

Why We Filter Our Photos and How It Impacts Engagement

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Abstract

A variety of simple graphical *filters* are available to camera phone users to enhance their photos on the fly; these filters often stylize, saturate or age a photo. In this paper, we present a combination of large-scale data analysis and small scale in-depth interviews to understand filter-work. We look at producers' practices of photo filtering and gain insights in the roles filters play in engaging photo consumers' by driving their social interactions. We first interviewed 15 Flickr mobile app users (photo producers) to understand their use and perception of filters. Next, we analyzed how filters affect a photo's engagement (consumers' perspective) using a corpus of 7.6 million Flickr photos. We find two groups of serious and casual photographers among filter users. The serious see filters as correction tools and prefer milder effects. Casual photographers, by contrast, use filters to significantly transform their photos with bolder effects. We also find that filtered photos are 21% more likely to be viewed and 45% more likely to be commented on by consumers of photographs. Specifically, filters that increase warmth, exposure and contrast boost engagement the most. Towards the ongoing research in social engagement and photo-work, these findings suggest several practical implications such as designing filters for both serious and casual photographers or designing methods to prioritize and rank content in order to maximize engagement.

Introduction

Mobile phone photography has dramatically risen in popularity recently. For example, the various iPhone models have been Flickr's most popular cameras for years¹. In its first year, Instagram saw over 150 million photos uploaded. Now, at the time of this writing, Instagram users upload 60 million photos a day on average². Part of the success of mobile camera phone sharing is attributed to the use of on-camera visual effects. These effects, or *filters*, provide a quick preset path to an artistic rendering of the photo. Mobile photo-sharing sites, such as Instagram and Flickr, provide several filter options; the goal of filters is to give photos a better

exposure or stylized look without knowledge of photo processing. Yet, despite their widespread use and the HCI community's interest in mobile photography (Ames et al. 2010; Balabanović, Chu, and Wolff 2000; Kirk et al. 2006), there is little work—scholarly or otherwise—around filters, their use, and their effect on photo-sharing communities. While existing scholarly work has extensively examined textual content in social networks (Hutto, Yardi, and Gilbert 2013), we know of a very few similar studies on why people filter their photos and what makes photos engaging and interesting (Bakhshi, Shamma, and Gilbert 2014).

Vitally important to the sites that play host to filtered images, this paper presents the results of a mixed-method study exploring the motivations behind filter use, and their impact on photo engagement. We take a user-centric approach to study filters. First, we aim to understand the content creators and their viewpoints on filter use. Our next goal is to examine how this effects the viewers' engagement. How do viewers respond to the filtered photos compared to the non-filtered ones? To summarize, we build our work around the following two research questions:

RQ1- Producers' perspective: Who are the mobile photographers and why/when do they use filters?

RQ2- Consumers' perspective: How do consumers respond to filtered photos? Are they more/less engaging?

To answer our research questions, we designed a mixed-method study based on interviews with 15 Flickr mobile users and quantitative analysis of 7.6 million Flickr photos (some of which were cross-posted from Instagram). Our work illuminates the practices of post-processing from producers' perspectives and how viewers engage with filtered photos.

In this study, we find that there are two groups, *serious hobbyist* and *casual photographer*, among users of Flickr mobile app. Both serious and casual photographers like to apply filters on their photos, but have very different motivations in mind. Serious photography hobbyists use filters as a photography tool to control for quality of the photo correct errors, manipulate colors and highlight certain objects. Although some of these motivations are common among casual photographers as well, the main motive among them is to make their photos look more fun, unique and special for sharing. Note that this suggests that filters play a social role (i.e., uniqueness) as well as their more obvious visual



Figure 1: Example of an original photo (top left photo) and many filtered variations. Some filters change contrast, brightness, saturation; some add warmth or cool colors or change the borders. Photos: © by ayman on Flickr.

one. After understanding how producers perceive and use filters, we take an additional step to examine role of filters in engaging photo consumers. We find that filtered photos are considerably more engaging than original ones—with filters that increase warmth, exposure and contrast boosting engagement the most. Our work explores a new path toward understanding social aspects of photowork. The findings of this work also provide several design implications, such as designing effective filters for both serious and casual use cases.

Background

In this section, we provide background and motivation for our work from previous literature. We first provide some background in impact of content on user behavior and engagement. We then, discuss prior research in studying visual content on social networks. Finally, we provide background on filters and visual effects in photography.

Role of Content on User Engagement

Much research attention has gone into investigating what makes content in an online community interesting to its members. For example, on Twitter, researchers have used retweeting as a measure of community interest/engagement, and have investigated the features that predict retweeting. Suh et al. (2010) found that the presence of URLs and hashtags in tweets predicted more retweeting, as did a richer connection with the community. More recently, Gilbert et al. studied Pinterest, a social networking site based on images, and found the properties of an image that makes the content more interesting to users (2013). The properties used in this work are based on meta data and not the content of images.

When it comes to visual analysis of content of photos, there is little existing scholarly work. In a recent piece, Hochman et al. analyzed colors in photos uploaded to Instagram from two different cities of New York and Tokyo and found differences across the two locations (Hochman and Schwartz 2012). For instance, hues of pictures in New York were mostly blue-gray, while those in Tokyo were characterized by dominant red-yellow tones. In another Instagram paper, Bakhshi et al. studied the engagement value of photos with human faces in them (2014). They found that photos with faces are more likely to receive likes and comments. Another study on Instagram, performed visual analysis of

the photos to group them into different categories and analyzed each category of photo in terms of popularity (Hu, Manikonda, and Kambhampati 2014).

