

Teens Engage More with Fewer Photos: Temporal and Comparative Analysis on Behaviors in Instagram

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ABSTRACT

Research has suggested that teens are more active and engaged than adults on social media. Most of such observations, however, have been made through the analysis of limited ethnographic or cross-sectional data. Using a temporally extended, large-scale dataset and comparative analyses to remedy this shortcoming, in this paper, we examined how and why the age difference in the behaviors of users in Instagram might have occurred through the lenses of social cognition, developmental psychology, and human-computer interaction. We proposed two hypotheses — *teens as digital natives* and *the need for social interactions* — as the theoretical framework for understanding the factors that help explain the behavioral differences. Our computational analysis identified the following novel findings: (1) teens post fewer photos than adults; (2) teens remove more photos based on the number of Likes that the photos received; and (3) teens have less diverse photo content. Our analysis was also able to confirm prior ethnographic accounts that teens are more engaged in Liking and commenting, and express their emotions and social interests more than adults. We discussed theoretical and practical interpretations and implications as well as future research directions from the results. Our datasets are available at: <https://goo.gl/LqTYNv>

CCS Concepts

Human-centered computing → Collaborative and social computing → Social media

Keywords

Teens; age difference; comparative analysis; Instagram.

1. INTRODUCTION

Social media has been widely adopted in people’s daily lives, especially through the help of mobile devices, allowing them to access, create, and interact with a wide range of information. In particular, teens are known to be highly engaged in social media [1][15]. According to Pew Research reports, 73 percent of all American teens now use a smartphone, 81 percent of them use social media, and 92 percent of them are online daily with their smartphone [11][24][27]. Most noteworthy is the phenomenon that teens and young adults appear to be early adopters — and arguably the most active users — of social media [8]. For them, social media has become a new channel and a new way of representing themselves [31] to share their everyday activities and

thoughts with friends [12] to establish and maintain social connections and networks [30], and to learn something new and useful [19].

Research has studied several factors that drive such uses of social media by teens. On the one hand, being acclaimed as the “digital natives” [37], teens grow up with an abundance of communication technology and are believed to be more technologically-savvy than adults. On the other hand, from a developmental perspective, teens may consider social media as an exciting opportunity for social interaction space [19] and self-display [25], while adults may be more concerned about their information privacy in online disclosure. Given that socialization is an especially influential process in childhood and adolescence, interaction with their peers through social media plays an important role in teens’ life and has a significant impact on teens’ self-esteem and psychological well-being [45]. Their social media use is driven by their needs — they would stay active online to build and maintain connections with their peers through online interactions.

However, both the assumption of teens being active users in social media and the rationale behind this assumption have not been sufficiently studied and validated through their actual use of social media. First, despite the growing body of work that examines teens’ online behaviors and technology use, little effort has been put into directly comparing teens’ and adults’ social media use and activities. Thus, it is difficult to determine if teens’ actual use of social media is unique compared to other age groups. Second, existing studies of social media use have been mostly limited to ethnographic accounts (e.g., interviews, focus groups, etc.) or self-reported survey studies, while empirical investigation of large-scale user data is lacking. The latter is particularly useful for developing an understanding of behavioral patterns of teens in social media and the underlying strategies that they may use to manage their online activities. However, such an approach faces technical challenges. For example, identifying teens versus adults in social media is non-trivial, because many users often do not publicly reveal their age information nor, in many cases, do social networking sites (SNS) ask for user’s age information at the time of registration.

In this regard, we seek to address the aforementioned limitations of social media studies and investigations. We strive to better understand and articulate teens’ behavioral characteristics in social media by augmenting theoretical understandings of teens as well as additional behavioral patterns in social media. This paper is the extension of our previous work [20], which presented two main contributions. First, we introduced our hybrid method of textual pattern matching and facial recognition to detect users’ age information in a large scale, and collected user information and usage data from a total of 27,000 teens and adults in Instagram, an online photo sharing site. Second, we presented some preliminary

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comparative analyses between teens and adults. We found that teens tended to have fewer photos than adults because of limited topics and photo removal. We also found that teens tended to have more selfies exhibiting a higher level of self-representation.

This paper significantly extends our previous work [20] in the following four important ways:

- First, our previous study lacked theoretical understanding of the underlying factors for behavioral differences that teens and adults showed. Thus, in this paper, we outline our two hypotheses based on the developmental literature and related work, serving as the theoretical foundation for explaining how age factors in social media behaviors.
- Second, our study significantly extends some of the previous findings by presenting the difference in the number of users who posted and removed photos as well as in the total number of posted and removed photos based on the topics. We add an additional behavioral difference — relationship between removed photos and the number of Likes — to strengthen our finding.
- Third, our study employs a comprehensive temporal analysis using time series dataset to empirically analyze the way teens and adults use Instagram over time, and examine the different interaction patterns with other users that teens and adults show.
- Finally, based on the empirical findings, we draw theoretical, practical interpretations and implications that may provide useful insights and guidance for future research and design.

Compared to existing research in this domain, this paper presents an analysis with large-scale user activity data to extensively reveal online behavioral patterns and empirical understandings as well as to identify potential factors that drive these patterns. Our analysis is guided by the following research questions:

- RQ1: *Do teens behave differently from adults in Instagram? Are teens more active users than adults?*
- RQ2: *If behavioral differences from different age groups are identified, what are social, psychological or technological factors that may explain such behavioral differences?*

Regarding RQ1, our study shows mixed findings. Comparatively, it appears that adults post more photos, whereas teens engage more in interactions with their social networks through Liking, commenting, and expressing more emotional and social interests. Regarding RQ2, we develop two hypotheses — *teens as digital natives and the need for social interactions* — based on previous literature and interpret behavioral and social aspects from the results of RQ1. We identify behavioral patterns which indicate that, while self-representation seems to be universally important for social media users irrespective of age, teens tend to show more behavioral activities in social media, manage their social media content to meet their social needs, and interact with more diverse users. On the other hand, adults tend to focus on expressing their identity and engagement through content creation (e.g., adults tend to post more photos than teens) and to interact with relatively smaller number of and less diverse users.

