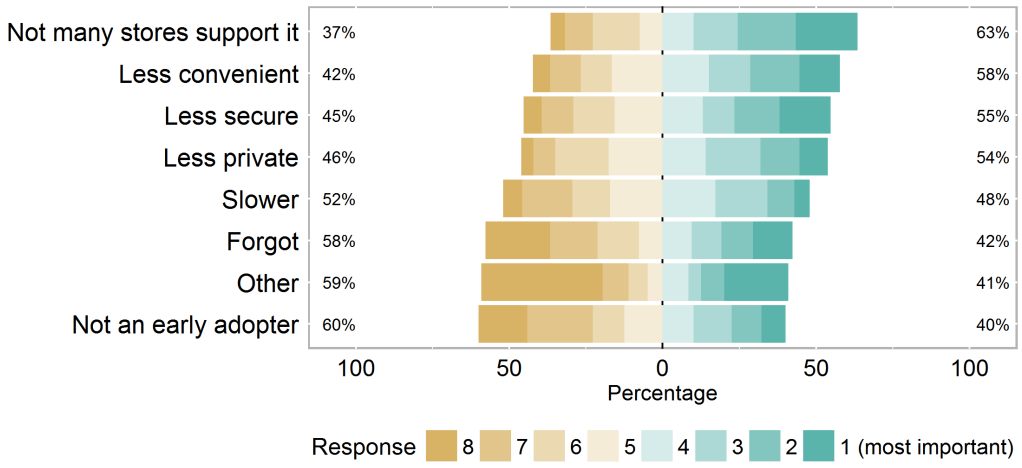


Figure 4.3: Reasons for *not using* Android Pay, sorted based on the overall distribution of the ranks between 1 and 8, where 1 represents the most important rank.

it, please specify what that reason is." Figures 4.2 and 4.3 show the reasons for not using Apple Pay and Android Pay, sorted based on the overall distribution of the importance ranks between 1 and 8. The option order was randomized in the survey.

Apple Pay Non-users

For Apple Pay, *"It is less secure than using debit or credit cards to swipe-and-pay in stores"* (`less secure`) and *"It is less private than using debit or credit cards to swipe-and-pay in stores"* (`less private`) were the top two reasons. To clarify, the term "private" was defined as follows in the survey: *"Private means limiting access others, including Apple, may have to your card details and transaction information."* Usability-related reasons, *"It is less convenient than using debit or credit cards to swipe-and-pay in stores"* (`less convenient`) and *"It is slower than using debit or credit cards to swipe-and-pay in stores,"* (`slower`) were ranked lower than the security-related reasons. The differences in rank distribution between `less secure` and `slower`, and between `less private` and `slower` were statistically significant (all $p < 0.005$, Bonferroni-corrected Mann-Whitney U test). `Not many stores support it` ranked third, indicating that availability is another important reason for not using Apple Pay. `Not many stores support it` ranked higher than `slower` and `not an early adopter` ($p < 0.05$, Bonferroni-corrected Mann-Whitney U test).

Table 4.2: The number of participants who chose each reason as the most important reason for *not using* Apple Pay or Android Pay. Note, those numbers may not add up to exactly match the numbers presented in Table 4.1 because some participants skipped questions.

Apple Pay			**Android Pay**		
Reason	Count		Reason	Count	
`Less secure`	40	(22.22%)	`Not many stores support it`	64	(20.13%)
`Not many stores support it`	35	(19.44%)	`Less secure`	53	(16.67%)
`Forgot`	25	(13.89%)	`Other`	47	(14.78%)
`Other`	22	(12.22%)	`Less convenient`	42	(13.21%)
`Less private`	20	(11.11%)	`Forgot`	41	(12.89%)
`Less convenient`	19	(10.56%)	`Less private`	30	(9.43%)
`Not an early adopter`	19	(10.56%)	`Not an early adopter`	25	(7.86%)
`Slower`	6	(3.33%)	`Slower`	16	(5.03%)

Android Pay Non-users

In contrast, `Not many stores support it` was the top reason for not using Android Pay. `Not many stores support it` ranked higher than `slower`, `not an early adopter`, *"I just forgot to use it"* (`forgot`), and `other` with statistical significance ($p < 0.005$, Bonferroni-corrected Mann-Whitney U test). This is probably because Android Pay (launched later) is less available than Apple Pay. `Less convenient` ranked second for Android Pay (compared to being ranked fourth for Apple Pay), indicating that the Android Pay nonusers have more concerns about its usability. Difference in the ranking distribution between `less secure` and `slower` was statistically significant ($p < 0.05$, Bonferroni-corrected Mann-Whitney U test) but the difference between `less private` and `slower` was not ($p = 0.08$, Bonferroni-corrected Mann-Whitney U test).

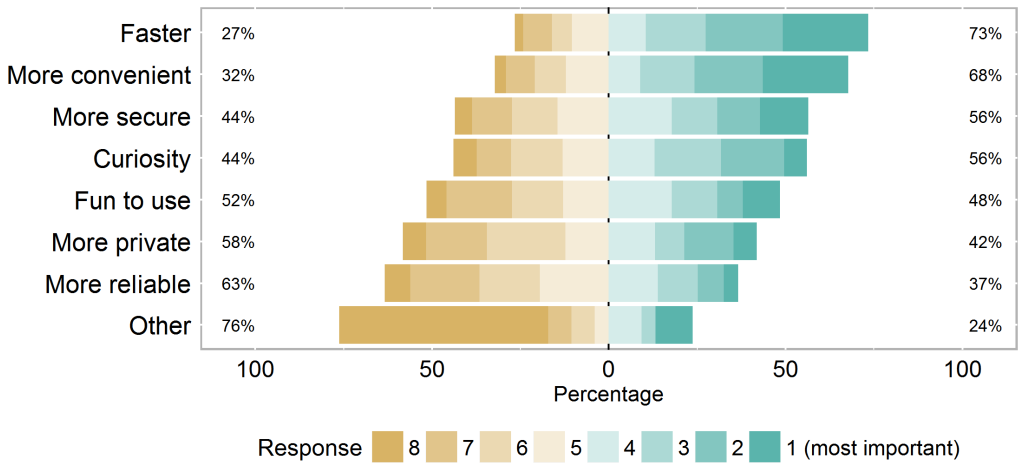


Figure 4.4: Reasons for *using* Apple Pay, sorted based on the overall distribution of the ranks between 1 and 8, where 1 represents the most important rank.

4.2.2 Reasons for using mobile tap-and-pay

We asked the users *"If you are using Apple (Android) Pay to pay in stores, why do you use it?"* We used the same option-ranking format as the previous ("reasons for not using") question. Figures 4.4 and 4.5 show the reasons for using Apple Pay and Android Pay, sorted based on the overall distribution of the importance ranks between 1 and 8.

Apple Pay Users

For Apple Pay users, *"It is faster than using debit or credit cards to swipe-and-pay in stores"* (`faster`) and *"It is more convenient than using debit or credit cards to swipe-and-pay in stores"* (`more convenient`) were the top two reasons. Both were

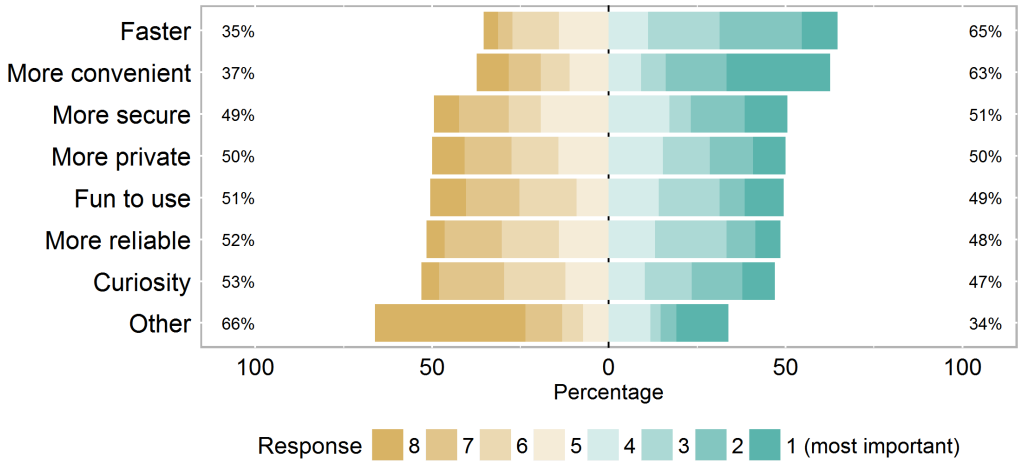


Figure 4.5: Reasons for *using* Android Pay, sorted based on the overall distribution of the ranks between 1 and 8, where 1 represents the most important rank.

usability-related reasons. This contrasts with the observations for the nonusers who picked security as their biggest concern. `Faster` ranked higher than *"It is more secure than using debit or credit cards to swipe-and-pay in stores"* (`more secure`), *"I'm curious about a new technology"* (`curiosity`), *"It is fun to use"* (`fun`), *"It is more private than using debit or credit cards to swipe-and-pay in stores"* (`more private`), *"It is more reliable than using debit or credit cards to swipe-and-pay in stores"* (`more reliable`), and `other` with statistical significance (all $p < 0.05$, Bonferroni-corrected Mann-Whitney U test). Even though `more secure` was not the most important factor for using Apple Pay, it ranked third overall, indicating that security is still an important factor. The differences in the ranking distribution between `more secure` and `more reliable`, and between `more secure` and `other` were statistically significant (all $p < 0.05$, Bonferroni-corrected Mann-Whitney U

Table 4.3: The number of participants who chose each reason as the most important reason for *using* Apple Pay or Android Pay.

Apple Pay			**Android Pay**		
Reason	Count		Reason	Count	
`Faster`	30	(25.21%)	`More convenient`	29	(29.90%)
`More convenient`	30	(25.21%)	`More secure`	12	(12.37%)
`More secure`	17	(14.29%)	`Fun`	11	(11.34%)
`Fun`	13	(10.92%)	`Faster`	10	(10.31%)
`Curiosity`	8	(6.72%)	`Other`	10	(10.31%)
`More private`	8	(6.72%)	`More private`	9	(9.28%)
`Other`	8	(6.72%)	`Curiosity`	9	(9.28%)
`More reliable`	5	(4.20%)	`More reliable`	7	(7.22%)

test).

Android Pay Users

Similar trends were observed with Android Pay users, where the top three reasons were the same as the reasons for using Apple Pay. This reinforces the observation that usability is the most important factor for mobile tap-and-pay users. The top two reasons for Apple Pay were `faster` and `more convenient`, both at 25.21%. Usability also dominated the Android Pay responses; `more convenient` was chosen as the most important reason by 29.90% of the users. `More secure` came at third for Apple Pay with 14.29%, and second for Android Pay at 12.37%. However, for Android Pay, the differences between the second, third, and fourth factors were small.

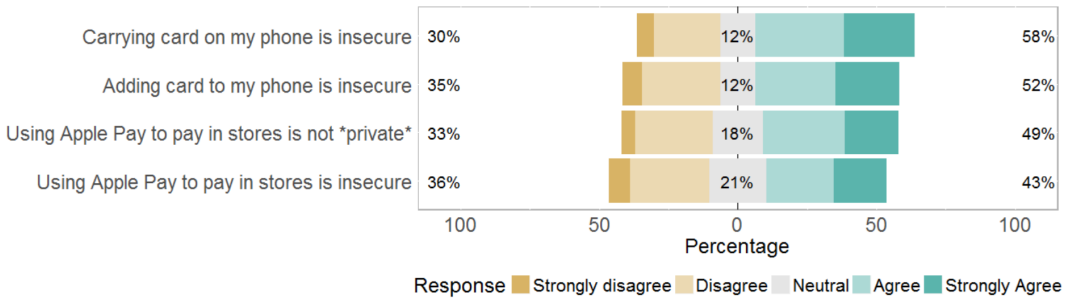


Figure 4.6: Ranking of security reasons for *not using* Apple Pay.