Photos, Communication and Social Behavior

The camera phones became the most predominant consumer imaging device (Van House et al. 2004); resulting in increasingly large visual datasets representing a range of technology mediated social practices. Yet, most of the existing research focuses on the sending of images and the range of ways in which people use their camera phones (Ling, Julsrud, and Yttri 2005; Mäkelä et al. 2000). Traditional qualitative approaches to image analysis are typically designed to highlight nuanced social and cultural cues that contribute to an image’s meaning (Mitchell 2011; Rose 2012). Some other studies have reviewed the types and context of communication carried out via MMS, including using camera phones for work-related communication and for certain aspects of domestic communication, such as problem-solving and time management (Frehner 2008; Scifo 2005). Some research concentrates on users and their use of technology through interviews (Kindberg et al. 2004; 2005; Koskinen 2005). However, these techniques can also be time consuming to perform and can produce subjective results that limit generalizability.

Automated processes for image recognition using computer vision techniques (Bhatt and Kankanhalli 2011; Branson et al. 2010) are effective for annotating content in very large collections of images but are not designed to support interpretivist techniques for understanding the meaning images carry beyond literal depiction. Previous literature shed light on those aspects of images that can help with social connections and have potential to promote social connections in the online space (Lin and Faste 2012). Contextual interviews focusing on users’ photo sharing, organizing, and viewing behaviors indicated that people are socially motivated by photographs, are selective in what they view, and use photographic narratives to correspond with others and to browse information. Looking across image data collected from several online communities, McDonald (2007) identified four types of visual conversation styles evident through posted images (positional play, image quote, text-in-picture, and animation).

Previous research in psychology and art history suggest that pleasing and dynamically balanced composition in photos arises aesthetics value in an image (Arnheim 1983; 2001). There are some experimental research in cognitive psychology that confirms these findings (Locher, Jan Stappers, and Overbeeke 1998; Locher, Stappers, and Overbeeke 1999; McManus, Edmondson, and Rodger 1985).

Filters and Visual Effects

Recent work on creativity found that digital artifacts that are special are often self-made, such as presentations, animations and photo montages (Petrelli and Whittaker 2010). These results have shown that crafting and making with digital media can make these media more special or cherished, and in fact, being self-made or augmented appears

to be one of the main reasons people cherish their digital possessions (Golsteijn et al. 2012; Odom et al. 2009; Rosner and Ryokai 2010).

Digital images are stored in the form of picture elements or pixels. The process of editing can change the pixels to enhance the image in many ways. Camera or computer image editing programs often offer basic automatic image enhancement features that correct color hue and brightness imbalances as well as other image editing features, such as red eye removal, sharpness adjustments and automatic cropping. These tools are complex and more catered to experts rather than end users. Filters, on the other hand, are tools that give users the opportunity to enhance their photos, without the need to go through professional software. Most photo filters manipulate colors, saturation, light exposure or simulate a change in focus. There are different use cases introduced by each filter. Filters can age a photo, make colors more vibrant, or give photos a cooler color temperature. Some filters overlay masks in the image or add borders or frames (Meehan 1998). Figure 1 shows some of the filter effects on a sample photo. Instagram and Flickr are among the most popular mobile photo-sharing platforms that provide users with a variety of filter choices.

Our work. When it comes to online practices and mobile photography, our understanding of visual values of photos and their impact on user experience and engagement is limited. In this work we aim to study the perception of filters through the eyes of both producers and viewers (consumers) of photographs. To our knowledge, our work is the first to look at filtering and visual post-processing practices on photo sharing communities, it is also the only study looking at the impacts of these visual effects in engaging users.

Method

We use a mixed-method approach to answer our research questions. Our goal is to understand both perspectives of photographers (producers) and viewers (consumers) in filter use. Our approach is two-fold: first, we take a qualitative approach and interview 15 users of Flickr mobile to gain deeper insight into motivations behind using filters. We opted to use a qualitative approach towards understanding producers because there is limited data available on the site on motivations of photography and filter use. Then, we focus on viewers impression of filtered photos by looking at quantitative data obtained from Flickr activities. There is limited knowledge to gather from qualitative methods to understand engagement and value of filtered photos in the eye of viewer. For this purpose, the Flickr log data helped us to understand the consumers’ perspective in a large scale.

Qualitative Approach: Participants

To understand what photographers have in mind when filtering their photos, we opted to use a qualitative method. To recruit participants for our study, we emailed a pre-screening survey to a database of potential study participants. We screened for Flickr users who used the mobile app at least a few times a month. This assured that they were familiar with the app and the filter options through the mobile interface.

Motive	Example
improving aesthetics	make the clouds look distinct from the sky
adding vintage effects	give an old look to an old theater
highlighting objects	focus the attention on the face
manipulating colors	change the saturation of food
making photos appear more fun and unique	emulate film by removing colors from a portrait of an old man

Table 1: Summary of users’ motives in applying filters on their photos. We provided an example for each motive.

Nine of our participants mentioned that they use the web interface, though our interview didn’t focus on this usage. Those who matched our recruitment criteria were scheduled for a 60-minute interview session.

We received over 50 responses and conducted interviews until we reached data saturation after the 15th interview, hearing consistent stories about attitudes and behaviors with respect to their Flickr use. Of the 15 participants, 10 were interviewed in person and 5 were interviewed remotely through telephone and Skype. In all the sessions, participants were video-recorded. All participants were located in the United States. Those interviewed in person were located in the San Francisco Bay Area. The sample consisted of 5 women and 10 men ranging between 29 and 53 years old, with a median of 35. During the interview sessions, we mostly asked about participants use of camera phone, Flickr app and other photo sharing apps such as Instagram. We then asked participants to choose random photos from their photostream and explain why they filtered it or left it as original. Additionally we asked them to apply different filters on their choice of unfiltered photos and explain which filters work better. At times, we asked them to go back to their photos and describe how filtering changed the ways the photo looked. Other than the mobile phone camera, eight of the participants stated that they own digital SLR cameras. The other seven used their phone as their primary photo taking device. We iteratively coded interviews for emerging themes using an inductive approach (Wolcott 1994).