2. RELATED WORK

In this section, we present two hypotheses grounded by previous theoretical insights and implications to better understand how age factors in social media behaviors.

2.1 Perspectives on teens in social media

The notion of “digital natives” was first proposed by Prensky [37], which describes a new generation who has spent their entire lives surrounded by technologies and tools of the digital age. This notion has sparked a wide range of debate. Much of the opposition argues that the so-called digital natives do not necessarily possess the natural fluency and technological skills that they are assumed to, nor are they necessarily more intensive users of digital media than many so-called “digital immigrants” — people of the older generation who transitions from traditional media to new [44].

However, although the term may exaggerate the inter-generational gap and overlook the intra-generational digital divide, research has shown that young people in general, especially teens, are highly tech-savvy [23]. When it comes to social media contexts, studies show that teens tend to be early and fast adopters of newer or better online social space [5]. They also show that teens tend to use multiple social media sites and maintain different forms of communication [39], and can quickly switch between different platforms to take advantage of their unique features [38].

As a result of the digital proficiency and skillfulness, teens are likely to be active users of digital media. For instance, a national survey of teens in 2009 confirmed that age and Internet access are positively associated with digital literacy and Internet use [26]. Thus, we hypothesize that teens would exhibit more behavioral activities in social media, and would be capable of utilizing more technological features afforded by the platform:

- H1: *Teens are more active users of social media than adults, because they will be engaged in more behavioral activities and utilize more technological affordances on the social media (in this paper, Instagram).*

2.2 Teens & other age groups in social media

Some of the differences in social media use between teens and adults can be explained by their different levels of digital literacy and perceived competence. However, as discussed above, this assumed generational digital divide is rather ambiguous in reality. As the design of social media interfaces has become increasingly intuitive and easy to use, adults are quickly catching up in number when it comes to the use of some of the most popular social media websites, such as Facebook and Pinterest [11]. If technological literacy is not the determining factor, what other factors might lead to the unique behavioral patterns of the different age groups?

Social media offers abundant opportunities for social connections and social interactions; therefore, it serves to provide a virtual “social context” [1], an immediate social environment in which social and situational variables can greatly shape individual behavior. Therefore, individuals would behave in accordance with the social norms and in response to social influence they experience in social media. Previous developmental literature suggests that teens are particularly prone to such social influence. Consistent with such theoretical assertions, uses and gratification research [32][33] has also found that individuals use social media mainly for relationship maintenance, social surveillance, and social interaction, among other purposes (e.g., entertainment, self-status seeking, information seeking, etc.).

However, especially for teens, communication with their peers emerges as the single most important motivation for SNS use [4]. Ethnographic data have shown high teen engagement in online socialization opportunities and social behaviors unique to the mediated environment [8]. Teens also tend to maintain a social

network with a large number of users [36] and consider social media a place for self-representation and for establishing their own identity [20][25].

In this regard, we hypothesize that teens would show more social activities than adults to stay connected with their peers through various means that are unique to the social media site:

- H2: *Teens are more engaged with social interactions with other users than adults through communication features (e.g., Likes, comments, tags, etc.) offered by Instagram.*

Overall, there have been a lot of research efforts on studying teens and generational perspectives in social media. However, very few studies have explicitly articulated differences from a large, data-driven longitudinal and comparative analysis. To fill this gap, this paper introduces a new method and presents less explored aspects, and a comprehensive picture of teens’ social media behaviors.

In the following section, we will describe our method and process of data collection.

3. DATA COLLECTION

Instagram was chosen for data collection for two main reasons. First, Instagram is one of the most popular SNS with users who create and share mainly photos every day. Because of its high popularity, there has been a great volume of research studies on Instagram. Examples include exploring the relationship between photo content and engagement [3], analyzing photo content and user types [18], studying Like activities through the structural, influential, and contextual perspectives [21], and studying tag-based Like networks formed by Instagram users who have the same tags [16]. Second, given the fact that more than 90 percent of Instagram users are under the age of 35 [11], it is suitable to study our target age groups of teens and adults. By following Erikson’s eight stages of psychosocial development¹, we define our target user populations as follows (note that we intentionally add a five-year gap between two age groups to minimize the ambiguity in estimating ages):

- **Teens:** people who are between 13 and 19 years old.
- **Adults:** people who are between 25 and 39 years old.

We used the programming API² to extract usage data for all users. The data collection was done between April and May 2014. We first chose one random seed user and crawled the followers of the seed user until we collected 150,000 users. We then randomly chose 1,000 users from the pool of 150,000 users and again crawled the followers of 1,000 users until we reached 2 million unique users. We used this two-step and random-seed crawling process in order to minimize the bias in sampling a homogenous population.

The dataset includes various pieces of user information, such as name, the number of photos posted, the number of Likes, tags and comments in the photo, the number of followers and followings, and a bio description, which are all associated with the individual accounts (Figure 1). From this data, we found some trends of teens in Instagram, which motivated us to investigate reasons behind those trends.