4.2.3 Feelings towards security and usability of mobile tap-and-pay

Apple Pay / Android Pay Non-users

The ranking of security reasons for not using Apple Pay and Android Pay are shown in figures 4.6 and 4.7. The main reason for not using is that, people felt more insecure about carrying and accessing debit or credit card on their phone. For Apple Pay, the differences in rank distribution between `carrying card on my phone is insecure` and `using Apple Pay to pay in stores is insecure` is statistically significant ($p < 0.005$, Bonferroni-corrected Mann-Whitney U test). For Android Pay, the differences in rank distribution between `carrying card on my phone is insecure` and `using Android Pay to pay in stores is insecure`, and `carrying card on my phone is insecure` and `Using Android Pay to pay in stores is not *private*` is statistically significant ($p < 0.0001$, Bonferroni-corrected Mann-Whitney U test).

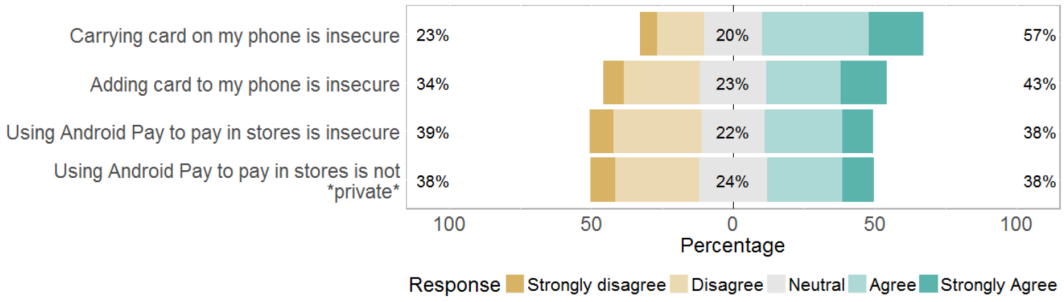


Figure 4.7: Ranking of security reasons for *not using* Android Pay.

The ranking of usability reasons for not using Apple Pay and Android Pay are shown in figures 4.8 and 4.9. The main reason for not using Apple Pay is that, people felt `Adding card to their phone is inconvenient`. However, there is no statistical significance for the differences in the rank distribution among all the usability reasons. The main reason for not using Android Pay is that, people felt `using Android Pay in stores is inconvenient`. Also, the differences in rank distribution between `using Android Pay to pay in stores is inconvenient` and `Carrying/accessing card on my phone is inconvenient`, and `using Android Pay to pay in stores is inconvenient` and `Adding card to phone is slow` are statistically significant ($p < 0.0001$, Bonferroni-corrected Mann-Whitney U test). `Carrying/accessing card on my phone is slow` ranks second for not using Android Pay and the difference in rank distribution is statistically significant with `Adding card to my phone is slow` ($p < 0.0005$, Bonferroni-corrected Mann-Whitney U test).

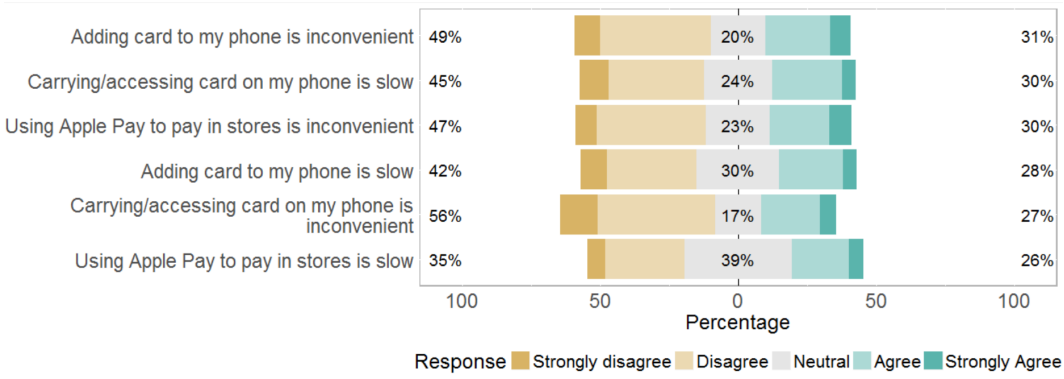


Figure 4.8: Ranking of usability reasons for *not using* Apple Pay.

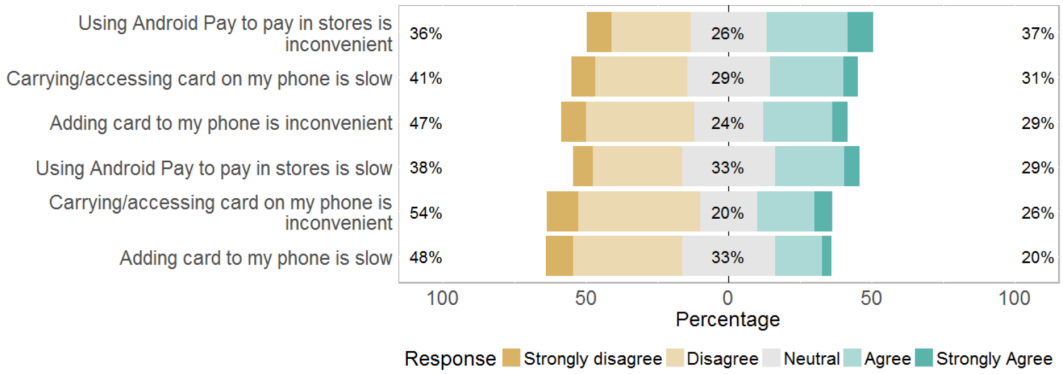


Figure 4.9: Ranking of usability reasons for *not using* Android Pay.

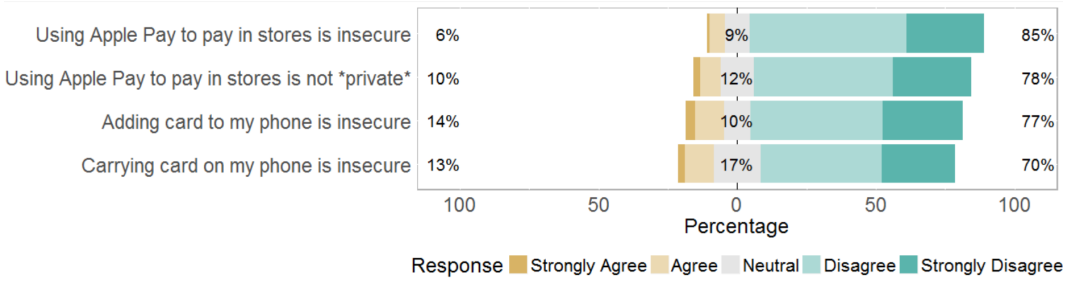


Figure 4.10: Ranking of security reasons for *using* Apple Pay.

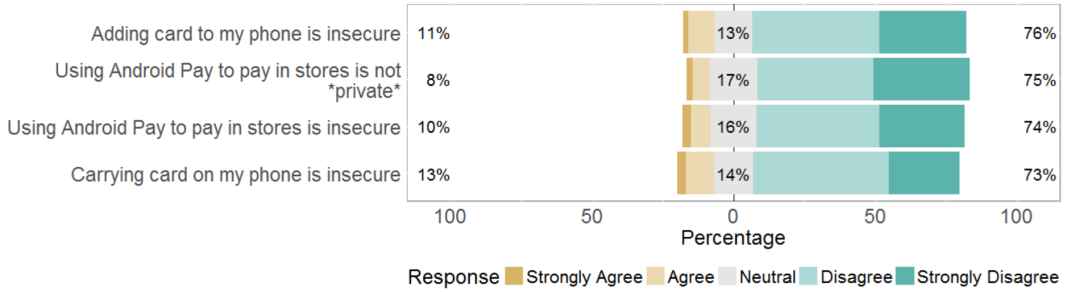


Figure 4.11: Ranking of security reasons for *using* Android Pay.

Apple Pay / Android Pay Users

The ranking of security reasons for using Apple Pay and Android Pay are shown in figures 4.10 and 4.11. The main reason for using Apple Pay is that, people strongly disagree on using Apple Pay in stores is insecure. The main reason for using Android Pay is that, people strongly disagree on adding cards on phone is insecure. However, there is no statistical significance for the differences in distribution of ranks between any of these reasons in both Apple Pay and Android Pay.

The ranking of usability reasons for using Apple Pay and Android Pay are shown

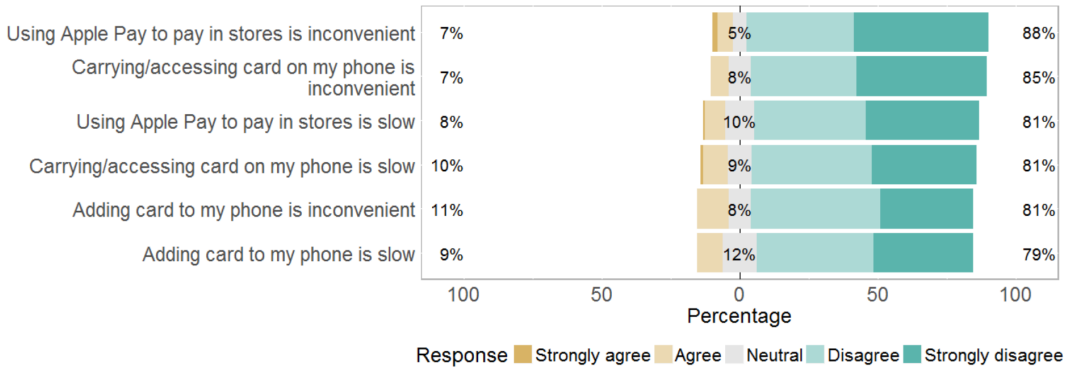


Figure 4.12: Ranking of usability reasons for *using* Apple Pay.

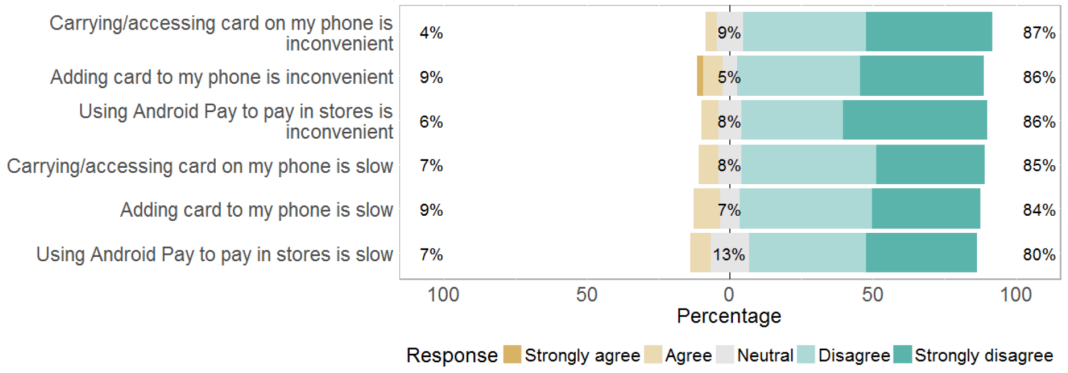


Figure 4.13: Ranking of usability reasons for *using* Android Pay.

in figures 4.12 and 4.13. The main reason for using Apple Pay is that, people strongly disagree on using Apple Pay in stores is inconvenient. The main reason for using Android Pay is that, people strongly disagree on carrying/accessing cards on phone is inconvenient. However, there is no statistical significance for the differences in distribution of ranks between any of these reasons in both Apple Pay and Android Pay.