Quantitative approach: Flickr Mobile Data

To understand the role of filters on engaging users, we perform a large-scale quantitative study on Flickr. We randomly collected public photo meta-data from Flickr through their API; these photos were identified by the API as having been uploaded from Flickr’s or Instagram’s mobile app. In total, the dataset consists of over 7.6 million photos, approximately 4.1 million posted from Instagram and 3.5 million from Flickr’s mobile app, uploaded between late 2012 and mid 2013. We identified whether they were posted as original or filtered by checking their machine tags, auto-generated tags from the uploading application. For this study, we wish to predict engagement using two dependent variables: implicit usage (viewing a photo) and explicit ac-

tions (commenting on a photo) (Yew and Shamma 2011).

Implicit dependent variable. We use the number of *views* of each photo as an implicit measure of behavior. It quantifies the number of distinct users who viewed the photo.

Explicit dependent variable. *Comments* are explicit forms of actions taken on each photo. The number of comments quantifies the number of distinct comments users posted on the photo.

Control features. Every user on Flickr has a *photostream* which can be viewed by other users, depending on the privacy settings on a per photo basis. Tags on Flickr are used by the search index to help people find photos. We use the photostream views and tags as controls for finding photos, either through user's stream or direct search.

The Flickr relationship model between people is asymmetric: users form into social networks based on "follow" relationships. The number of followers is our measure of the user's audience size. This is a powerful and intuitive control, as we would expect users with larger audiences to have higher baseline probability of being viewed or commented on by their followers. We also use the *account's age* measured in months as a measure of seniority of the user on the site. The longer a user is on Flickr, the larger this value.

Filter feature. Filters are the focal point of our study. For every image, we identified whether it was shared as original or was filtered before it was shared by checking its machine tags. We coded *is filtered* as a factor variable, with a value of 1 for filtered photo and 0 otherwise. Figure 1 shows an original photo and examples of a variety of filters applied to it.

Further, we reverse engineered each filter by comparing the red, green, blue, and luminosity histogram channels of the uploaded no-filter image with a filtered one. This allowed us to describe a filter as a change in saturation, contrast, color temperature, and/or exposure. The filters which added an aging effect, through the introduction of dust, scratches, and noise, were visually identified as well. We use these features as descriptors based on the theoretical frameworks around colors, saturation and lighting effects (Gorn et al. 1997; Guilford 1934; Guilford and Smith 1959; Hemphill 1996).

RQ1: Producers' perspective

To answer our first research question, we conduct interviews with Flickr mobile users. Among the users of the mobile app, we find two main groups: (1) Those who consider photography as a serious hobby. These users usually own a professional or semi-professional Digital SLR camera that they use aside from their mobile devices. They have knowledge of photo processing with softwares and they care about the quality of photo they take and process. They use their mobile phone cameras for unplanned events, whenever carrying a camera is intrusive or when they do not need high resolution. (2) Those who take casual photos mainly for the purpose of documenting objects, events and people and sharing them with their family and friends. This group of users are not familiar with photo post-processing outside of filter use. We will discuss the differences in filter use between these two groups later in this section.

Why Use Filters?

We find a variety of reactions toward filters among our participants; six of them almost always filter their photos, six of them filter their photos occasionally (depending on the photo) and three participants are familiar with filters but do not use them. Table 1 summarizes the reasons participants mentioned as their motivations for filter use. These motivations may overlap in certain scenarios and are not necessarily exclusive.

Improving aesthetics. One of the main motivations for filter use is to enhance a photo and correct for brightness, saturation, contrast and focus. While one would expect that the general goal of filtering is to improve aesthetics of the photo, this reason is more popular among the serious photography hobbyist because mobile phones do not give many options to control for such factors inside the camera. On the other hand the serious hobbyists are more knowledgeable about quality photography and so more inclined to fix errors and make their photos look more professional looking using filters. The user can upload the photo through the app and use filters to apply certain effects; for example increasing the contrast so the clouds can be more visible in the sky:

"Sometimes you want to, where you'd take a picture of clouds, to show the clouds, then you have to somehow enhance those little differences between the sky and cloud, so you would enhance the contrast, then I look for those filters."
(P6)

The filters that are used for enhancement are usually milder in the effect intensity and are applied to enhance the photo while keeping the main imagery or the subject with minimal alterations. Some of the participants who were interested in applying filters to their photos for the purpose of enhancing their photos shared the concern that having strong filters might devalue the main image.

Adding vintage effects. Sometimes producers use filters to give their photos a look and feel that is relevant but non-existent. For example a few of participants mentioned that they like to make their photos black and white whenever the existence of the color is not necessary to the aesthetics of the photo. One of the popular subjects of black and white filters are photos that want to bring out attention to a certain texture rather distract viewers with colors (see Figure 2). Another reason mentioned by participants for applying black and white filters is to give an older look to the image or emulate film:

"It's my favorite bar in San Jose, it's called Singlebarrel and it's kind of an old speak-easy theme, like in the 20s. I just thought that [black and white] fit the theme of bar better."
(P3)

Aged look is another popular feature introduced by the filter apps. The sentiments toward using this feature is highly variant across participants. Some participants stated that they love using the sepia tones and the aged look effects on their photos, while some other (more of serious hobbyist group) found it too artificial.