Classifying users to a specific age group was challenging. Most social media platforms, including Instagram, neither collect nor

publicly disclose users’ age information. To address this challenge, in our prior paper, we proposed a method that leverages two existing media contents (i.e., bio descriptions and profile

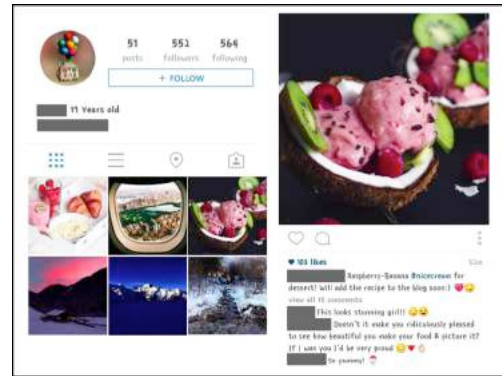


Figure 1. Mock-up Instagram page (username anonymized), illustrating poster-related information (e.g., # posts, # followers, # following, bio, etc.) and photo-related information (e.g., # Likes, tags, comments, etc.).

images) with existing APIs [20]. First, we applied textual pattern recognition algorithms to parse a list of patterns that specifically describe users’ age in the bio (e.g., “I am 17 years old,” “I’m 23”). Second, we used a facial recognition technique, Face++³, to auto-detect the age information from people’s profile images, which has been utilized and showed a high accuracy in another study [3]. Figure 2 illustrates the method and process of data collection.

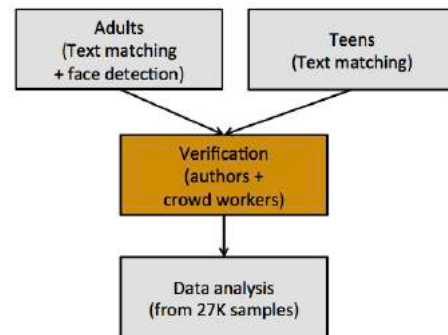


Figure 2. Data collection method and process.

With the data collected, we manually verified the age of all users to make sure that the data accurately represented each group from a total of five human judges (i.e., two authors and three crowd workers in Amazon Mechanical Turk). We finally had a total of 26,885 teens and adults for the analysis. See [20] for the more detailed process of data collection.

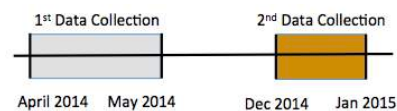


Figure 3. We found a trend from the 1st dataset and temporally extended it to create the 2nd dataset with the same number of users (13,533 teens and 13,352 adults).

We additionally collected the dataset from the same 26,885 users in 12-hour intervals over 12 days (from Dec. 26, 2014 to Jan. 6,

¹ <https://goo.gl/dYfXYZ>

² <https://www.instagram.com/developer/>

³ <http://www.faceplusplus.com/>

2015) to investigate the patterns of usage and engagement over time in Instagram. Figure 3 illustrates the construction of two datasets. For the analysis, we calculated the delta of photo counts in every two consecutive time slots and checked the total number of photos that users have posted, the number of users who added photos, and the number of users who removed their photos in 12 hours.

Lastly, in order to protect the privacy and confidentiality of the Instagram users in our sample, privacy-preserving measures were taken throughout different stages of this study. More specifically, during the process of manual age verification, we removed all identifiable and sensitive information (i.e. name, ID, and email address) from the profiles and photos before they were presented to crowd workers. Moreover, during data analysis, we removed all user identifiable information (except for age), and aggregated and analyzed the data at a group level.⁴

4. RESULTS

In this section, we report our analyses on the usage data from a total of 26,885 teens and adults. We first briefly summarize our previous findings about the two primary usage differences (i.e., teens tend to post less and be engaged more than adults) between two groups [20], and then introduce and explain several factors that may influence those two findings.

4.1 Teens’ behavioral differences

Our analysis on the usage of Instagram from all users showed that teens tend to post fewer Photos but show more activities in Liking, Tagging, and Commenting (see Table 1). As all variables show a long-tailed distribution, we used the median value for the analysis.

Table 1. Summary of activities by two groups. Teens tend to post less but be engaged more in other activities than adults [20].

	Teens (13,533)		Adults (13,352)	
	Median	SD	Median	SD
# Photos	110	272	175	487
# Likes	3,293	29,851	2,150	24,829
# Tags	446	2,595	294	2,511
# Comments	175	1,016	35	1,023
# Followers	401	3,683	348	5,700
# Followings	286	2,045	272	2,699

We also calculated the ratio of Likes, Tags, and Comments to Photos and found that teens are likely to receive more Likes (teens: 56.10; adults: 40.03; we used eta-square (η^2) for the effect size: 0.09), add more tags (teens: 6.34; adults: 4.70; η^2 : 0.01), and have more comments (teens: 2.52; adults: 1.06; η^2 : 0.07) per photo than adults (statistically, all showed significant differences; $p < 0.001$). This indicates that the way of using and engaging in Instagram between teens and adults is different. In the following sections, we investigated several factors that might lead to having these results.

4.2 Factors of behavioral differences: (1) teens have fewer photos in Instagram

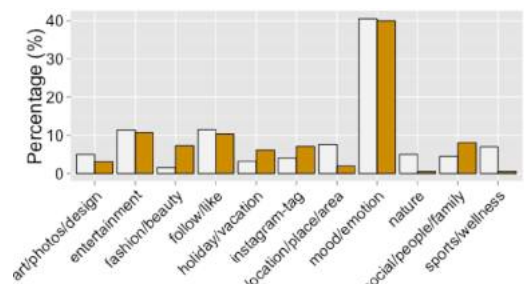
4.2.1 Lack of topic diversity in photos

We first examined the list of topics that are presented in teens’ and adults’ photos. We assumed that, for teens, activities and topics of photos might be limited, because they are financially or

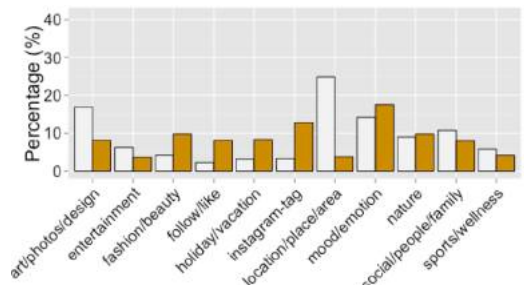
culturally dependent on their parents to venture outside of their daily activities compared to adults. To test our assumption, we used tags in both posted and removed photos in order to find the topics of photos that users have or used to have (but removed).