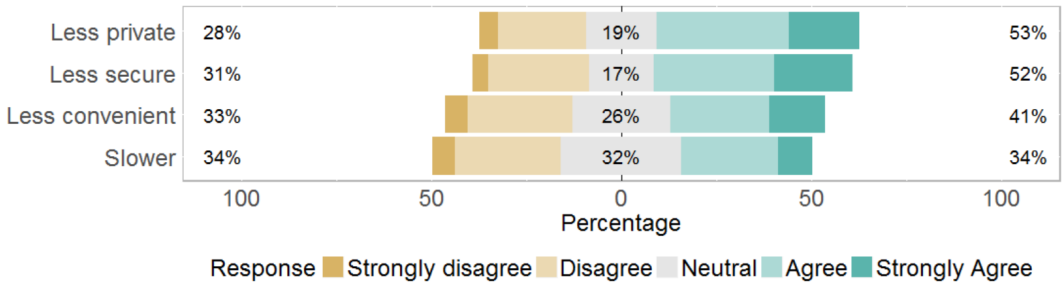


Figure 4.14: Ranking of security and usability reasons for *not using* Apple Pay compared with traditional debit or credit cards.

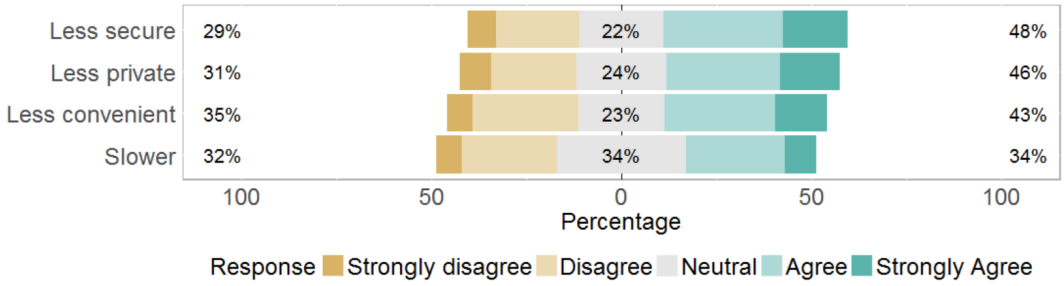


Figure 4.15: Ranking of security and usability reasons for *not using* Android Pay compared with traditional debit or credit cards.

4.2.4 Comparision against traditional cards

Apple Pay / Android Pay Non-users

When compared to traditional cards as shown in figures 4.14 and 4.15, people felt using Apple Pay to pay in stores is less secure and less private than using traditional debit or credit cards to swipe-and-pay in stores. The differences in rank distribution between `less private` and `slower`, and `less secure` and `slower` is statistically significant ($p < 0.05$, Bonferroni-corrected Mann-Whitney U test).

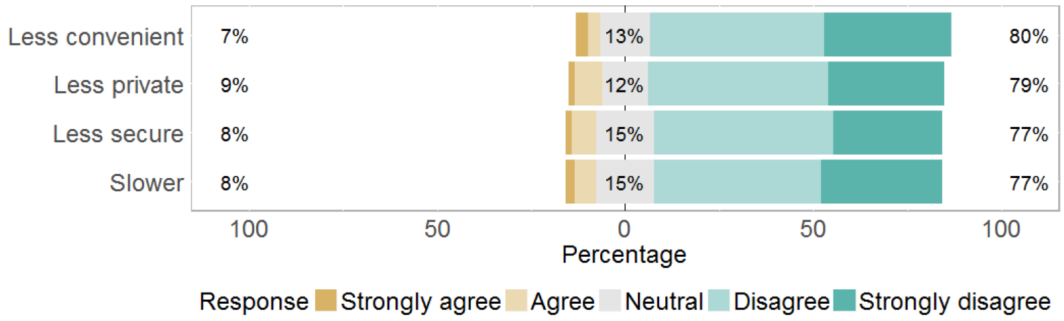


Figure 4.16: Ranking of security and usability reasons for *using* Apple Pay compared with traditional debit or credit cards.

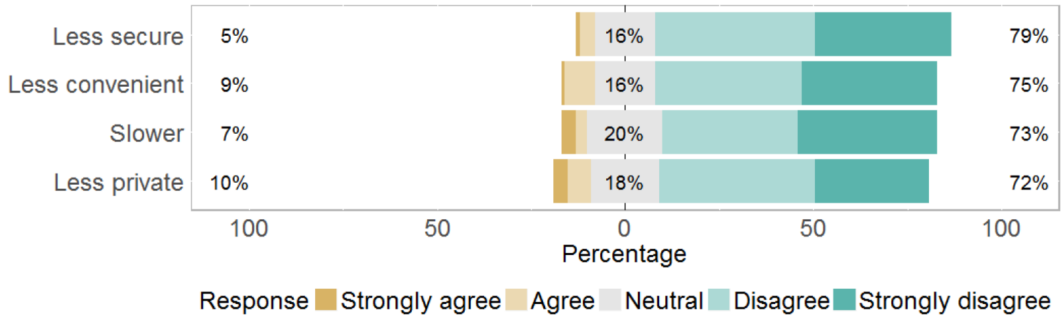


Figure 4.17: Ranking of security and usability reasons for *using* Android Pay compared with traditional debit or credit cards.

Similarly, people felt using Android Pay to pay in stores is less secure. The differences in rank distribution between `less secure` and `slower` is statistically significant ($p < 0.05$, Bonferroni-corrected Mann-Whitney U test).

Apple Pay / Android Pay Users

When compared to traditional cards as shown in figures 4.16 and 4.17, people strongly disagree that using Apple Pay to pay in stores is less convenient than using traditional debit or credit cards to swipe-and-pay in stores. Whereas people strongly disagree that using Android Pay to pay in stores is less secure than using traditional debit or credit cards to swipe-and-pay in stores. However, the differences in ranking distributions are not statistically significant for both Apple Pay and Android Pay.

Chapter 5: Discussion and Other Findings

Importance of usability for Apple Pay users

`More convenient` and `faster` were ranked as the top two factors for using Apple Pay (see figure 4.4). `Faster` showed statistically significant superiority in the overall ranking distribution over both `more secure` and `more private`. Table 4.3 reinforces this observation. We collected sufficient evidence from the second study to accept the first hypothesis "`H1:` usability (more convenient and faster) is a more important factor than security (more secure and more private) for using Apple Pay." Considering that mobile tap-and-pay is a security-critical application, this finding is intriguing, as Apple Pay users still favor usability over security as the primary reason for using the technology.

Security concerns for Apple Pay nonusers

The second hypothesis was "`H2:` security (less secure and less private) is a more important factor than usability (less convenient and slower) for not using Apple Pay." Our ranking results in figure 4.2 show `less secure` and `less private` as the top two factors for not using Apple Pay. The differences in the importance score distribution between `less secure` and `slower`, and between `less private` and `slower` were statistically significant. Table 4.2 shows that a much large pro-

portion of Apple Pay nonusers chose `less secure` (22.22%) as the most important reason, compared to `less convenient` (10.56%) and `slower` (3.33%). Based on this evidence, we accepted the second hypothesis.

Security and Usability concerns for Android Pay users

The third hypothesis was "`H3:` there is no statistically significant difference between the importance of usability and security factors for using Android Pay". From the table 4.2, there are more participants who chose `more convenient` (29.90%) over `more secure` (12.37%) as their top reason for using Android Pay, whereas, the other usability factor `faster` (10.31%) is not. Also, our ranking results in figure 4.5 that usability (`less convenient` and `slower`) factors are more considered than security (`less secure` and `less private`) factors. However, none of the differences in the ranking distribution between those factors is significant. Based on these results, we accept the third hypothesis.

Security and Usability concerns for Android Pay nonusers

The fourth hypothesis was "`H4:` there is no statistically significant difference between the importance of usability and security factors for not using Android Pay". From the Table 4.2, a large portion of Android Pay nonusers chose `less secure` (16.67%) as the most important reason, compared to `slower` (5.03%) and `less convenient` (13.21%). Our ranking results in Figure 4.3 show smaller

Table 5.1: The percentages of the participants who correctly answered 0, 1, 2, or 3 security knowledge questions.

# correct	**Apple Pay**		**Android Pay**	
0	85	(24.36%)	219	(42.86%)
1	184	(52.72%)	175	(34.24%)
2	43	(12.32%)	50	(9.78%)
3	37	(10.60%)	67	(13.11%)

gaps between the security (`less secure` and `less private`) and usability (`less convenient` and `slower`) factors and the difference in ranking distribution between `less private` and `slower` was not statistically significant. However, the difference in ranking distribution between `less secure` and `slower` was statistically significant. Based on these results, we don't have enough evidence to accept the fourth hypothesis.

Security knowledge Vs Adoption rates

We asked the same three questions described in the first study "Procedures" about the security mechanisms used in Apple (Android) Pay, and gave 6 options to choose from – there was only one correct answer for each question. There was no motivation for the participants to use smart guessing techniques to answer these questions correctly as there was no additional reward for getting them right.

As shown in Table 5.1, for both Apple Pay and Android Pay, about 77% of the participants got just one or less correct, indicating that the majority have limited knowledge about the specific security mechanisms being used in mobile tap-and-

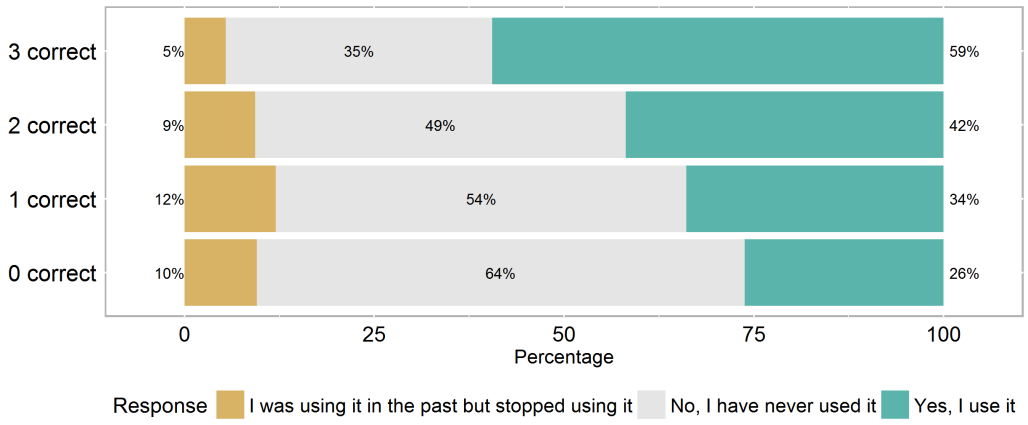


Figure 5.1: Percentages of stopped users, users and nonusers grouped by the number of security knowledge questions they answered correctly for Apple Pay.

pay. In particular, about 81% of the *nonusers* (for both technologies) answered one or less correctly. About 68% Apple Pay *users* and 63% Android Pay *users* answered one or less correctly, indicating that the users, overall, were more knowledgeable.

Next, we analyzed the correlation between the participants' using or not using status and the number of security knowledge questions they correctly answered (i.e., the security knowledge level). We found a positive association for both Apple Pay ($\phi = 0.15$, Cramer's V test) and Android Pay ($\phi = 0.17$, Cramer's V test). As shown in figures 5.1 and 5.2, participants who are more knowledgeable about the security mechanisms are more likely to be using mobile tap-and-pay.