Highlighting objects. Sometimes filters can help bringing out the focus to a certain object in the photo. This feature in filters is very popular, specially for photos of people where

the focus is mostly the person and less the surroundings. Sometimes the photographer wants to bring out certain aspects of the landscape that in the original photo might not be recognizable, or remove certain distractions so that the feature stands out. Figure 2 is an example photo in which our participant applied black and white filter to emphasize the roughness of the landscape:

“Its a lake that had no water in the winter. This is now covered with water and this [the hill area] was all brown and this [trees] was green. I think it had more to say with the roughness of the landscape. I didn’t want to actually show the soil and the trees. I wanted to show the roughness of the landscape, the reflection of the water, the fog and this.” (P6)

Another example where the participant mentioned how filters helped him to focus the attention of the viewer on the main subject of the photo:

“I have a shot of my children from the back and they are looking at something, so I use the filter to give it kind of a very subtle kind of border that focuses their attention a little bit more on the foreground and less on the background.” (P12)

Manipulating colors. Many of the current filters on Flickr and Instagram apps manipulate the colors by adjusting saturation, brightness, contrast or simply by changing the color gradients into warmer or cooler colors. Our participants mentioned that one of the main uses of filters is to either emphasize on certain colors or reduce the diversity of colors in a photo:

“I tend to filter just about almost everything, depending on what I’m trying to draw attention to in the picture. Say, I’m trying to bring out the color of something, I’ll use a filter that does that, or if I wanted to make it look like aged or something, I’ll do something that way.” (P3)

Some of the participants also mentioned how they use filters to adjust for the right levels of saturation and brightness in colors:

“I’d just try to play around with the saturation to get all the bright colors. I like to do this once in a while. I just go through all the different filters and see which one looks better.” (P11)

Making the photos appear more fun and unique. Other than primarily photographic motives, sometimes filters help users give their photos a fun and unique look that they could not capture through the camera. The goal of this filter is to impress the viewers and so the motive is more social and more popular among the casual photographers. Our casual photographers who do not have much knowledge of photography as an art, described the filters primarily as tools that make the photos more special:

“They make some pictures more fun and more interesting and more unique. That being said, because most of the pictures that I’m sharing are just get across pictures of my baby to show my parents or whatever. I don’t feel like they’re the target audience.” (P5)

Sometimes these fun and unique looks are not imagined by the photographer or not intended until when the filter is applied:



Figure 2: Participant describes how the black and white filter helped him show the roughness of the landscape (Photo used by permission of the participant).

“Sometimes, it’s hard to imagine what I can do with the filters until I get to it. Even when I’m taking the picture. For instance, this picture [Figure 3] was taken at Central Park. When I clicked it, I just clicked it because it was looking good that day. I came back and I tried that, displaying it within filters, and I realized that this filter looks good. It gives it a particular look that I could not have even thought of before I applied it.” (P2)

Serious Hobbyist vs. Casual Photographer

As we briefly mentioned earlier, there are differences in filter use among serious hobbyist photographers and the casual photographers. While serious hobbyists like to use filters as enhancement methods for correcting errors in their photos, casual photographers take advantage of filters to make their photos more special and fun. That said, serious hobbyists are more selective with filters, having specific filters in mind to correct for lighting, focus and color manipulations. Casual photographers, however, are more open to new types of filters and often go through multiple filters before choosing one.

Serious hobbyists are interested in subtle changes where the value is mostly in the imagery itself while mild filters made some of the details more visible. They express their dislike in Instagram-like filters where the image completely changes by filters:

“I don’t want the treatment of the image to detract from what’s happening in the photograph. A lot of these apps, they just pile stuff on top of stuff on top of stuff, so they have scratchy lens, scratchy film, vignetted, soft on the edges, hyper saturated, super desaturated, super high contrast. Basically, pardon my French, they’re taking a really shitty photograph, and they’re putting so much stuff on top of it that it doesn’t really matter anymore. You don’t even see the image.” (P10)

Some of them also expressed concern in how filters might devalue the art in the image by making it easy for casual photographers to create beautiful photos:

“My 10-year-old cousin, he takes the app. He takes the photo. He passes it through filters and it’s beautiful. You feel great

and you feel a bit sad. Sad because the actual art in it is lost into the filter” (P6)

For casual photographers, the act of sharing is the primary intention when taking mobile photos; While in case of serious hobbyists the image itself is the most important. Our casual participants confirmed that when they take photos with their mobile phones they usually think of their audience interest on social media or Flickr.

When is Original Better than Filtered?

There are a lot of cases when users prefer to share the photo without filtering it. A few the participants mentioned that the practice of applying takes times and effort and so they do not always want to put the effort into filtering their photos. These set of users only filter those photos that they think are worth the effort. Photos that have special people or subjects in them are among those. Other times the original photo is of good quality and the photographer does not want to change the content of the photo with filters because the details captured in the photo might be lost.

“This is a photo taken from above a little cove and it’s a pretty fast shot at waves breaking. There’s enough going on in the photo where it’s not a static landscape or anything. The movement was interesting and it isn’t too washed out color-wise. I felt it was enough was good about it that I didn’t need to start messing with it.” (P1)

On the other hand some participants, specially those with lower tendency of using filters, mentioned that some of the filter effects are too bold and too much to the extent that it detracts from the image itself.