Table 2. LDA-discovered topics from all users (N=26,885). Tags were used for topic discovery [20].

Topic	Tag examples
Arts/photos/design	photo, interior, architect, design, building
Entertainment	music, movie, pop, rock, song, star, dance
Fashion/beauty	makeup, model, fashion, jewelry, beauty
Follow/like	followme, followback, follow, tagsforlike
Foods	food, coffee, yummy, delicious, dessert
Instagram-tags	instagood, instalove, instadaily, instashare
Locations	nyc, boston, spain, brazil, dutch, europe
Mood/emotion	love, happy, depressed, bored, sad, great
Nature	sky, sun, ocean, beach, flower, sunset
Social/ people	family, girlfriend, friends, folks, gay, pets
Sports/wellness	hiking, biking, fitness, cleaneating, soccer



(a) Teens (N=13,533)



(b) Adults (N=13,352)

Legend: █ Posted █ Removed

Figure 4. Percentage of the posted and removed photos based on LDA-discovered topics (x-axis), where N=26,885. Teens show a very high result in the mood/emotion topic both for posted and removed photos whereas adults show more diverse topics.

We identified latent topics from the tags of users’ photos through an LDA analysis [6] using Mallet [28]. We used tags to infer photo content, because research has found that people tend to add tags that represent the photos they post [17]. We also obtained a list of ground-truth tag topics from two popular websites (i.e., tagsforlikes.com and tagstagram.com). We manually coded the types of photo topics from Mallet’s output into those topics. Table 2 summarizes the 11 topics extracted from our dataset. We then calculated the percentage of topics from posted and removed photos for each group, as presented in Figure 4.

Figure 4 shows a clear difference between two groups in terms of topic types. On the one hand, for teens, more than half of posted and removed photos were in “Mood/emotion” and “Follow/Like.”

⁴ Our datasets are available at: <https://goo.gl/LqTYNv>

These topics are not necessarily tied to the content of photos but rather describe one’s emotional status or intention to have more followers. In addition, topics of posted and removed photos for teens are highly correlated ($r = 0.92, p < 0.001$), indicating that teens show quite similar patterns when managing their photos. On

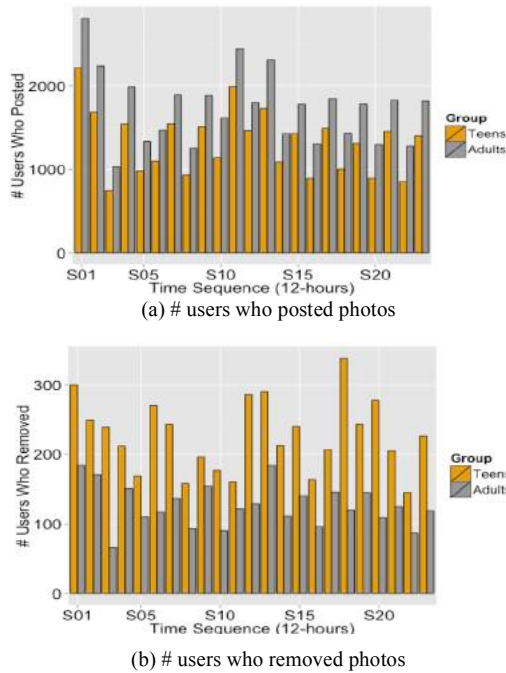


Figure 5. Number of users who (a) posted or (b) removed photos over 12 days (N=26,885). More adults post and more teens remove photos.

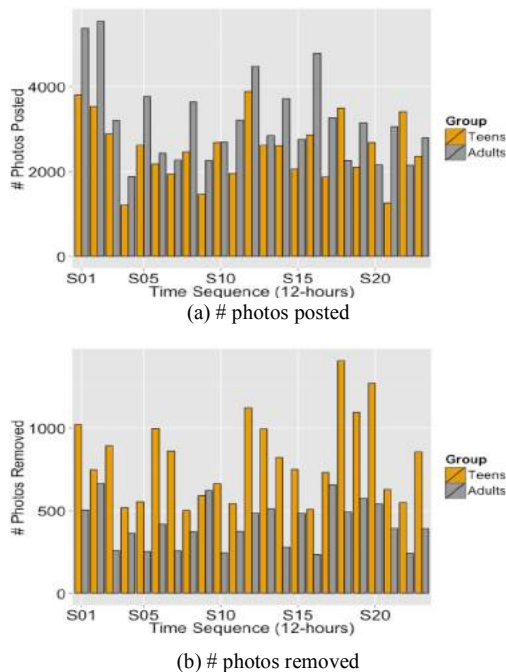


Figure 6. Number of photos (a) posted and (b) removed over 12 days (N=26,885). More photos posted by adults and more photos removed by teens.

the other hand, adults showed a high ratio in more diverse topics

from their photos, including “Arts/photos/design,” “Locations,” “Mood/emotion,” “Nature,” and “Social/people.”

Unlike popular topics presented in teens’ photos, these topics imply more diverse content in the photos, such as photos that depict different facets of cities and countries around the world, photos of arts and design (some of them were taken professionally), photos of a variety of people, and so on. Similarly, adults present quite diverse topics from removed photos, and, unlike teens, topics from posted and removed photos do not correlate with each other ($r = 0.09, p = 0.77$). In summary, it appears that teens’ posted and removed photos have less diverse topics compared to adults’ ones.