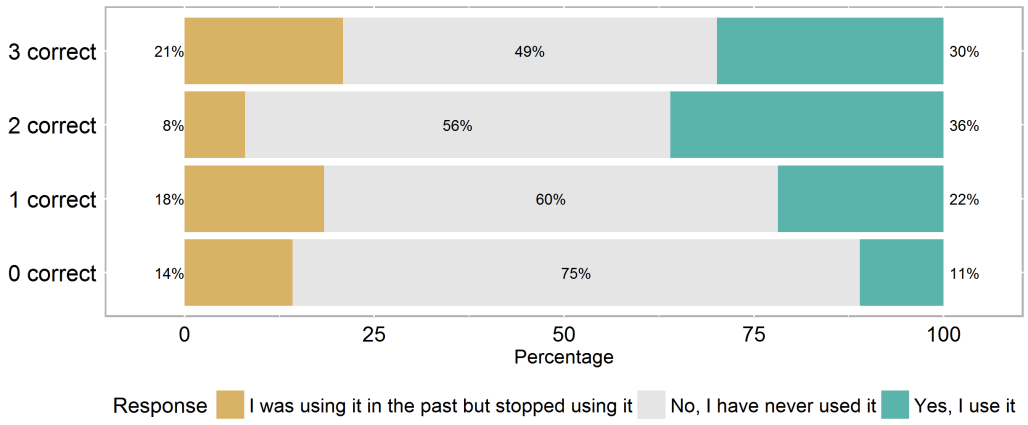


Figure 5.2: Percentages of stopped users, users and nonusers grouped by the number of security knowledge questions they answered correctly for Android Pay.

Table 5.2: The percentages of stopped users, nonusers and users grouped by gender.

Options	**Male**		**Female**	
No, I have never used	242	(52.2%)	274	(70.2%)
Yes, I use it	146	(31.5%)	74	(18.9%)
I was using it in the past but stopped using it	74	(15.9%)	42	(10.8%)

Gender Vs Adoption rates for tap-and-pay

From the Table 5.2, about 31.5% males were using tap-and-pay where as only 18.9% females were using. Also, the percentage of males who stopped using tap-and-pay (15.9%) is higher than females (10.8%), indicating that males are more likely to adopt mobile tap-and-pay when compared to females.

Next, we analyzed the correlation between the participants' using or not using status and gender (for both both Apple Pay and Android Pay together). We found a positive association with $\phi = 0.19$, Cramer's V test (Apple Pay) and $\phi = 0.22$, Cramer's V test (Android Pay) indicating that male participants are more likely

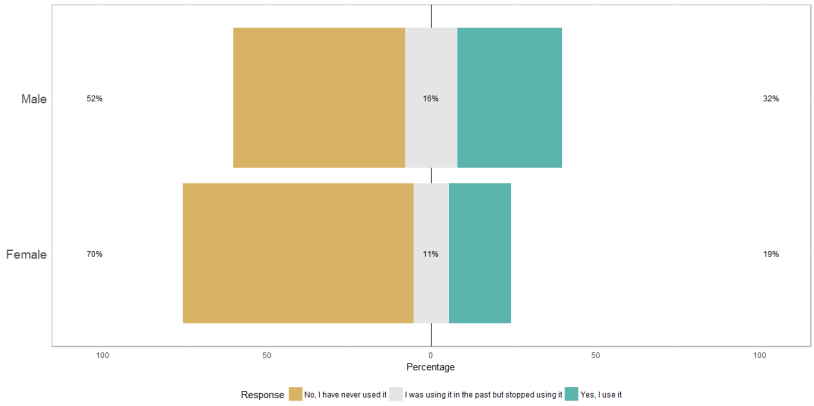


Figure 5.3: Percentages of stopped users, users and nonusers grouped by gender.

to be using mobile tap-and-pay than females.

Security knowledge Vs Gender

There is no much difference in the level of security knowledge between males and females for Apple Pay ($p = 0.196$, chi-squared test) and Android Pay ($p = 0.423$, chi-squared test). About 25% of males and 21% of females have correctly answered more than 2 security questions.

Gender Vs Age

There are 79.94 % and 78.47 % people who are less than 35 years for Apple Pay and Android Pay respectively. We analyzed the correlation between gender and age. There is no difference in the distribution of males and females with age for ($p = 0.1448$, chi-squared test) Apple Pay and ($p = 0.823$, chi-squared test) Android

Pay.

Security knowledge Vs Age

Next, we analyzed the dependence of the level of security knowledge people have with age. There is no difference in the distribution of security awareness for ($p = 0.4924$, chi-squared test) Apple Pay and ($p = 0.093$, chi-squared test) Android Pay.

Chapter 6: Limitations

Qualitative Study Limitations

One of the limitations of our qualitative study is that the results of the interviews are not generalizable. The results of the analyses could have been impacted by our biases (e.g., our interests in security and usability), which we tried to minimize by having two separate coders and periodically discussing disagreements to reach consensus. Moreover, the participants could have misunderstood some of the questions or could have interpreted them differently. To keep the chances of such misunderstanding low and ensure consistency, we had two researchers interviewing together, and conducted a pilot study with 19 participants prior to the real interviews. We learned about potential inconsistencies (e.g., interpreting the meaning of privacy) through the pilot study, and were extra careful in explaining them during the real study. Our follow-up quantitative study was designed to address some of those limitations.

Quantitative Study Limitations

Our online survey has two limitations. First, we asked our participants to take two pictures as shown in Figure 4.1, and email them to us during the survey. This part of the survey could have introduced a bias toward a more technically savvy group

of smart phone users. We mitigated this limitation by presenting clear example photos, and providing detailed instructions on how those two pictures should be taken. Also, through the in-person interviews, we learned that a large portion of the mobile tap-and-pay users, or those that are aware of the technologies, are technically savvy in nature anyway. Second, the MTurk workers do not always represent general Apple Pay or Android Pay users. Hence, any generalization of the results presented in this work needs to be performed with caution.

Chapter 7: Conclusion

Our study results show that *usability* is the most important reason for using mobile tap-and-pay. However, for Apple Pay nonusers, *security concerns* were the most important factor for not using it. A common *security misconception* we identified among the nonusers (who mentioned security as their top concern) was that they felt storing card information on their phones is less secure than physically carrying cards inside their wallets. However, only about 15% of such nonusers were knowledgeable about the secure storage mechanisms being used. We also identified a *usability misconception* where the participants falsely believed that a payment application needs to be launched before they can make a payment, and as a result, felt that mobile tap-and-pay is inconvenient and slow.

Our findings suggest that technology adoption rates (only about 36% for Apple Pay and 21% for Android Pay) could potentially improve with increased awareness of the security protections and convenience offered by tap-and-pay solutions over traditional swipe-and-pay. An important future research would be to study how education of nonusers about the security protections in mobile tap-and-pay affects their mental models and decisions to use the technology.

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APPENDICES

Appendix A: First Study - Apple Pay Questionnaire

Edit this form

Mobile payment interview - Apple Pay version (OSU)

1. Demographics

What is your age?

- 18 to 24 years
- 25 to 34 years
- 35 to 44 years
- 45 to 54 years
- 55 to 64 years
- Age 65 or older
- Prefer not to answer

What is your gender?

- Female
- Male
- Prefer not to answer

What is the highest level of education you have completed?

- No schooling completed
- Less than high school
- High school / GED
- College / bachelor's degree / associate's degree
- After bachelor's degree / master's degree / professional degree (e.g., MD, LLB) / doctorate degree (PhD)
- Prefer not to answer

What is your current occupation?

- Architecture and Engineering Occupations
- Arts, Design, Entertainment, Sports, and Media Occupations
- Sales and Related Occupations
- Business and Financial Operations Occupations
- Building and Grounds Cleaning and Maintenance Occupations
- Management Occupations
- Education, Training, and Library Occupations
- Personal Care and Service Occupations
- Protective Service Occupations
- Computer and Mathematical Occupations
- Life, Physical, and Social Science Occupations
- Production Occupations
- Healthcare Practitioners and Technical Occupations
- Food Preparation and Serving Related Occupations

- Office and Administrative Support Occupations
- Farming, Fishing, and Forestry Occupations
- Installation, Maintenance, and Repair Occupations
- Legal Occupations
- Construction and Extraction Occupations
- Community and Social Service Occupations
- Healthcare Support Occupations
- Transportation and Materials Moving Occupations
- A student
- Retired
- Out of work
- Unable to work
- Prefer not to answer
- Other:

What is your ethnicity?

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or Other Pacific Islander
- White
- Prefer not to answer
- Other:

2. Smartphone proficiency and security awareness

What is the model of your phone?

- iPhone 6
- iPhone 6 Plus
- iPhone 6s
- iPhone 6s Plus
- I have no idea

On average, how many minutes do you spend on your phone each day?

(Enter your answer in "minutes")

On average, how frequently do you unlock your phone?

- Once a day
- A few times a day
- Once per hour
- A few times per hour
- I have no idea

For how long, in total, have you been using a smartphone (not necessarily iPhones)?

- Less than a year

- 1 to 2 years
- 2 to 3 years
- 3 to 4 years
- 4 to 5 years
- Over 5 years

Does your phone store any sensitive or confidential information?

- Yes
- No
- I have no idea

Safari allows you to save your credit card numbers to auto-fill when requested by a website form. Do you know how to change Safari settings to disable this auto-fill feature?

- Yes
- No
- I do not understand this question

A simple passcode is a 4- or 6-digit number. Simple passcode is the default unlock mechanism. Do you know how to enable longer or alphanumeric passcode on your iPhone?

- Yes
- No
- I do not understand this question

Do you know how to turn off an app's access to your camera in the settings?

- Yes
- No
- I do not understand this question

3. Apple Pay usage details

How familiar are you with Apple Pay?

- I have no idea what Apple Pay is and how it works
- I know what Apple Pay is, but don't know how it works
- I know what Apple Pay is, and have some idea as to how Apple Pay works
- I know what Apple Pay is, and have good understanding of how Apple Pay works

Have you set up Apple Pay on your iPhone (i.e., added a debit card or credit card)?

- Yes
- No
- I have no idea

Do you use Apple Pay to pay (tap-and-pay) in stores?

- No, I have never used it
- Yes, I use it
- I was using it in the past but stopped using it

How frequently do you use Apple Pay to pay in stores on average?

How long have you been using Apple Pay to pay in stores?

What are the most common places where you use Apple Pay to pay?

How many debit and credit cards do you own in total?

How many of those cards have you added to Apple Pay?

How many of those cards have you actually used to pay in stores using Apple Pay?

4. Why use or not use Apple Pay?

If you are not using Apple Pay to pay in stores, why do you not use it?

If you are using Apple Pay to pay in stores, why do you use it?

If you stopped using Apple Pay to pay in stores, why did you use it, and why did you stop using it?

How do you feel about the security of adding debit or credit card information through Passbook?

How do you feel about the security of storing your debit or credit card information on your phone?

How do you feel about the security of using Apple Pay to pay in stores?

How do you feel about the privacy of using Apple Pay to pay in stores?

How do you feel about the usability (convenience, time, ease of use) of adding debit or credit card information through Passbook?

How do you feel about the usability (convenience, time, ease of use) of carrying and accessing debit or credit cards on your phone?

How do you feel about usability (convenience, time, ease of use) of using Apple Pay to pay in stores?

Was Apple Pay an important new feature that influenced your decision to buy a new iPhone? Why or why not?

Do you have suggestions for improving Apple Pay user experience?

Do you have suggestions for improving Apple Pay security?

5. Familiarity with Apple Pay security

How familiar are you with the techniques/mechanisms that Apple Pay use to protect your security and privacy?