“In some ways when I think of Instagram, I think about it as very filtered pictures. The sort of pictures I’m taking, because I would like to be a bit artsy, I’m tending to find a clean shot of an object or an angle is a little bit more my language for expression. I’m intrigued by the filters. If I can add that in a way that makes sense in due course, then I’m definitely interested.” (P15)

Another reason that users might not use filters on their photos is the subject of the photo. Sometimes the subject is important to be captured in its reality and without alterations. These subjects usually have memory values so that the user wants to remember the subject in its original way:

“Like if I’m taking a picture of my frog, I want like that actual frog. I don’t want a filter. Like usually if it’s like something natural or organic, I don’t want a filter applied... For example, this was a private art sale. For this, I didn’t use any filter because I always wanted to remember that painting the way it is in its natural state with good light in Carmel, like a painting. Something like a painting because you really want to capture the painting as it as intended to be viewed.” (P4)

Sometimes the photo is taken to document a certain event or people and so alteration would spoil the original purpose:

“Generally, if it’s in a group shot, it’s about capturing the memory of that moment, I wouldn’t apply filters on it. I would try to keep it as original as possible. It’s not for the art. It’s for capturing the moment.” (P2)



Figure 3: Participant describes how the filter surprised her with a new look for the photo that she did not imagine while taking the photo (Photo used by permission of the participant).

To summarize, we found that two main groups of mobile photography users, the serious hobbyist and the casual photographer, use filters to improve aesthetics of their photos, manipulate the colors or highlight certain objects. We also find that although more common among casual photographers, mobile app users like to apply filters to transform their photos into fun and unique looks or add artificial vintage effects. Next, we describe how filters are perceived by the large scale audience on photo sharing communities like Flickr. Are they engaging the viewer more or less than the original camera photos?

RQ2: Consumers’ perspective

In the previous sections we asked people about their own intentions and motivations in filter use. To broaden our view, we next consider how viewers engage with filtered photos. Particularly, we ask what effect their choices to use filters have on people who view those photos. While the photo creator’s motivations are essential to understanding filter work, it is also important to understand how the general audience engages with such content.

For this purpose, we conduct a large scale study on photos shared by Instagram and Flickr apps on Flickr and evaluate the role of filters in engaging users. A large quantitative study here helps us evaluate the role of filters on the general Flickr users. We use a dataset consisting of 7.6 million photos’ meta-data collected from Flickr. We use two regression models to study the effect of filters on engagement. Each model takes the number of views and comments as dependent variables, considering control and filter features as predictors. Specifically, we use *negative binomial* estimators, because views and comments are highly skewed count measurements that cannot include negative values. The regression coefficients β , table 2, allow us to understand the effect of an independent variable on the number of views/comments. To be able to compare coefficients, we *z*-score all numerical variables before performing regression.

Variable	β_{views}	β_{comments}
is filtered	0.19	0.37
followers	0.58	1.21
photostream views	0.59	0.46
tags	0.28	0.003
account's age	0.04	-0.18
(Intercept)	2.26	-2.77

Table 2: Results of negative binomial regression with number of views and number of comments as dependent variables. For all coefficients $\text{Std.Err} < 10^{-2}$ and $p < 10^{-15}$. The results show that a filtered photo is 21% more likely to receive views and 45% more likely to receive comments. Other variables are used as controls.

Both engagement models show significance, $p < 10^{-15}$, for all predictors. We use the Chi-squared Test to find the significance of the regression model, by computing the reduction in deviance from a *null model*. For our model for the views, we found the reduction in deviance $\chi^2 = 7.4M - 5.9M$, or a 19% drop, on 5 degrees of freedom. For the comments model, we find reduction of $\chi^2 = 1.3M - 0.94M$, or 28% drop, on 5 degrees of freedom. The test rejected the null hypothesis for both models, $p < 10^{-15}$; hence, the regression models are well-suited to characterize the effects of the independent variables.

Photo Views

As expected, the views model shows that the largest coefficient belongs to photostream views: as more users view a photostream, it is more likely for a photo in that photostream to be viewed as well. It is also expected that the number of followers is another large contributor to the number of views. The follower/following relationship on Flickr allows followers of a user to see all public photo updates of that user in their feed. The larger the number of followers, the greater the audience of the shared photo and hence it is more likely for the photo to be viewed.

Tags on Flickr have an important role in finding photos as they are highly used for search. From our views model, we can conclude that the more tags a photo is associated with, the higher the number of views. Overall, all three ways of searching that leads to viewing a photo, either through photostream views, followers list or tags list are common ways to increase the number of views. Our results also show that the account's age has a positive but small role in the change in views.

Our main objective is to explore the impact of filters on photo engagement. With regards to view count, our results show that filters are indeed strongly positively correlated with the number of views. Existence of a filter can increase the chances of photo being viewed by other users by 21%. We calculate the percentage by replacing the coefficients in the negative binomial equation.

Variable	β_{views}	β_{comments}
warm temperature	0.06	0.23
increase saturation	-0.02	0.07
increase contrast	0.08	0.13
increase exposure	0.10	0.16
age effect	0.06	-0.08
(Intercept)	2.04	-2.69

Table 3: Results of negative binomial regression with number of views and number of comments as dependent variable. The filter features are used as independent variables. For all coefficients $\text{Std.Err} < 0.02$ and $p < 10^{-10}$. The results show that warm temperature, higher contrast, and higher exposure increase chances of receiving views and comments.

Photo Comments

In the comments model, the photostream views has a large positive coefficient but ranks second after the number of followers among predictors. This shows that the number of followers is far more effective in explaining the comments than the photostream views. We also observe from the model that the effect of tags ($\beta = 0.003$) is negligible, giving most of the credit to the number of followers. Given that commenting is a more social type of engagement compared to views, it seems intuitive that the followers contributes the most to it's variance. On the other hand, our results from the comments model show that the account's age effect is negative ($\beta = -0.18$). In effect, the long term site users are less likely to receive comments on their mobile posts than the new users. This is surprising and suggests future work to further explain these observations. We observe a strong positive relationship ($\beta = 0.37$) between comments and filtered photos. This means filtered photos receive 45% more comments than the original ones.