4.2.2 Post fewer and remove more photos

In addition to the topics of photos, we used the data showing the temporal usage reports (collected in the second phase) to measure the number of users who posted or removed photos, and that of posted or removed photos. For removed photos, we checked if each individual photo still existed by comparing a list of photos every 12-hours.

Figures 5 and 6 show the number of photos posted or removed and the number of users who posted or removed photos over time, respectively. From almost the same number of users in each group, the results show that fewer teens tend to post photos ($t(42) = -3.89, p < 0.001$), but more teens tend to remove photos than adults ($t(42) = 8.01, p < 0.001$). Regarding the total number of photos posted and added, teens posted fewer photos ($t(42) = -3.76, p < 0.001$) and removed more photos than adults ($t(42) = 6.14, p < 0.001$).

4.2.3 Remove photos with fewer Likes

Prior research has found that many teens tend to manipulate their photo content to receive as many Likes as possible or sometimes remove some photos that have received too few Likes [8][27]. Because there has been no attempt to examine this phenomenon through a large-dataset analysis, we measured whether the usage data from our sample showed a similar perspective, which also supports the idea of teens having fewer photos.

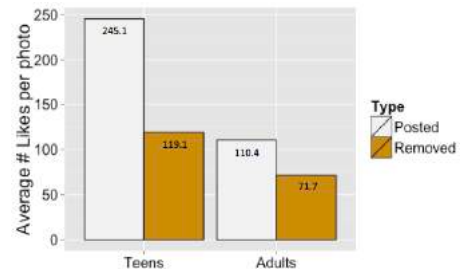


Figure 7. Average number of Likes per photo for posted and removed photos (N=26,885). Removed photos from adults have 35.0% fewer Likes than posted photos, whereas teens show 51.4% fewer Likes. Teens remove more photos that have fewer Likes than adults.

We first measured the number of Likes that the removed photos received and compared it to the number of Likes that all posted photos received. As we had the usage data 12-days in a row, we could calculate how many Likes had been in the removed photos. We then checked if teens removed photos that had relatively fewer Likes compared to the average of all of their photos. Figure 7 shows the result of the differences. The average number of Likes per posted photo is 245.1 for teens and 110.4 for adults. The average of Likes per removed photo is 119.1 for teens and 71.7 for adults. Then adults’ removed photos have 35.0 percent fewer

Likes than the posted (and kept) photos, whereas teens' removed photos have 51.4 percent fewer Likes than their posted (and kept) photos ($t(44) = 7.08, p < 0.01$). This result indicates that both user groups tend to remove photos that have fewer Likes than their overall photos, but teens show larger differences.

4.3 Factors of behavioral differences: (2) teens engage more in Instagram

To understand the level of engagement, we examined four aspects of teens and adults including: (1) how many Likes and comments they have had over time, which implies a level of activities in Liking and commenting; (2) how fast they replied to other users' comments added to their photos, which implies a level of one's interest in interacting with other users; (3) how they engaged with other users through comments, which implies a level of their engagement; and (4) what they wrote in their comments, which implies their intention through commenting.

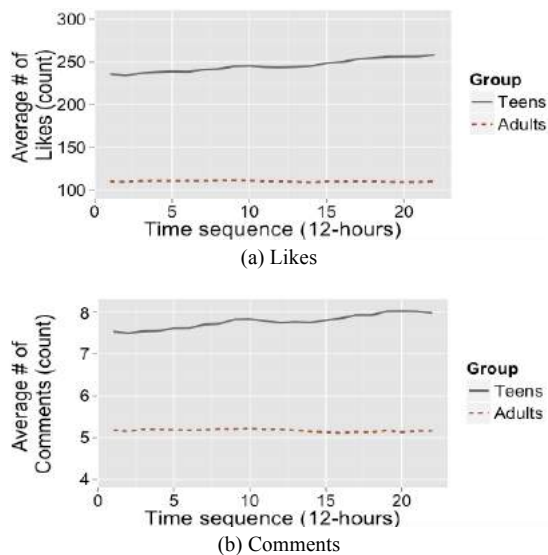


Figure 8. The average number of Likes and comments in every 12 hours (N=26,885). Teens show the steady increase over time for both Likes and comments while adults remain flat.

4.3.1 Teens have more Likes and comments over time

We measured the average number of Likes and comments teens and adults have had over time. Figure 8 illustrates the average number of Likes and photos over 12 days. Not surprisingly, teens showed the higher number of Likes and comments every day than adults ($p < 0.0001$). However, a more interesting aspect is that teens presented an overall increase, especially in Likes. In addition, when we consider this as a cumulative result, a total number of Likes for teens will be much higher than adults, which also implies high engagement in Liking. On the other hand, for adults, the average number of Likes and that of comments do not seem to be changed a lot. This implies that adults are likely to receive the similar number of Likes, even after they add new photos (i.e., in the previous section, we found that more adults post more photos than teens as shown in Figures 5 and 6). This further means that adding more photos does not necessarily lead to having more Likes or comments in adults' case. Figure 8 does not show a saturation point (i.e., no increase after reaching the certain number of Likes) for teens. However, for adults, the number seems to reach the threshold of having around 110 Likes

and 5 comments. In summary, this result supports well the idea of teens engaging more in Instagram activities than adults.

4.3.2 Teens reply to others' comments more quickly

Adding user's name right after the "@" symbol has been widely used in social media for replying to another user and helping establish a language for communicating. We can think about a scenario where an original photo poster, @robinson, checked one comment (e.g., "Nice pic, where did you take it?") added to his photo by another user, @johndoe. Then, @robinson added a new comment (e.g., "@johndoe, I took this photo when I visited New York") and mentioned @johndoe in his comment.