- I have no idea how Apple Pay protects my security and privacy
- I'm aware of the mechanisms used by Apple Pay to protect my security and privacy, but don't know how they work
- I'm aware of the mechanisms used by Apple Pay to protect my security and privacy, and have some idea about how they work
- I'm aware of the mechanisms used by Apple Pay to protect my security and privacy, and have good understanding of how they work

Do you understand how Apple Pay protects your tap-and-pay transaction privacy? Explain briefly.

Do you understand how Apple Pay protects your tap-and-pay transaction security? Explain briefly.

Do you understand how Apple Pay protects your debit or credit card details? Explain briefly.

Do you understand how Apple Pay ensures that only you can pay in stores with your phone? Explain briefly.

6. Apple Watch

Do you own an Apple Watch? If no, skip this section.

- Yes
- No

Do you use Apple Pay on your watch to pay in stores?

- No, I have never used it
- Yes, I use it

I was using it in the past but stopped using it

If you are not using Apple Pay on your watch to pay in stores, why do you not use it?

If you are using Apple Pay on your watch to pay in stores, why do you use it?

If you stopped using Apple Pay on your watch to pay in stores, why did you use it, and why did you stop using it?

Do you understand how Apple Pay works on your watch without Touch ID (fingerprint scanning feature)? Explain briefly.

How do you feel about using Apple Pay on your watch without Touch ID?

Which of the two devices (iPhone or Apple Watch) do you prefer to use to pay in stores? Why?

7. Comparing Apple Pay against traditional credit cards

How do you feel about the security of Apple Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Apple Pay is less secure but still use it, why do you use it?

If you feel Apple Pay is more secure but stopped using it, why did you stop using it?

How do you feel about the privacy of Apple Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Apple Pay is less private but still use it, why do you use it?

If you feel Apple Pay is more private but stopped using it, why did you stop using it?

How do you feel about the usability (convenience, time, ease of use) of Apple Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Apple Pay is harder to use, takes longer, or is less convenient, but still use it, why do you use it?

If you feel Apple Pay is easier to use, quicker, or is more convenient, but stopped using it, why did you stop using it?

Which of the two payment methods (Apple Pay and swipe-and-pay with debit or credit cards) do you prefer to use to pay in stores if both payment methods are available? Why?

Submit

Never submit passwords through Google Forms.

Edit this form

Mobile payment interview - Apple Pay nonuser version (OSU)

1. Demographics

What is your age?

- 18 to 24 years
- 25 to 34 years
- 35 to 44 years
- 45 to 54 years
- 55 to 64 years
- Age 65 or older
- Prefer not to answer

What is your gender?

- Female
- Male
- Prefer not to answer

What is the highest level of education you have completed?

- No schooling completed
- Less than high school
- High school / GED
- College / bachelor's degree / associate's degree
- After bachelor's degree / master's degree / professional degree (e.g., MD, LLB) / doctorate degree (PhD)
- Prefer not to answer

What is your current occupation?

- Architecture and Engineering Occupations
- Arts, Design, Entertainment, Sports, and Media Occupations
- Sales and Related Occupations
- Business and Financial Operations Occupations
- Building and Grounds Cleaning and Maintenance Occupations
- Management Occupations
- Education, Training, and Library Occupations
- Personal Care and Service Occupations
- Protective Service Occupations
- Computer and Mathematical Occupations
- Life, Physical, and Social Science Occupations
- Production Occupations
- Healthcare Practitioners and Technical Occupations
- Food Preparation and Serving Related Occupations

- Office and Administrative Support Occupations
- Farming, Fishing, and Forestry Occupations
- Installation, Maintenance, and Repair Occupations
- Legal Occupations
- Construction and Extraction Occupations
- Community and Social Service Occupations
- Healthcare Support Occupations
- Transportation and Materials Moving Occupations
- A student
- Retired
- Out of work
- Unable to work
- Prefer not to answer
- Other:

What is your ethnicity?

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or Other Pacific Islander
- White
- Prefer not to answer
- Other:

2. Smartphone proficiency and security awareness

What is the model of your phone?

- iPhone 6
- iPhone 6 Plus
- iPhone 6s
- iPhone 6 Plus
- I have no idea

On average, how many minutes do you spend on your phone each day?

(Enter your answer in "minutes")

On average, how frequently do you unlock your phone?

- Once a day
- A few times a day
- Once per hour
- A few times per hour
- I have no idea

For how long, in total, have you been using a smartphone (not necessarily iPhones)?

- Less than a year

- 1 to 2 years
- 2 to 3 years
- 3 to 4 years
- 4 to 5 years
- Over 5 years

Does your phone store any sensitive or confidential information?

- Yes
- No
- I have no idea

Safari allows you to save your credit card numbers to auto-fill when requested by a website form. Do you know how to change Safari settings to disable this auto-fill feature?

- Yes
- No
- I do not understand this question

A simple passcode is a 4- or 6-digit number. Simple passcode is the default unlock mechanism. Do you know how to enable longer or alphanumeric passcode on your iPhone?

- Yes
- No
- I do not understand this question

Do you know how to turn off an app's access to your camera in the settings?

- Yes
- No
- I do not understand this question

3. Apple Pay usage details

How familiar are you with Apple Pay?

- I have no idea what Apple Pay is and how it works
- I know what Apple Pay is, but don't know how it works
- I know what Apple Pay is, and have some idea as to how Apple Pay works
- I know what Apple Pay is, and have good understanding of how Apple Pay works

Have you set up Apple Pay on your iPhone (i.e., added a debit card or credit card)?

- Yes
- No
- I have no idea

Do you use Apple Pay to pay (tap-and-pay) in stores?

- No, I have never used it
- Yes, I use it
- I was using it in the past but stopped using it

4. Why use or not use Apple Pay?

If you are not using Apple Pay to pay in stores, why do you not use it?

How do you feel about the security of adding debit or credit card information through Passbook?

How do you feel about the security of storing your debit or credit card information on your phone?

How do you feel about the security of using Apple Pay to pay in stores?

How do you feel about the privacy of using Apple Pay to pay in stores?

How do you feel about the usability (convenience, time, ease of use) of adding debit or credit card information through Passbook?

How do you feel about the usability (convenience, time, ease of use) of carrying and accessing debit or credit cards on your phone?

How do you feel about usability (convenience, time, ease of use) of using Apple Pay to pay in stores?

Was Apple Pay an important new feature that influenced your decision to buy a new iPhone? Why or why not?

Do you have suggestions for improving Apple Pay user experience?

Do you have suggestions for improving Apple Pay security?

5. Familiarity with Apple Pay security

How familiar are you with the techniques/mechanisms that Apple Pay use to protect your security and privacy?

- ○ I have no idea how Apple Pay protects my security and privacy
- ○ I'm aware of the mechanisms used by Apple Pay to protect my security and privacy, but don't know how they work
- ○ I'm aware of the mechanisms used by Apple Pay to protect my security and privacy, and have some idea about how they work
- ○ I'm aware of the mechanisms used by Apple Pay to protect my security and privacy, and have good understanding of how they work

Do you understand how Apple Pay protects your tap-and-pay transaction privacy? Explain briefly.

Do you understand how Apple Pay protects your tap-and-pay transaction security? Explain briefly.

Do you understand how Apple Pay protects your debit or credit card details? Explain briefly.

Do you understand how Apple Pay ensures that only you can pay in stores with your phone? Explain briefly.

6. Apple Watch

Do you own an Apple Watch? If no, skip this section.

- Yes
- No

Do you use Apple Pay on your watch to pay in stores?

- No, I have never used it
- Yes, I use it
- I was using it in the past but stopped using it

If you are not using Apple Pay on your watch to pay in stores, why do you not use it?

If you are using Apple Pay on your watch to pay in stores, why do you use it?

If you stopped using Apple Pay on your watch to pay in stores, why did you use it, and why did you stop using it?

Do you understand how Apple Pay works on your watch without Touch ID (fingerprint scanning feature)? Explain briefly.

How do you feel about using Apple Pay on your watch without Touch ID?

Which of the two devices (iPhone or Apple Watch) do you prefer to use to pay in stores? Why?

7. Comparing Apple Pay against traditional credit cards

How do you feel about the security of Apple Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Apple Pay is more secure but don't use it, why do you not use it?

How do you feel about the privacy of Apple Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Apple Pay is more private but don't use it, why do you not use it?

How do you feel about the usability (convenience, time, ease of use) of Apple Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Apple Pay is easier to use, quicker, or is more convenient, but don't use it, why do you not use it?

Which of the two payment methods (Apple Pay and swipe-and-pay with debit or credit cards) do you prefer to use to pay in stores if both payments are available? Why?

Submit

Never submit passwords through Google Forms.

Appendix B: First Study - Android Pay Questionnaire

Edit this form

Mobile payment interview - Android Pay version (OSU)

1. Demographics

What is your age?

- 18 to 24 years
- 25 to 34 years
- 35 to 44 years
- 45 to 54 years
- 55 to 64 years
- Age 65 or older
- Prefer not to answer

What is your gender?

- Female
- Male
- Prefer not to answer

What is the highest level of education you have completed?

- No schooling completed
- Less than high school
- High school / GED
- College / bachelor's degree / associate's degree
- After bachelor's degree / master's degree / professional degree (e.g., MD, LLB) / doctorate degree (PhD)
- Prefer not to answer

What is your current occupation?

- Architecture and Engineering Occupations
- Arts, Design, Entertainment, Sports, and Media Occupations
- Sales and Related Occupations
- Business and Financial Operations Occupations
- Building and Grounds Cleaning and Maintenance Occupations
- Education, Training, and Library Occupations
- Personal Care and Service Occupations
- Protective Service Occupations
- Computer and Mathematical Occupations
- Life, Physical, and Social Science Occupations
- Production Occupations
- Healthcare Practitioners and Technical Occupations
- Food Preparation and Serving Related Occupations
- Office and Administrative Support Occupations

- Farming, Fishing, and Forestry Occupations
- Installation, Maintenance, and Repair Occupations
- Legal Occupations
- Construction and Extraction Occupations
- Community and Social Service Occupations
- Healthcare Support Occupations
- Transportation and Materials Moving Occupations
- A student
- Retired
- Out of work
- Unable to work
- Prefer not to answer
- Other:

What is your ethnicity?

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or Other Pacific Islander
- White
- Prefer not to answer
- Other:

2. Smartphone proficiency and security awareness

What is the model of your phone? (e.g., Samsung Galaxy S5, LG Nexus 4, HTC One, Motorola Moto X)

On average, how many minutes do you spend on your phone each day?

(Enter your answer in "minutes")

On average, how frequently do you unlock your phone?

- Once a day
- A few times a day
- Once per hour
- A few times per hour
- I have no idea

For how long, in total, have you been using a smartphone (not necessarily Android phones)?

- Less than a year
- 1 to 2 years
- 2 to 3 years
- 3 to 4 years
- 4 to 5 years

- Over 5 years

Chrome allows you to save your credit card numbers to auto-fill when requested by a website form. Do you know how to change Chrome settings to disable this auto-fill feature?

- Yes
- No
- I do not understand this question

Do you know how to change the screen lock option to "alpha-numeric password" in the settings?

- Yes
- No
- I do not understand this question

Do you know how to view app permissions after installation?

- Yes
- No
- I do not understand this question

3. Android Pay usage details

How familiar are you with Android Pay?

- I have no idea what Android Pay is and how it works
- I know what Android Pay is, but don't know how it works
- I know what Android Pay is, but don't know how it works
- I know what Android Pay is, and have good understanding of how Android Pay works

Have you set up "tap and pay" on Android Pay?

- Yes
- No
- I have no idea

Do you use Android Pay to pay (tap-and-pay) in stores?