Which Filters Impact Engagement?

So far we looked at why people use filters and how it impacts the photos engagement. Now, we ask: What makes filters engaging? Are all filters equally engaging? What photo transformations increase the likelihood of being viewed and commented on? In this section, we investigate the properties of filters that make them engaging.

We extract certain transformations, commonly used in photo filters, and use them as predictors in our models. The features identify whether the filter has a warming effect, aging effect or adds saturation, contrast or exposure. We use views and comments as proxies for engagement and we construct *negative binomial regression* models. Both models rejected the null hypothesis of Chi-Squared test, with $p < 10^{-15}$. Table 3 summarizes the β coefficients for both models.

The results show that an increase in contrast and exposure positively affects the number of views and comments. This confirms some of the findings we had in the motivation section where participants mentioned that they use filters to bring out colors or concentrate on certain objects in

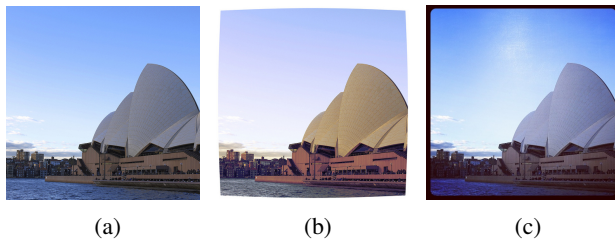


Figure 4: Examples of (a) a raw image and (b) an engaging filter that adds contrast and warmth, and (c) a less-engaging filter, which introduces artifacts and adds a cooler temperature. Photos: ☹️📷👤 by ayman on Flickr.

the photo. Many of the participants in the qualitative study mentioned that they prefer filters that bring out contrast more often:

“Graphite and Noir are black and white and they bring out the contrast more than the other pictures. I like high contrast pictures.” (P2)

Filters with warm temperature significantly increase number of comments and their effect on number of views is also positive. The aging effect seem to increase the views but decrease the number of comments. Our participants also showed interest in some of the filters that add aging effects and introduce warm colors:

“I like Sepia looks. Sepia looks with high contrast. Sepia looks usually have low contrast, whereas I like Sepia looks with high contrast on similar image like this. For that, I have to play around with, to get that look.” (P2)

We also find that effect of saturation on views is small and negative while on comments, it has a positive impact. Figure 4 shows examples of some filters that are engaging and some that are less-engaging.

Photographically speaking, filters which auto-enhance a photo (e.g. correct for contrast and exposure) drive more engagement. We find the less-engaging filters exhibit transformation effects which are exaggerated and often cause photographic artifacts and/or loss of highlight details. The exception being filters which make a photo look antique.

Discussion and Implications

We conduct a mixed-method approach toward understanding perspectives of producers and consumers of filtered mobile photos. Through conducting interviews with 15 Flickr mobile users we find that most users like to apply filters on their photos. We find two groups of Flickr mobile users; the first group are serious photography hobbyists who own professional cameras aside from their mobile devices. They have knowledge of photo post-processing outside of mobile filters. This group of users use their mobile cameras for convenience and availability. Those of them who apply filters on their photos use the mild effects mostly to correct errors, enhance the photo or bring out colors or objects. Those who do not use filters as much are mostly concerned about the artifacts and artificial look of filters on their photos.

The second group of Flickr mobile users mainly rely on their phones for taking photos. They are casual photographers who enjoy recording moments or events in their daily lives and share them with their friends and family. The casual photographers like to give cool and unique look to their photos by applying filters. Filters help them make their photos appear cooler and sometimes more fun. Some of them do not use filters due to them taking more effort and time. We find that sharing is main purpose of filtering for casual photographers and as we saw in the quantitative analysis part of the paper that filtered photos are more engaging.

Through quantitative analysis of mobile photos, we find that filtered photos attract more implicit usage as well as explicit action from viewers. Filtered photos are 21% more likely to be viewed and 45% more likely to receive comments, compared to non-filtered ones. Specifically, we find that filters that impose warm color temperature, boost contrast and increase exposure, are more likely to be noticed. Other filters showed no significant effects (See Figure 4). We control for several features that might affect a photos’ engagement. We find that the number of followers strongly influences both views and comments. This is intuitive, as a higher follower count increases photo distribution. Similarly, we also see photostream views are positively correlated with photo views and comments. The number of tags is also a driving factor for views but not for comments. The relative importance of followers compared to photostream views is stronger in comments than views, suggesting stronger social dependency in comments.

These results highlight the motivations behind using filters and how it might impact the perceptions of the viewers. We have shown that many casual photographers enjoy filtering their photos and so filters made post-processing easier for those who do not have knowledge of photography. There is some concern that pre-made filters reduce the value of the art presented in the imagery; however, we also find that the serious photographers are able to distinguish between photos filtered in a professional way compared to the ones filtered for artificial cool looks.

On the other hand our findings show that filters might directly impact the level of engagement on photos. Our results also connect to psychological studies of color (Guilford 1934; Guilford and Smith 1959; Hemphill 1996), and they emphasize the importance of emotionally evocative visual content. Our work echoes the findings of earlier text-based studies: emotional activation is an important underlying driver of engagement within online social networks (Hutto, Yardi, and Gilbert 2013). In color theory, warm colors such as red and yellow are known to elicit feelings of arousal and cheerfulness, and our results seem to echo this (Walters, Apter, and Svebak 1982). Our findings shed light on how to construct engaging content; filters influence the engagement on Flickr. Although we do not claim that every image filtered will be viewed significantly more, on average filtered image seem to affect an observer’s likelihood of engagement.