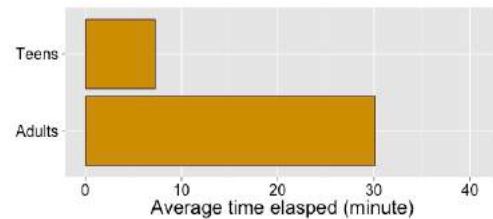


Figure 9. Avg. time elapsed when the original photo posters (N=26,885) commented and mentioned @name_of_previous_commenter right after @name_of_previous_commenter's comment. Teens tend to reply more quickly than adults.

Based on the scenario above, we measured how quickly the original photo posters replied to other users' comments that were added to their photos. As shown in figure 9, we found that teens replied to the previous comments from other users in around 7.2 minutes, which is significantly shorter than adults who replied in around 30.0 minutes.

4.3.3 Teens engage with more diverse users through commenting activities

To measure a number of other users that our sample users are engaging with through their comments, we first calculated the ratio of the number of comments with @others_username to that of all comments for each group. We found that teens showed a higher ratio result (45.2%) than adults (34.1%). This indicates that more teens are adding @username in their comments in order to, for example, call other users, or start and maintain conversations.

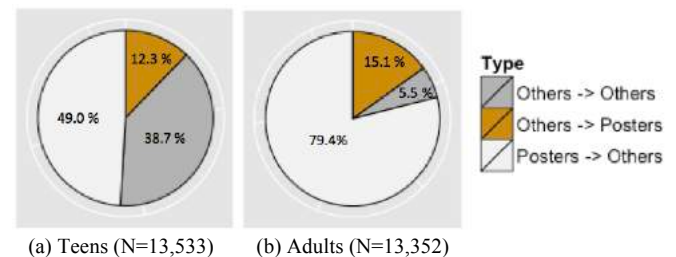


Figure 10. Results of three types of adding comments with @. Teens show a higher result in "others→others" than adults, and adults show a higher result in "posters→others" than teens.

We further examined additional types of commenting with respect to two dimensions: (1) "users in the comments" — those who added comments and those who were mentioned in the comments — and (2) "user types" — original photo posters and other users. By combining these two dimensions, then, we derived three directional aspects of commenting with @: (1) original photo posters mentioned other users (posters → others); (2) other users

mentioned the original photo posters (others → posters); and (3) other users mentioned other users (others → others), excluding the original photo posters, in their comments.

Figure 10 shows the break-downs of three types. First, teens have fewer cases (49.0%), where the original photo posters commented @others (posters → others) in their comments, than adults (79.4%). Second, teens have fewer cases (12.3%), where other users mentioned @photo_posters in their comments (others → posters), than adults (15.1%). Third, teens show more cases (38.7%) where other users mentioned @others in their comments (others → others) than adults (5.5%).

When we consider these results together, most comments (79.4% + 15.1% = 94.5%) in adults’ photos are associated with the adult photo posters, whereas more than half of the comments (49.0% + 12.3% = 61.3%) in teens’ photos are associated with teen photo posters. It is interesting to note that many other users who commented on teens’ photos mentioned other “third users” in their comments (38.7%), whereas only very few cases of others → others are observed (5.5%) in adults’ photos.

In order to gain a more concrete idea of patterns of commenting, we further measured the percentage of (non-overlapping) unique users who were mentioned in photo poster’s comments, and the percentage of unique users who mentioned the photo poster in their comments.

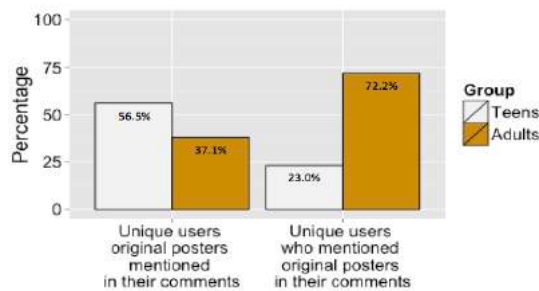


Figure 11. Percentage of (non-overlapping) unique users whom photo posters mentioned in their comments and unique users who mentioned the photo posters in their comments with @. For teens, (1) the original photo posters mentioned more unique users in their comments and (2) other users who added comments to teens’ photos mentioned more third users. However, these were opposite in adults’ comments.

Figure 11 shows the results with two interesting insights. First, teens mentioned other users in their comments (56.5%) more than adults (37.1%). Second, a majority (72.2%) of the comments on adults’ photos were directed toward the original photo posters by mentioning their usernames, whereas less than a quarter (23.0%) of the comments on teens’ photos were directed toward the original photo posters. Instead, 77.0% of the comments on teens’ posts mentioned other people’s usernames.

Given that comments and mentions can reach users instantly through push notifications (Figure 12) and are therefore effective communication tools on Instagram, this result shows the different communication patterns between teens and adults. Teens are known to be highly active in being connected with others [8][15] through texts, emails, and social media [7][34] and responding quickly (Figure 9), thus it is reasonable enough to assume that they utilize a notification feature for communication. The comparison in Figure 11 reveals that teens tend to use the comment section to reach out to and interact with a more diverse and bigger network of users, while adults tend to use comments

and mentions to have a more direct and interpersonal interaction (with fewer other users), showing more person-to-person or individual-oriented interactions.

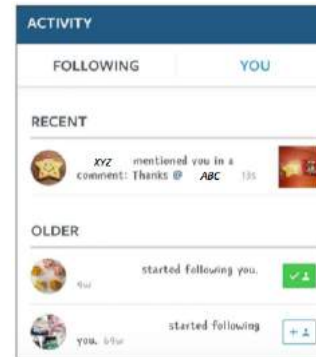


Figure 12. Instagram interface that shows one’s activity. When a user (named XYZ; anonymized) adds @ABC (anonymized) in his comment, a notification will be sent to ABC as well as added to her activity page, indicating her name was mentioned in @XYZ’s comment.