- No, I have never used it
- Yes, I use it
- I was using it in the past but stopped using it

How frequently do you use Android Pay to pay in stores on average?

How long have you been using Android Pay to pay in stores?

What are the most common places where you used Android Pay to pay?

How many debit or credit cards do you own in total?

How many of those cards have you added to Android Pay?

How many of those cards have you actually used to pay in stores using Android Pay?

4. Why use or not use Android Pay?

If you are not using Android Pay to pay in stores, why do you not use it?

If you are using Android Pay to pay in stores, why do you use it?

If you stopped using Android Pay to pay in stores, why did you use it, and why did you stop using it?

How do you feel about the security of adding debit or credit card information through Android Pay?

How do you feel about the security of storing your debit or credit card information on your phone?

How do you feel about the security of using Android Pay to pay in stores?

How do you feel about the privacy of using Android Pay to pay in stores?

How do you feel about the usability (convenience, time, ease of use) of adding debit or credit card information through Android Pay?

How do you feel about the usability (convenience, time, ease of use) of carrying and accessing debit or credit cards on your phone?

How do you feel about usability (convenience, time, ease of use) of using Android Pay to pay in stores?

Was Android Pay an important new feature that influenced your decision to buy your phone? Why or why not?

Do you have suggestions for improving Android Pay user experience?

Do you have suggestions for improving Android Pay security?

5. Familiarity with Android Pay security

How familiar are you with the techniques/mechanisms that Android Pay use to protect your security and privacy?

- I have no idea how Android Pay protects my security and privacy
- I'm aware of the mechanisms used by Android Pay to protect my security and privacy, but don't know how they work
- I'm aware of the mechanisms used by Android Pay to protect my security and privacy, and have some idea about how they work
- I'm aware of the mechanisms used by Android Pay to protect my security and privacy, and have good understanding of how they work

Do you understand how Android Pay protects your tap-and-pay transaction privacy? Explain briefly.

Do you understand how Android Pay protects your tap-and-pay transaction security? Explain briefly.

Do you understand how Android Pay protects your credit and debit card details? Explain briefly.

Do you understand how Android Pay ensures that only you can pay in stores with your phone? Explain briefly.

7. Comparing Android Pay against traditional credit cards

How do you feel about the security of Android Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Android Pay is less secure but still use it, why do you use it?

If you feel Android Pay is more secure but stopped using it, why did you stop using it?

How do you feel about the privacy of Android Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Android Pay is less private but still use it, why do you use it?

If you feel Android Pay is more private but stopped using it, why did you stop using it?

How do you feel about the usability (convenience, time, ease of use) of Android Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Android Pay is harder to use, takes longer, or is less convenient, but still use it, why do you use it?

If you feel Android Pay is easier to use, quicker, or is more convenient, but stopped using it, why did you stop using it?

Which of the two payment methods (Android Pay and swipe-and-pay with debit or credit cards) do you prefer to use to pay in stores? Why?

Submit

Never submit passwords through Google Forms.

Edit this form

Mobile payment interview - Android Pay nonuser version (OSU)

1. Demographics

What is your age?

- 18 to 24 years
- 25 to 34 years
- 35 to 44 years
- 45 to 54 years
- 55 to 64 years
- Age 65 or older
- Prefer not to answer

What is your gender?

- Female
- Male
- Prefer not to answer

What is the highest level of education you have completed?

- No schooling completed
- Less than high school
- High school / GED
- College / bachelor's degree / associate's degree
- After bachelor's degree / master's degree / professional degree (e.g., MD, LLB) / doctorate degree (PhD)
- Prefer not to answer

What is your current occupation?

- Architecture and Engineering Occupations
- Arts, Design, Entertainment, Sports, and Media Occupations
- Sales and Related Occupations
- Business and Financial Operations Occupations
- Building and Grounds Cleaning and Maintenance Occupations
- Education, Training, and Library Occupations
- Personal Care and Service Occupations
- Protective Service Occupations
- Computer and Mathematical Occupations
- Life, Physical, and Social Science Occupations
- Production Occupations
- Healthcare Practitioners and Technical Occupations
- Food Preparation and Serving Related Occupations
- Office and Administrative Support Occupations

- Farming, Fishing, and Forestry Occupations
- Installation, Maintenance, and Repair Occupations
- Legal Occupations
- Construction and Extraction Occupations
- Community and Social Service Occupations
- Healthcare Support Occupations
- Transportation and Materials Moving Occupations
- A student
- Retired
- Out of work
- Unable to work
- Prefer not to answer
- Other:

What is your ethnicity?

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or Other Pacific Islander
- White
- Prefer not to answer
- Other:

2. Smartphone proficiency and security awareness

What is the model of your phone? (e.g., Samsung Galaxy S5, LG Nexus 4, HTC One, Motorola Moto X)

On average, how many minutes do you spend on your phone each day?

(Enter your answer in "minutes")

On average, how frequently do you unlock your phone?

- Once a day
- A few times a day
- Once per hour
- A few times per hour
- I have no idea

For how long, in total, have you been using a smartphone (not necessarily Android phones)?

- Less than a year
- 1 to 2 years
- 2 to 3 years
- 3 to 4 years
- 4 to 5 years

- Over 5 years

Chrome allows you to save your credit card numbers to auto-fill when requested by a website form. Do you know how to change Chrome settings to disable this auto-fill feature?

- Yes
- No
- I do not understand this question

Do you know how to change the screen lock option to "alpha-numeric password" in the settings?

- Yes
- No
- I do not understand this quetion

Do you know how to view app permissions after installation?

- Yes
- No
- I do not understand this question

3. Android Pay usage details

How familiar are you with Android Pay?

- I have no idea what Android Pay is and how it works
- I know what Android Pay is, but don't know how it works
- I know what Android Pay is, but don't know how it works
- I know what Android Pay is, and have good understanding of how Android Pay works

Have you set up "tap and pay" on Android Pay?

- Yes
- No
- I have no idea

4. Why use or not use Android Pay?

If you are not using Android Pay to pay in stores, why do you not use it?

How do you feel about the security of adding debit or credit card information through Android Pay?

How do you feel about the security of storing your debit or credit card information on your phone?

How do you feel about the security of using Android Pay to pay in stores?

How do you feel about the privacy of using Android Pay to pay in stores?

How do you feel about the usability (convenience, time, ease of use) of adding debit or credit card information through Android Pay?

How do you feel about the usability (convenience, time, ease of use) of carrying and accessing debit or credit cards on your phone?

How do you feel about usability (convenience, time, ease of use) of using Android Pay to pay in stores?

Was Android Pay an important new feature that influenced your decision to buy your phone? Why or why not?

Do you have suggestions for improving Android Pay user experience?

Do you have suggestions for improving Android Pay security?

5. Familiarity with Android Pay security

How familiar are you with the techniques/mechanisms that Android Pay use to protect your security and privacy?

- I have no idea how Android Pay protects my security and privacy
- I'm aware of the mechanisms used by Android Pay to protect my security and privacy, but don't know how they work
- I'm aware of the mechanisms used by Android Pay to protect my security and privacy, and have some idea about how they work
- I'm aware of the mechanisms used by Android Pay to protect my security and privacy, and have good understanding of how they work

Do you understand how Android Pay protects your tap-and-pay transaction privacy? Explain briefly.

Do you understand how Android Pay protects your tap-and-pay transaction security? Explain briefly.

Do you understand how Android Pay protects your credit and debit card details? Explain briefly.

Do you understand how Android Pay ensures that only you can pay in stores with your phone? Explain briefly.

7. Comparing Android Pay against traditional credit cards

How do you feel about the security of Android Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Android Pay is more secure but don't use it, why do you not use it?

How do you feel about the privacy of Android Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Android Pay is more private but don't use it, why do you not use it?

How do you feel about the usability (convenience, time, ease of use) of Android Pay tap-and-pay compared to traditional swipe-and-pay debit or credit card purchases?

If you feel Android Pay is easier to use, quicker, or is more convenient, but don't use it, why do you not use it?

Which of the two payment methods (Android Pay and swipe-and-pay with debit or credit cards) do you prefer to use to pay in stores? Why?

Submit

Never submit passwords through Google Forms.

Appendix C: Second Study - Apple Pay Questionnaire

Apple Pay User Experience Survey

*Required

1. Demographics

Enter the survey-code given to you from the previous page *
(We will use this number to track your participation)

What is your age?

What is your gender?

- Female
- Male
- Prefer not to answer

What is the highest level of education you have completed?

- No schooling completed
- Less than high school
- High school / GED
- College / bachelor's degree / associate's degree
- After bachelor's degree / master's degree / professional degree (e.g., MD, LLB) / doctorate degree (PhD)
- Prefer not to answer
- Other:

What is your current occupation?

- Architecture and Engineering Occupations
- Arts, Design, Entertainment, Sports, and Media Occupations
- Sales and Related Occupations
- Business and Financial Operations Occupations
- Building and Grounds Cleaning and Maintenance Occupations
- Management Occupations
- Education, Training, and Library Occupations
- Personal Care and Service Occupations
- Protective Service Occupations
- Computer and Mathematical Occupations
- Life, Physical, and Social Science Occupations
- Production Occupations
- Healthcare Practitioners and Technical Occupations
- Food Preparation and Serving Related Occupations
- Office and Administrative Support Occupations
- Farming, Fishing, and Forestry Occupations
- Installation, Maintenance, and Repair Occupations

- Legal Occupations
- Construction and Extraction Occupations
- Community and Social Service Occupations
- Healthcare Support Occupations
- Transportation and Materials Moving Occupations
- A student
- Retired
- Out of work
- Unable to work
- Prefer not to answer
- Other:

What is your ethnicity?

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or Other Pacific Islander
- White
- Prefer not to answer
- Other:

Continue »

6% completed

Apple Pay User Experience Survey

*Required

2. Smartphone proficiency and security awareness

What is the model of your phone? *

- ○ iPhone 6
- ○ iPhone 6 Plus
- ○ iPhone 6s
- ○ iPhone 6s Plus
- ○ I have no idea
- ○ Other:

On average, how many minutes do you spend on your phone each day?
(Enter your answer in "minutes")

On average, how frequently do you unlock your phone?

- ○ Once a day
- ○ A few times a day
- ○ Once per hour
- ○ A few times per hour
- ○ I have no idea

For how long, in total, have you been using a smartphone (not necessarily iPhones)?

- ○ Less than a year
- ○ 1 to 2 years
- ○ 2 to 3 years
- ○ 3 to 4 years
- ○ 4 to 5 years
- ○ Over 5 years
- ○ Other:

On your iPhone, Safari allows you to save your credit card numbers to auto-fill when requested by a website form. Do you know how to change Safari settings to disable this auto-fill feature?

- ○ Yes
- ○ No
- ○ I do not understand this question

A simple passcode is a 4- or 6-digit number. Simple passcode is the default unlock mechanism. Do you know how to enable longer or alphanumeric passcode on your iPhone?

- ○ Yes
- ○ No
- ○ I do not understand this question

Do you know how to turn off an app's access to your camera in the settings?

- Yes
- No
- I do not understand this question

« Back Continue »

13% completed

Apple Pay User Experience Survey

3. Apple Pay familiarity

How familiar are you with Apple Pay?

- I have no idea what Apple Pay is and how it works
- I know what Apple Pay is, but don't know how it works
- I know what Apple Pay is, and have some idea as to how Apple Pay works
- I know what Apple Pay is, and have good understanding of how Apple Pay works

Have you set up Apple Pay on your iPhone (i.e., added a debit card or credit card)?

- Yes
- No
- I have no idea

Do you use Apple Pay to pay (tap-and-pay) in stores?