Design Implications

Our findings provide several design implications for mobile photo-sharing communities such as Flickr and Insta-

gram. We showed that the mobile photographers belong to the two groups of serious hobbyist and the casual photographers. While there are many similarities in their use of mobile phones for photography, many of their editing needs and aesthetics values differ. Considering these two groups of users and their expectations from the filters can help designing for better user experience. For example, the app can offer tuning options on each filter. As we mentioned earlier, many of the serious photography hobbyists prefer their effects mild and filters to be less noticeable. On the other hand the casual photographers like the artifacts that make their photos visibly different and unique. Allowing users to tune the changes of a filter on their photos will help both groups.

Our findings can also be used to improve filter construction. While filters seem to be related to content usage and social engagement, not every filter works equally in driving views and comments. The filters which increase the saturation, for example, do not drive engagement as much as warm temperature, high exposure, high contrast filters. Designers can use the findings of this work to build photo feeds that takes advantage of photos with such filters, or include the findings of this paper in algorithms that decide what is trending or popular, or design filters with engagement in mind. Additionally, the present findings may shed light on how to filter, prioritize and highlight photos from the global image stream, especially ones that have just been submitted and therefore haven't had time to accumulate very many views and comments.

Theoretical Implications

Above, we explore design-oriented research questions that may help shed light on our findings. We believe the present research also suggests new directions for Computer Mediated Communication (CMC) theory. Researchers have found that a creative touch on digital artifacts such as photo montages makes them more special and cherished (Petrelli and Whittaker 2010). In this work we show in a large scale that filtered photos are more viewed and commented on. Could this be due to aesthetics enhancements of filters on the photos or due to value added by personal creative touch? We like the self-made or augmented artifacts more, but could this also affect our viewers on social media? Researchers might leverage this work to investigate the role of creativity and personal touch on large scale viewer's engagement.

This work is a first step opening a larger set of research directions and areas of investigation. While we find how people use filters and that filtered photos are more likely to engage users, we can't say how much of this effect comes from the content of the photo. For example, is it that users filter their engaging content before sharing, or that filters increase the engagement of the photo? Regardless of the cause, our findings invite deeper analysis of content of the photo and its impact.

We see in this work that users like to apply filters on their photos even though it is a time-consuming process and requires spending more effort. This suggests that post-processing as a tool to enhance photos can motivate creations. Many of our participants mentioned that the changing their photos through filters makes those photos more special

and fun. We also see that the viewers tend to engage with those photos more than the original snapshots. This opens a new question for researchers of CMC: Are filtered photos more engaging and fun because of the filters or simply because they are result of personal creations?

Future work can also look at other visual characteristics of multimedia and study their impact on online behavior. For example, computer vision techniques, from visual features to scene detection, can be used to further design of such applications and improve understanding of photo engagement. How does photo content change other explicit social behaviors, such as likes/favorites or sharing to other communities? Can we suggest more appropriate filters based on the color composition of photos? For example recommending filters that enhance brightness when the photo is too dark.

It is also worth considering how filters are used in different subjects. For example, are people using highly saturated filters on photos of food, while using aging filters on street photography subjects? Another direction for future work is to examine the intensity of filters on how they engage users. Are milder effects more likely to be engaging than the bold filters?

Conclusion

Filters are becoming increasingly popular among users of mobile photo sharing tools and sites. In this work, we take a first step towards understanding motivations behind filter use and their impact on user engagement. Our contributions are two-fold. First we perform a qualitative study to understand motivations of producers in applying filters on their photos. We find that both serious and casual photographers use mobile app filters on their photos. The serious hobbyists apply filters to correct their photos, expose certain objects or manipulate certain colors. More so casual photographers like to add artificial vintage effects to their photos and make them more playful and unique. Our second contribution is an empirical study on 7.6 million mobile uploaded photos to analyze the effect of filters on viewers' engagement. We find that filtered photos are more likely to be viewed and commented on. This work has several implications both for theory and design of technology.

References

- Ames, M.; Eckles, D.; Naaman, M.; Spasojevic, M.; and Van House, N. 2010. Requirements for mobile photoware. *Personal and Ubiquitous Computing* 14(2):95–109.
- Arnheim, R. 1983. *The power of the center: A study of composition in the visual arts*. Univ of California Press.
- Arnheim, R. 2001. *Art and visual perception*. Stockholms Universitet.
- Bakhshi, S.; Shamma, D. A.; and Gilbert, E. 2014. Faces engage us: Photos with faces attract more likes and comments on instagram. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*.
- Balabanović, M.; Chu, L. L.; and Wolff, G. J. 2000. Storytelling with digital photographs. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, 564–571. ACM.