4.3.4 Teens post emotional, social interests

Lastly, we measured the words in the comments with @ by teens and adults as the response to others’ comments. We utilized Linguistic Inquiry and Word Count (LIWC) [35] in order to parse words representing tones and psychological components in the comments. We first randomly chose a total of around 6,000 teens and adults and compared word count (i.e., related to talkativeness and verbal fluency), the number of words longer than six letters (i.e., the higher it is, the less emotional and connected), and a level of social interests and that of emotionality.

Table 3. Analysis on comments from randomly selected teens (N=2,927) and adults (N=2,928) using LIWC. Teens show a higher result in social and emotional connection in their comments. Eta-square (η^2) was used for the effect size.

	Teens	Adults	Effect size (η^2)
Word count*	86.4	191.9	0.04
Words > 6 letters*	9.1	10.4	0.02
Social interests*	13.7	11.2	0.01
Emotionality*	38.0	31.0	0.07

*p < 0.001.

Table 3 summarizes the result. The word count and words longer than 6 letters for teens were lower than for adults. However, social interests and emotionality were higher for teens than for adults. It shows that although adults add longer comments, their comments are less emotional and oftentimes psychologically distant. Teens’ comments were shorter but more emotional and embodied social aspects. Teens might spend less time on commenting because they have shorter texts. This perhaps implies that promptness is an important factor for teens when interacting with others as shown in Figure 9.

5. DISCUSSION

In this paper, we have presented an in-depth analysis on the social media usage of two different age groups – teens and adults. We primarily focused on investigating the factors that may affect the earlier findings where teens tend to have fewer photos but be more engaged in Instagram. We attempted to detail the reasons behind these trends based on the theoretical foundations and the

analysis on the large datasets collected from a total of 26,885 teens and adults through mixed methods (i.e., text matching, face detection, and crowd workers). In this section, we first summarize two trends and the underlying factors, which we assumed and found through the analysis, and then discuss those factors within a lens of our hypotheses. We finally discuss study limitations and future work.

5.1 Two trends and the corresponding factors identified from the data analysis

For the first trend, where teens have fewer photos than adults, we have identified the following insights that explain it:

- Having fewer topics to post seems to lead teens to post fewer photos over time. Teens are likely to add and remove topics that mostly describe their emotional status or their intention to have more followers, while adults showed more diversity.
- Teens tend to add fewer photos and remove more photos than adults based on the analysis on the temporal usage dataset.
- Teens tend to remove photos that have relatively fewer Likes compared to adults.

For the second trend, where teens engage more than adults, we have discovered the following insights:

- Teens have more Likes and comments per photo than adults, and our analysis from the temporal usage dataset shows that teens are likely to receive more of them.
- Teens tend to reply more quickly to others' comments added to their photos than adults.
- Teens tend to add more comments with @username and have more non-overlapping (unique) users mentioned in their comments. Users who added comments to teens' photos also mentioned many diverse third-users in their comments. Thus, given that users will receive a push notification whenever there is a new message added to their photos or comments, it is likely that the original photo posters (teens) will see and be aware of the user names mentioned in the comments. Teens tend to add more comments that show social interests and emotionality. Conversely, adults tend to post fewer comments with @ and mention fewer unique users in their comments. Users who commented on adults' photos mentioned the original photo posters more than teens.

5.2 Theoretical and practical interpretation and implications

5.2.1 Hypothesis on digital natives

First of all, H1 (digital native hypothesis) was partially supported. Teens in Instagram were fairly active in all activity categories but were not necessarily more active than adult users in all aspects. In particular, they were found to create less content than adult users, despite their high engagement in commenting, Liking and tagging activities.

This finding has several implications. First, it shows that social media engagement is a multi-facet concept that encompasses not only content creation but also social interactions in various means.

Second, it indirectly supports the assumption of tech-savvy teens [5][23] in the sense that teen users were more likely to utilize the diverse features afforded by the interface for social networking purposes. Both hashtags and Likes are unique features of the new social media, which may be unfamiliar to some of the adult users. However, teens in our sample effectively utilized such features for proactive socialization.

Third, while examining teens' activities in Instagram, we identified an interesting pattern that they tend to manage their personal profile through content removal. This could also be an indicator of their skilled use of social media, where we found a possible link to a privacy aspect. For instance, teen privacy research has suggested that technology-savvy and -native teens would limit or remove their online postings (often after the fact) as a privacy protection mechanism rather than limiting their overall online activities and information revelation [22]. Similarly, based on the survey result out of 622 teens, research has found that 62 percent of teens (382) deleted or edited their content posted in the past as a way of their privacy strategy [14][46]. This unique strategy shows how today's teens manage their online content in different ways than older generations. In addition, content deletion could be a novel way to manage teens' online self-representation, and this is also related to our second hypothesis.

5.2.2 Hypothesis on social interactions

Secondly, H2 (social interaction hypothesis) was supported. Our findings showed that social interaction was the primary motive for teens and had significantly shaped their behaviors in Instagram. Not only did teens receive more Likes and comments than adults — and following the social rule of reciprocity [13], we could assume that they left more Likes and comments on other users' profiles prior and/or in return — but their content deletion appeared to be associated with a lack of Likes. Teens' content management strategy appears to be for the purpose of self-presentation: compared to adults, teenagers especially may want to display the "popular self" [19]. For them, they would think that only keeping the most Liked posts could help create a perception that the profile is popular. This result shows a strong empirical and longitudinal field evidence for the previously established relationship between online self-presentation and psychological factors such as self-esteem and narcissism [29].

Our analyses showed that adults appeared to create more original content and to have kept more user-generated content (UGC) than teens. This finding shows some interesting perspectives. On the one hand, adults may have access to more resources and life experiences, which serve well as their source of content creation, while such resources and experiences are lacking for teens. On the other hand, existing research has suggested that, different from consumption and participation in UGC, the production of UGC is primarily driven by the needs of self-actualization [41].