- No, I have never used it
- Yes, I use it
- I was using it in the past but stopped using it

« Back Continue »

20% completed

Apple Pay User Experience Survey

5. Why do you use Apple Pay?

If you are using Apple Pay to pay in stores, why do you use it? Rank the options below in order of importance from 1 to 8, 1 being the most important reason.

(If there is no "Other" reason, leave its ranking as blank. *Private* means limiting access others, including Apple, may have on your card details and payment transaction information)

	1 (most important)	2	3	4	5	6	7	8 (least important)
It is more reliable than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It is more secure than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It is more *private* than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It is more convenient than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
I'm curious about a new technology	○	○	○	○	○	○	○	○
It is fun to use	○	○	○	○	○	○	○	○
It is faster than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
Other reason (specify below)	○	○	○	○	○	○	○	○

If you had "Other" reason and ranked it in the previous question, please specify what that reason is:

« Back Continue »

33% completed

Apple Pay User Experience Survey

4. Why do you not use Apple Pay?

If you are not using Apple Pay to pay in stores, why do you not use it? Rank the options below in order of importance from 1 to 8, 1 being the most important reason

(If there is no "Other" reason, leave its ranking as blank. *Private* means limiting access others, including Apple, may have on your card details and payment transaction information)

	1 (most important)	2	3	4	5	6	7	8 (least important)
It is less secure than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
I just forgot to use it	○	○	○	○	○	○	○	○
Other reason (specify below)	○	○	○	○	○	○	○	○
I'm not an early adopter	○	○	○	○	○	○	○	○
It is slower than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It is less convenient than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
Not many stores support Apple Pay	○	○	○	○	○	○	○	○
It is less *private* than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○

If you had "Other" reason and ranked it in the previous question, please specify what that reason is:

« Back Continue »

26% completed

Apple Pay User Experience Survey

6. Why did you stop using Apple Pay?

If you stopped using Apple Pay to pay in stores, why did you stop using it? Rank the options below in order of importance from 1 to 8, 1 being the most important reason.

(If there is no "Other" reason, leave its ranking as blank. *Private* means limiting access others, including Apple, may have on your card details and payment transaction information)

	1 (most important)	2	3	4	5	6	7	8 (least important)
Not many stores support Apple Pay	○	○	○	○	○	○	○	○
It was less *private* than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It was slower than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
Due to my habit of using cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It was less secure than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It was less convenient than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
I just forgot to use it	○	○	○	○	○	○	○	○
Other reason (specify below)	○	○	○	○	○	○	○	○

If you had "Other" reason and ranked it in the previous question, please specify what that reason is:

« Back Continue »

40% completed

Apple Pay User Experience Survey

7. Apple Pay usage details

How frequently do you use Apple Pay to pay in stores on average?

- ○ Once a month
- ○ Several times a month but less than once a week
- ○ Once a week
- ○ Several times a week but less than once a day
- ○ Once a day
- ○ Several times a day
- ○ Other:

How long have you been using Apple Pay to pay in stores?

- ○ A few days
- ○ A few weeks
- ○ A few months
- ○ Started using it soon after it first came out (about a year)

What are the most common places where you use Apple Pay to pay? (Check all that apply)

- ☐ Grocery stores (e.g., Whole Foods)
- ☐ Fast food chains (e.g., McDonalds, Subway)
- ☐ Drug stores (e.g., Walgreens)
- ☐ Retail stores (e.g., Target, Best Buy)
- ☐ Other:

How many debit cards and credit cards do you own in total?
(Provide a single number)

How many of those cards have you added to Apple Pay?
(Provide a single number)

How many of those cards have you actually used to pay in stores using Apple Pay?
(Provide a single number)

« Back Continue »

46% completed

Apple Pay User Experience Survey

8. Your feelings toward Apple Pay

Please read the following statements about your feelings toward Apple Pay security and privacy, and tell us whether you agree or disagree.

(Apple Pay *privacy* means how Apple Pay limits access others, including Apple, may have to your card details and payment transaction information)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I feel that carrying and accessing debit or credit card on my phone is insecure	○	○	○	○	○
I feel that using Apple Pay to pay in stores is insecure	○	○	○	○	○
I feel that using Apple Pay to pay in stores is not *private*	○	○	○	○	○
I feel that adding debit or credit card information through the Wallet app is insecure	○	○	○	○	○

Please read the following statements about your feelings toward Apple Pay usability, and tell us whether you agree or disagree.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I feel that carrying and accessing debit or credit card on my phone is inconvenient	○	○	○	○	○
I feel that carrying and accessing debit or credit card on my phone is slow	○	○	○	○	○
I feel that using Apple Pay to pay in stores is slow	○	○	○	○	○
I feel that adding debit or credit card information through the Wallet app is slow	○	○	○	○	○
I feel that using Apple Pay to pay in stores is inconvenient	○	○	○	○	○

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I feel that adding debit or credit card information through the Wallet app is inconvenient	○	○	○	○	○

Please read the following statement about your feelings toward using Apple Pay compared to traditional debit or credit cards, and tell us whether you agree or disagree.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I feel that using Apple Pay to pay in stores is less secure than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○
I feel that using Apple Pay to pay in stores is less *private* than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○
I feel that using Apple Pay to pay in stores is more secure than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○
I feel that using Apple Pay to pay in stores is slower than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○
I feel that using Apple Pay to pay in stores is less convenient than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○

Which of the two payment methods, Apple Pay and traditional debit or credit cards, do you prefer to use to pay in stores if both payment methods are available?

- ○ Swipe-and-pay with traditional debit or credit cards
- ○ Apple Pay
- ○ I don't have a preference

If you feel that using Apple Pay to pay in stores is inconvenient, why do you feel this way?

(Skip this question if you feel using Apple Pay to pay in stores is convenient)

If you feel that using Apple Pay to pay in stores is slow, why do you feel this way?
(Skip this question if you feel using Apple Pay to pay in stores is fast)

How important was Apple Pay in influencing your decision to get a new iPhone?

- Very unimportant
- Unimportant
- Somewhat unimportant
- Neutral
- Somewhat important
- Important
- Very important

« Back Continue »

53% completed

Apple Pay User Experience Survey

9. Familiarity with Apple Pay security

How familiar are you with the techniques/mechanisms that Apple Pay use to protect your security and privacy?

(Apple Pay *privacy* means how Apple Pay limits access others, including Apple, may have to your card details and payment transaction information)

- I have no idea how Apple Pay protects my security and *privacy*
- I'm aware of the mechanisms used by Apple Pay to protect my security and *privacy*, but don't know how they work
- I'm aware of the mechanisms used by Apple Pay to protect my security and *privacy*, and have some idea about how they work
- I'm aware of the mechanisms used by Apple Pay to protect my security and *privacy*, and have good understanding of how they work

What is the security mechanism that protects your tap-and-pay transaction privacy?

(Protecting privacy means limiting access others, including Apple, may have to your card details and payment transaction information)

- Fingerprint-based authentication (Touch ID)
- I do not understand how to answer the question
- There is no right answer to choose from
- One time unique number and transaction-specific dynamic security code
- Secure Element chip
- I do not understand the question

What is the security mechanism that is used to securely store and protect your credit or debit card details?

- One time unique number and transaction-specific dynamic security code
- There is no right answer to choose from
- Secure Element chip
- I do not understand the question
- I do not understand how to answer the question
- Fingerprint-based authentication (Touch ID)

What is the security mechanism that ensures only you can use the cards stored on your iPhone to pay in stores?

- Fingerprint-based authentication (Touch ID)
- I do not understand the question
- One time unique number and transaction-specific dynamic security code
- There is no right answer to choose from
- Secure Element chip
- I do not understand how to answer the question

« Back Continue »

60% completed

Apple Pay User Experience Survey

10. Apple Watch ownership

Do you own an Apple Watch?

- (●) Yes
- ( ) No

« Back Continue »

66% completed

Apple Pay User Experience Survey

11. Apple Pay usage on Apple Watch

Have you used Apple Pay on your watch to pay in stores?

- ○ No, I have never used it
- ○ Yes, I use it
- ○ I was using it in the past but stopped using it

« Back Continue »

73% completed

Apple Pay User Experience Survey

13. Why do you use Apple Pay on your watch?

If you are using Apple Pay on your watch to pay in stores, why do you use it? Rank the options below in order of importance from 1 to 8, 1 being the most important reason.

(If there is no "Other" reason, leave its ranking as blank. *Private* means limiting access others, including Apple, may have on your card details and payment transaction information))

	1 (most important)	2	3	4	5	6	7	8 (least important)
Other reason (specify below)	○	○	○	○	○	○	○	○
It is fun to use	○	○	○	○	○	○	○	○
It is more *private* than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
It is more reliable than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
It is more convenient than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
It is faster than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
I'm curious about a new technology	○	○	○	○	○	○	○	○
It is more secure than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○

If you had "Other" reason and ranked it in the previous question, please specify what that reason is:

« Back Continue »

86% completed

Apple Pay User Experience Survey

12. Why do you not use Apple Pay on your watch?

If you are not using Apple Pay on your watch to pay in stores, but you are using Apple Pay on your iPhone, why do you not use it on your watch? Rank the options below in order of importance from 1 to 8, 1 being the most important reason

(If there is no "Other" reason, leave its ranking as blank. Skip this question if you don't use Apple Pay on both your iPhone and watch. *Private* means limiting access others, including Apple, may have on your card details and payment transaction information))

	1 (most important)	2	3	4	5	6	7	8 (least important)
I just forgot to use it	○	○	○	○	○	○	○	○
I'm not an early adopter	○	○	○	○	○	○	○	○
Not many stores support Apple Pay	○	○	○	○	○	○	○	○
Other reason (specify below)	○	○	○	○	○	○	○	○
It is less secure than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
It is less *private* than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
It is less convenient than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
It is slower than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○

If you had "Other" reason and ranked it in the previous question, please specify what that reason is:

« Back Continue »

80% completed

Apple Pay User Experience Survey

14. Why did you stop using Apple Pay on your watch?

If you stopped using Apple Pay on your watch to pay in stores, but continue to use it on your iPhone, why did you stop using it? Rank the options below in order of importance from 1 to 8, 1 being the most important reason.

(If there is no "Other" reason, leave its ranking as blank. Skip this question if you stopped using Apple Pay on both your watch and iPhone. *Private* means limiting access others, including Apple, may have on your card details and payment transaction information))

	1 (most important)	2	3	4	5	6	7	8 (least important)
Due to my habit of using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
It was less *private* than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
Not many stores support Apple Pay	○	○	○	○	○	○	○	○
It was slower than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
It was less convenient than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
Other reason (specify below)	○	○	○	○	○	○	○	○
It was less secure than using Apple Pay on iPhone to pay in stores	○	○	○	○	○	○	○	○
I just forgot to use it	○	○	○	○	○	○	○	○

If you had "Other" reason and ranked it in the previous question, please specify what that reason is:

« Back Continue »

93% completed

Apple Pay User Experience Survey

15. Your feelings toward using Apple Pay on your Apple Watch

How does Apple Watch ensure that only you can use your watch to pay in stores?

- ○ Apple Watch does not check my identity
- ○ A passcode needs to be entered when you put your Apple Watch on your wrist
- ○ I do not understand the question
- ○ Fingerprint-based authentication (Touch ID)
- ○ I do not understand how to answer the question
- ○ There is no right answer to choose from

Please read the following statement about your feelings toward using Apple Pay on your watch, and tell us whether you agree or disagree.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I feel that using Apple Pay on my watch is slower than using it on my iPhone	○	○	○	○	○
I feel that using Apple Pay on my watch is more secure than using it on my iPhone	○	○	○	○	○
I feel that using Apple Pay on my watch is less convenient than using it on my iPhone	○	○	○	○	○

Which of the two devices (iPhone or Apple Watch) do you prefer to use to pay in stores?