- Bhatt, C. A., and Kankanhalli, M. S. 2011. Multimedia data mining: state of the art and challenges. *Multimedia Tools and Applications* 51(1):35–76.
- Branson, S.; Wah, C.; Schroff, F.; Babenko, B.; Welinder, P.; Perona, P.; and Belongie, S. 2010. Visual recognition with humans in the loop. In *Computer Vision—ECCV 2010*. Springer. 438–451.
- Frehner, C. 2008. *Email, SMS, MMS: The linguistic creativity of asynchronous discourse in the new media age*, volume 58. Peter Lang.
- Gilbert, E.; Bakhshi, S.; Chang, S.; and Terveen, L. 2013. I need to try this?: a statistical overview of pinterest. In *Proceedings of the sigchi conference on human factors in computing systems*, 2427–2436. ACM.
- Golsteijn, C.; van den Hoven, E.; Frohlich, D.; and Sellen, A. 2012. Towards a more cherishable digital object. In *Proceedings of the Designing Interactive Systems Conference*, 655–664. ACM.
- Gorn, G. J.; Chattopadhyay, A.; Yi, T.; and Dahl, D. W. 1997. Effects of color as an executional cue in advertising: they're in the shade. *Management science* 43(10):1387–1400.
- Guilford, J. P., and Smith, P. C. 1959. a system of color-preferences. *the american journal of psychology* 72(4):487–502.
- Guilford, J. P. 1934. The affective value of color as a function of hue, tint, and chroma. *Journal of experimental psychology* 17(3):342.
- Hemphill, M. 1996. A note on adults' color–emotion associations. *The Journal Of Genetic Psychology* 157(3):275–280.
- Hochman, N., and Schwartz, R. 2012. Visualizing instagram: Tracing cultural visual rhythms. In *Proceedings of the workshop on social media visualization (socmedvis) in conjunction with the sixth international AAAI conference on weblogs and social media (ICWSM-12)*.
- Hu, Y.; Manikonda, L.; and Kambhampati, S. 2014. What we instagram: A first analysis of instagram photo content and user types. In *ICWSM*. AAAI.
- Hutto, C.; Yardi, S.; and Gilbert, E. 2013. A longitudinal study of follow predictors on twitter. In *Proceedings of the sigchi conference on human factors in computing systems*, 821–830. acm.
- Kindberg, T.; Spasojevic, M.; Fleck, R.; and Sellen, A. 2004. How and why people use camera phones. *HP Laboratories Technical Report HPL-2004-216*.
- Kindberg, T.; Spasojevic, M.; Fleck, R.; and Sellen, A. 2005. The ubiquitous camera: An in-depth study of camera phone use. *Pervasive Computing, IEEE* 4(2):42–50.
- Kirk, D.; Sellen, A.; Rother, C.; and Wood, K. 2006. Understanding photowork. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, 761–770. ACM.
- Koskinen, I. 2005. Pervasive image capture and sharing: Methodological remarks. In *Pervasive Image Capture and Sharing Workshop, Ubiquitous Computing Conference*.
- Lin, C., and Faste, H. 2012. Photographic social media: a framework for design. In *Proceedings of the Designing Interactive Systems Conference*, 244–247. ACM.
- Ling, R.; Julsrud, T.; and Yttri, B. 2005. Nascent communication genres within sms and mms. In *The Inside Text*. Springer. 75–100.
- Locher, P. J.; Jan Stappers, P.; and Overbeeke, K. 1998. The role of balance as an organizing design principle underlying adults' compositional strategies for creating visual displays. *Acta Psychologica* 99(2):141–161.
- Locher, P. J.; Stappers, P. J.; and Overbeeke, K. 1999. An empirical evaluation of the visual rightness theory of pictorial composition. *Acta psychologica* 103(3):261–280.
- Mäkelä, A.; Giller, V.; Tscheligi, M.; and Sefelin, R. 2000. Joking, storytelling, artsharing, expressing affection: a field trial of how children and their social network communicate with digital images in leisure time. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, 548–555. ACM.
- McDonald, D. W. 2007. Visual conversation styles in web communities. In *System Sciences, 2007. HICSS 2007. 40th Annual Hawaii International Conference on*, 76–76. IEEE.
- McManus, I.; Edmondson, D.; and Rodger, J. 1985. Balance in pictures. *British Journal of Psychology* 76(3):311–324.
- Meehan, J. 1998. *The Photographer's Guide to Using Filters*. Amphoto Books.
- Mitchell, C. 2011. *Doing visual research*. Sage.
- Odom, W.; Pierce, J.; Stolterman, E.; and Blevins, E. 2009. Understanding why we preserve some things and discard others in the context of interaction design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1053–1062. ACM.
- Petrelli, D., and Whittaker, S. 2010. Family memories in the home: contrasting physical and digital mementos. *Personal and Ubiquitous Computing* 14(2):153–169.
- Rose, G. 2012. *Visual methodologies: An introduction to researching with visual materials*. Sage.
- Rosner, D. K., and Ryokai, K. 2010. Spyn: augmenting the creative and communicative potential of craft. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2407–2416. ACM.
- Scifo, B. 2005. The domestication of camera phone and mms communication. *NYIRI, K.(2005) A sense of Place. The Global and the Local in Mobile Communications*. Viena, Pasagen Verlag.
- Suh, B.; Hong, L.; Pirolli, P.; and Chi, E. H. 2010. Want to be retweeted? large scale analytics on factors impacting retweet in twitter network. In *Social Computing (SocialCom), 2010 IEEE Second International Conference on*, 177–184. IEEE.
- Van House, N. A.; Davis, M.; Takhteyev, Y.; Ames, M.; and Finn, M. 2004. The social uses of personal photography: methods for projecting future imaging applications. *University of California, Berkeley, Working Papers* 3:2005.
- Walters, J.; Apter, M. J.; and Svebak, S. 1982. Color preference, arousal, and the theory of psychological reversals. *Motivation and emotion* 6(3):193–215.
- Wolcott, H. F. 1994. *Transforming qualitative data: Description, analysis, and interpretation*. Sage.
- Yew, J., and Shamma, D. A. 2011. Know your data: Understanding implicit usage versus explicit action in video content classification. *IS&T/SPIE Electronic Imaging (January 2011)*.