Such needs can be more salient for adults as they have well-established identities and confidence in voicing their identity. Shao [41] pointed out that participation in UGC, in forms such as commenting and Liking, is associated with social needs. Given that social needs are more salient for teen social media users, it would be reasonable to see the result where teens were more engaged in these social interactions than content creation. From the social capital perspective, despite the fact many scholars believe the active use of SNS is more effective in achieving social capital, some research indicates that passive use (e.g., Liking, commenting, or just lurking) of SNS can also function as a form of social investment and therefore contributes to social capital [10].

Another insight can be revealed from the finding in which teens tend to use limited tags (mood/emotion or follow/like) and topics (i.e., we can assume that topics would be limited from those tags compared to the tags from adults) when they did create content in Instagram. The limitation might be explained by the hypothesis of online environment as an "echo chamber," referring to a situation

in which information, ideas, or beliefs are amplified or reinforced by transmission and repetition inside an enclosed system [42]. In our study, the highly personalized content consumption enabled by online services allows users, young adults and adolescents in particular, to select only the content that they are interested in and the opinions that they agree with. Such selective exposure may lead to their limited scope of interest and topic diversity.

Lastly, our findings about comments and mentions in comments revealed the different strategies that teens and adults utilize to interact with their social networks. The fact that the mentions in comments on adults' profiles were used more frequently for direct communication with the original photo posters shows the adult users' preference for having or maintaining close, interpersonal interactions. Teens, however, tend to use the comment space to reach more and other users. They also responded more quickly to these comments through the Instagram notifications. This shows that teens maintained wider and more timely interactions with a large network of people. The social interaction that takes place in the comment space may have compensated for the limited content posted onto Instagram as well. This also in part affects the increase in Liking that teens showed compared to adults as teens make more new friends while adults seem to be more interested in interacting with established friend groups.

In summary, our data-driven temporal and comparative analysis unearths several new and unique insights on teens and their behaviors in social media. At the same time, the analysis substantiates the idea that teens leverage social media primarily as a "conversation space" [8] and use many features the platform provides in order to create connections and facilitate conversations and interactions [19]. Teens engage in social media not only because they are well aware of the intention of those activities, but also because they are familiar with technology use and the "tagging culture" in online space, which reinforces their social practice [1].

5.2.3 *Practical interpretations and implications*

Along with many theoretical insights, there are some practical interpretations and implications especially about the design of social media sites (in particular, Instagram).

There is a design opportunity where social networking sites can provide users with a summary of their usage. Several activity variables that are used for the analysis in this paper can be considered including the number of photos, Likes, comments, tags that users added, photo topics identified from the system, most popular photos based on the total number of Likes and comments, and etc. Then the social networking sites can leverage this design idea to provide one with a recommendation of other users who have shown similar activities or photos. This feature is expected to create interactive social space, which is beyond the one with simply one's followers/followings or location. As we found that teens and adults show distinctive usage differences in Instagram, this feature will give them chances to discover, meet and interact with new people who show similar interests and activities and/or are in the similar age. For example, teens and adults may find a list of users in their age groups more interesting and meaningful and want to check their photos, follow them, share messages or interests, because they may have more personal connections to peers. Yet, due to privacy concern, obviously, a careful design of supporting this new feature; for example, allowing users to control the visibility of some of their usage reports, should be taken into account.

5.3 Limitations and future work

Although we presented a number of insights, we acknowledge some limitations that can be handled in future studies.

First, errors may exist in the detection of age information even if we manually verified them. Many users provide additional social media links (e.g., Facebook, Twitter, etc.) in their profiles that we can leverage. Future studies that apply our method should obtain and corroborate additional age information from those sites.

Second, the age information auto-detected from users' bios or profile images could be incorrect when users have not updated them for a long period. This could affect the analysis of behavior differences by age. A possible remedy is, for instance, to double-check users' age information by comparing a user's "selfie" photos with the user's profile photos. However, a further study to validate its accuracy will be necessary.

Third, the results from our dataset may not represent the whole social media platforms and may only be limited to teens and adults in Instagram [40]. We plan to extend our study to other social media sites (e.g., Facebook, Flickr, etc.) to validate our method and compare results.

Lastly, we are very aware of the potential privacy issues that may arise from the analyses like ours if conducted improperly, and call on researchers to pay more attention to the ethical implications of collecting and using social media data for research purposes. Even if the data being gathered and analyzed are publicly available and accessible, users usually have no way to know about whether their data are used in research or about how to opt out. As Boyd and Crawford [9] suggest, social media scholars need to be aware of the "considerable difference between being in public and being public," and should therefore carefully consider privacy and ethical implications when collecting and analyzing publicly available data. Especially if the data concern teenage users, as in our study, we recommend researchers to take the best measures to minimize potential risk and harm, remove personally identifiable information, aggregate and analyze data at a group level, and adopt systematic data management strategies to ensure data security.

6. CONCLUSION

This paper contributes to deeper analyses on age differences in Instagram, more broadly in social media. Based on comparative analysis methods using large-scale datasets that represent teens' and adults' Instagram usage, we tested our hypotheses developed through the lenses of social cognition, developmental strategy, and human-computer interaction in order to explain how age factors in social media behaviors. Our computational analysis identified the following novel findings: (1) teens post fewer photos than adults; (2) teens remove more photos based on the number of Likes the photos received; and (3) teens have less diverse photo content. Our analysis also confirmed prior ethnographic accounts that teens are more engaged in Liking and commenting, and express their emotions and social interests more than adults. These behavioral patterns show the age differences in online communication strategies such that teens and adults adopt to meet their social, self-expression needs and to accommodate with their technological skills and preferences. Our study presents a number of new and theoretically, practically meaningful insights and guidelines for ongoing research studies in social media.

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