- ○ Apple Watch
- ○ iPhone
- ○ I don't have a preference

« Back Submit

100%: You made it.

Never submit passwords through Google Forms.

Appendix D: Second Study - Android Pay Questionnaire

Request edit access

Android Pay User Experience Survey

*Required

1. Demographics

Enter the survey-code shown above *
(We will use this number to track your participation)

What is your age?

What is your gender?

- Female
- Male
- Prefer not to answer

What is the highest level of education you have completed?

- No schooling completed
- Less than high school
- High school / GED
- College / bachelor's degree / associate's degree
- After bachelor's degree / master's degree / professional degree (e.g., MD, LLB) / doctorate degree (PhD)
- Prefer not to answer
- Other:

What is your current occupation?

- Architecture and Engineering Occupations
- Arts, Design, Entertainment, Sports, and Media Occupations
- Sales and Related Occupations
- Business and Financial Operations Occupations
- Building and Grounds Cleaning and Maintenance Occupations
- Management Occupations
- Education, Training, and Library Occupations
- Personal Care and Service Occupations
- Protective Service Occupations
- Computer and Mathematical Occupations
- Life, Physical, and Social Science Occupations
- Production Occupations
- Healthcare Practitioners and Technical Occupations
- Food Preparation and Serving Related Occupations
- Office and Administrative Support Occupations
- Farming, Fishing, and Forestry Occupations
- Installation, Maintenance, and Repair Occupations

- Legal Occupations
- Construction and Extraction Occupations
- Community and Social Service Occupations
- Healthcare Support Occupations
- Transportation and Materials Moving Occupations
- A student
- Retired
- Out of work
- Unable to work
- Prefer not to answer
- Other:

What is your ethnicity?

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or Other Pacific Islander
- White
- Prefer not to answer
- Other:

Continue »

11% completed

Android Pay User Experience Survey

*Required

2. Smartphone proficiency and security awareness

What is the model of your phone? *
(e.g., Samsung Galaxy S6, LG Nexus 5, HTC One, Motorola Moto X. If you don't know the model, write "I have no idea")

What is the model number of your phone (e.g., "D821" for LG Nexus 5) ? *
To find the model number, (1) Open the "Settings" app, (2) If your Settings menu has multiple tabs, select the "General" tab first, (3) Scroll down and select "About phone/About device," (4) Look for the "model number" entry.

On average, how many minutes do you spend on your phone each day?
(Enter your answer in "minutes")

On average, how frequently do you unlock your phone?

- Once a day
- A few times a day
- Once per hour
- A few times per hour
- I have no idea

For how long, in total, have you been using a smartphone (not necessarily your current phone)?

- Less than a year
- 1 to 2 years
- 2 to 3 years
- 3 to 4 years
- 4 to 5 years
- Over 5 years
- Other:

Chrome browser on your phone allows you to save your credit card numbers to auto-fill when requested by a website form. Do you know how to change Chrome settings to disable this auto-fill feature?

- Yes
- No
- I do not understand this question

Screen lock pattern is the lines you draw on the 3 by 3 grid (shown on the unlock screen) to connect dots. Screen lock pattern is the default unlock mechanism on Android. Do you know how to change the screen lock option to "alpha-numeric password" in the settings?

- Yes
- No

I do not understand this question

Do you know how to view app permissions after installation?

- Yes
- No
- I do not understand this question

« Back Continue »

22% completed

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Android Pay User Experience Survey

3. Android Pay familiarity

How familiar are you with Android Pay?

- I have no idea what Android Pay is and how it works
- I know what Android Pay is, but don't know how it works
- I know what Android Pay is, and have some idea as to how Android Pay works
- I know what Android Pay is, and have good understanding of how Android Pay works

Have you set up Android Pay on your phone (i.e., added a debit card or credit card)?

- Yes
- No
- I have no idea

Do you use Android Pay to pay (tap-and-pay) in stores?

- No, I have never used it
- Yes, I use it
- I was using it in the past but stopped using it

« Back Continue »

33% completed

Android Pay User Experience Survey

5. Why do you use Android Pay?

If you are using Android Pay to pay in stores, why do you use it? Rank the options below in order of importance from 1 to 8, 1 being the most important reason.

(If there is no "Other" reason, leave its ranking as blank. *Private* means limiting access others, including Google, may have on your card details and payment transaction information)

	1 (most important)	2	3	4	5	6	7	8 (least important)
It is more *private* than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It is fun to use	○	○	○	○	○	○	○	○
It is more reliable than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
Other reason (specify below)	○	○	○	○	○	○	○	○
It is more secure than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It is faster than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
I'm curious about a new technology	○	○	○	○	○	○	○	○
It is more convenient than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○

If you had "Other" reason and ranked it in the previous question, please specify what that reason is:

« Back Continue »

55% completed

Android Pay User Experience Survey

4. Why do you not use Android Pay?

If you are not using Android Pay to pay in stores, why do you not use it? Rank the options below in order of importance from 1 to 8, 1 being the most important reason

(If there is no "Other" reason, leave its ranking as blank. *Private* means limiting access others, including Google, may have on your card details and payment transaction information)

	1 (most important)	2	3	4	5	6	7	8 (least important)
Not many stores support Android Pay	○	○	○	○	○	○	○	○
It is less *private* than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
I'm not an early adopter	○	○	○	○	○	○	○	○
It is less convenient than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It is slower than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
Other reason (specify below)	○	○	○	○	○	○	○	○
I just forgot to use it	○	○	○	○	○	○	○	○
It is less secure than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○

If you had "Other" reason and ranked it in the previous question, please specify what that reason is:

« Back Continue »

44% completed

Android Pay User Experience Survey

6. Why did you stop using Android Pay?

If you stopped using Android Pay to pay in stores, why did you stop using it? Rank the options below in order of importance from 1 to 8, 1 being the most important reason.

(If there is no "Other" reason, leave its ranking as blank. *Private* means limiting access others, including Google, may have on your card details and payment transaction information)

	1 (most important)	2	3	4	5	6	7	8 (least important)
It was less *private* than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It was slower than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
It was less convenient than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
I just forgot to use it	○	○	○	○	○	○	○	○
Not many stores support Android Pay	○	○	○	○	○	○	○	○
It was less secure than using debit or credit cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○
Other reason (specify below)	○	○	○	○	○	○	○	○
Due to my habit of using cards to swipe-and-pay in stores	○	○	○	○	○	○	○	○

If you had "Other" reason and ranked it in the previous question, please specify what that reason is:

« Back Continue »

66% completed

Android Pay User Experience Survey

7. Android Pay usage details

How frequently do you use Android Pay to pay in stores on average?

- ○ Once a month
- ○ Several times a month but less than once a week
- ○ Once a week
- ○ Several times a week but less than once a day
- ○ Once a day
- ○ Several times a day
- ○ Other:

How long have you been using Android Pay to pay in stores?

- ○ A few days
- ○ A few weeks
- ○ A few months
- ○ Started using it soon after it first came out (about a year)

What are the most common places where you use Android Pay to pay? (Check all that apply)

- ☐ Grocery stores (e.g., Whole Foods)
- ☐ Fast food chains (e.g., McDonalds, Subway)
- ☐ Drug stores (e.g., Walgreens)
- ☐ Retail stores (e.g., Target, Best Buy)
- ☐ Other:

How many debit cards and credit cards do you own in total?
(Provide a single number)

How many of those cards have you added to Android Pay?
(Provide a single number)

How many of those cards have you actually used to pay in stores using Android Pay?
(Provide a single number)

« Back Continue »

77% completed

Android Pay User Experience Survey

8. Your feelings toward Android Pay

Please read the following statements about your feelings toward Android Pay security and privacy, and tell us whether you agree or disagree.

(Android Pay *privacy* means how Android Pay limits access others, including Google, may have to your card details and payment transaction information)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I feel that using Android Pay to pay in stores is insecure	○	○	○	○	○
I feel that carrying and accessing debit or credit card on my phone is insecure	○	○	○	○	○
I feel that using Android Pay to pay in stores is not *private*	○	○	○	○	○
I feel that adding debit or credit card information through the Android Pay app is insecure	○	○	○	○	○

Please read the following statements about your feelings toward Android Pay usability, and tell us whether you agree or disagree.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I feel that adding debit or credit card information through the Android Pay app is slow	○	○	○	○	○
I feel that adding debit or credit card information through the Android Pay app is inconvenient	○	○	○	○	○
I feel that carrying and accessing debit or credit card on my phone is slow	○	○	○	○	○
I feel that carrying and accessing debit or credit card on my phone is inconvenient	○	○	○	○	○

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I feel that using Android Pay to pay in stores is inconvenient	○	○	○	○	○
I feel that using Android Pay to pay in stores is slow	○	○	○	○	○

Please read the following statement about your feelings toward using Android Pay compared to traditional debit or credit cards, and tell us whether you agree or disagree.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I feel that using Android Pay to pay in stores is less *private* than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○
I feel that using Android Pay to pay in stores is slower than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○
I feel that using Android Pay to pay in stores is less secure than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○
I feel that using Android Pay to pay in stores is less convenient than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○
I feel that using Android Pay to pay in stores is more secure than using traditional debit or credit cards to swipe-and-pay in stores	○	○	○	○	○

Which of the two payment methods, Android Pay and traditional debit or credit cards, do you prefer to use to pay in stores if both payment methods are available?

- ○ Swipe-and-pay with traditional debit or credit cards
- ○ Android Pay
- ○ I don't have a preference

If you feel that using Android Pay to pay in stores is inconvenient, why do you feel this way?

(Skip this question if you feel using Android Pay to pay in stores is convenient)

If you feel that using Android Pay to pay in stores is slow, why do you feel this way?
(Skip this question if you feel using Android Pay to pay in stores is fast)

How important was Android Pay in influencing your decision to get a new phone?

- Very unimportant
- Unimportant
- Somewhat unimportant
- Neutral
- Somewhat important
- Important
- Very important

« Back Continue »

88% completed

Android Pay User Experience Survey

9. Familiarity with Android Pay security

How familiar are you with the techniques/mechanisms that Android Pay use to protect your security and privacy?

(Android Pay *privacy* means how Android Pay limits access others, including Google, may have to your card details and payment transaction information)

- I have no idea how Android Pay protects my security and *privacy*
- I'm aware of the mechanisms used by Android Pay to protect my security and *privacy*, but don't know how they work
- I'm aware of the mechanisms used by Android Pay to protect my security and *privacy*, and have some idea about how they work
- I'm aware of the mechanisms used by Android Pay to protect my security and *privacy*, and have good understanding of how they work

What is the security mechanism that protects your tap-and-pay transaction privacy?

(Protecting privacy means limiting access others, including Google, may have to your card details and payment transaction information)

- I do not understand the question
- There is no right answer to choose from
- Screen unlock patterns, passwords, PINs, or face unlocks
- I do not understand how to answer the question
- One time unique number and transaction-specific dynamic security code (tokenization)
- Cloud security and Host Card Emulation

What is the security mechanism that is used to securely store and protect your credit or debit card details?

- I do not understand how to answer the question
- One time unique number and transaction-specific dynamic security code (tokenization)
- Cloud security and Host Card Emulation
- Screen unlock patterns, passwords, PINs, or face unlocks
- There is no right answer to choose from
- I do not understand the question

What is the security mechanism that ensures only you can use the cards stored on your phone to pay in stores?

- There is no right answer to choose from
- Screen unlock patterns, passwords, PINs, or face unlocks
- Cloud security and Host Card Emulation
- One time unique number and transaction-specific dynamic security code (tokenization)
- I do not understand how to answer the question
- I do not understand the question

« Back Submit

100%: You made it.

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