

Accepted version, pre-print

Accepted May 12 2017 for publication in *Visual Communication*, officially published in Vol.18(1) (Feb 2019) or Vol.18(2) (May 2019).

Asko Lehmuskallio, Jukka Häkkinen, Janne Seppänen

Photorealistic computer-generated images are difficult to distinguish from digital photographs: A case study with professional photographers and photo-editors

Abstract:

There are strict guidelines on photoediting in newsrooms, and serious professional repercussions if failing to adhere to these, while computer-generated imagery is increasingly used in other areas of visual communication. This paper presents empirical research on the ability of professional photographers and editors to distinguish photographs from photorealistic computer-generated images by looking at them on a screen. Our results show clearly that those studied (n= 20) are unable to distinguish these from another, suggesting that it is increasingly difficult to make this distinction, particularly since most viewers are not as experienced in photography as those studied. Interestingly, those studied continue to share a conventional understanding of photography, that is not in line with current developments in digital photography and digital image rendering. Based on our findings, we suggest the need for developing a particular visual literacy that understands the computational in digital photography, and grounds the use of digital photography among particular communities of practice. When seeing photographs on screens, journals, exhibitions, or newspapers, we might actually be looking at computer-generated simulations, and vice versa.

Keywords: Computer-generated images; photography; simulation; digital culture; representation; photojournalism

1. Introduction

Press photographers need to adhere to strict guidelines in how photographs are shot, edited and published. With the advent of digital photography, discussions on the ethics of photo editing have resurfaced, discussions that documentary and news photographers have had to deal repeatedly with throughout the history of using photographic equipment. In recent years, photographers have been fired due to removing or adding content to images, Pulitzer-prize winning Narciso Contreras being only one famous example among many. He had retouched a photo of a fighter in Syria by removing from it the video camera of a colleague before sending the picture to the Associated Press.ⁱ

The discipline asked for in press photography concerns particularly photographic processes, that should leave decipherable traces in the images taken for, and published by, news media. Of particular concern in published guidelines are the technical characteristics of the photographs published.ⁱⁱ Has the picture been staged or re-enacted? Has content been removed or added?

In the field of journalism these questions regarding digital alteration have gained notable attention since the beginning of 1990s, and continue to this day (Reaves, 1992; Reaves, 1995; Schwartz, 1992; Huang, 2001; Lowrey, 2003; Mäenpää and Seppänen, 2010; Mäenpää, 2014). The discussions revolve around the ethical codes of photo editing (Solaroli 2015), the alleged objectivity of news photographs (Carlson 2009) and the empirical editing practices in newsrooms (Gürsel 2016). All of these discussions pay particular emphasis on the role that digitization plays, particularly since digital photographic practices seem to be more difficult to control and verify within journalistic practice.

While strict guidelines regarding photo-editing remain standard practice among photo journalists, computer-generated imagery is increasingly used in other fields of visual communication, such as advertising, cinema, and in TV series. When creating computer-generated imagery, render software

is used to create visualizations that have not been captured with a camera. If computer-generated imagery is photorealistic, it has a visual resemblance to images captured originally with a camera.

While photojournalistic practice focuses on uses of digital photo-editing, render engines, the software used to render images, already allow for creating photorealistic visualizations that may be difficult to distinguish from photographs. The at times heated discussions regarding uses of digital photography within press photography, and recent developments within computer-generated imagery point toward a seeming paradox in our understandings of photography. The images we see as photographs, might not contain any trace of an event outside of the photographic technology.

We will call the need to maintain a purity in photographic images a *conventional understanding* of photography, due to its reliance on conventions to maintain a particular causality in photographs. Of importance is here the idea that at the time a photographic image is taken something outside of the camera is actually having an effect on both the material surface of photographic film and, after developing and printing, to the photographic prints created. Here questions used to assess the images are the likes of: has the picture been staged or re-enacted? Has content been removed or added?

In the second case, developments in digital photography have been used to challenge this conception. Many scholars argue that digitalization has undermined the causal connection between a pre-photographic reality and the photographic image. WJT Mitchell claims that “[a]lthough a digital image may look just like a photograph when it is published in a newspaper, it actually differs as profoundly from a traditional photograph as does a photograph from a painting” (Mitchell, 2001, p. 3). Fred Ritchin (1991) suggests that the arrival of digital photography questions the role of photojournalism as bearing witness to events in news, due to the possibilities opened up for digital manipulation. And Rubinstein and Sluis (2013, p. 27-29) even write that the digital photograph “has to be considered as a kind of program, a process expressed as, with, in or through software. When the photograph became digital information, it not only became malleable and non-indexical, it

became computational and programmable.” Film-based and digital photography thus seem to be two completely different processes, digital photography being equated with computer-generated imagery.

We approach this apparent paradox by focusing on one detail that is of importance within these discussions: Can professional photographers, for whom a conventional understanding of photography is of importance for their professional practice, distinguish digital photographs from photorealistic computer-generated images by looking at them on a computer screen?

The rationale for the question is evident: If computational techniques for photorealistic image rendering are indeed so advanced that professional viewers cannot distinguish them from photos taken with a camera, our understanding of the digital photographic image, and of its relations have to be reassessed. This is particularly so, since many professional photographers still hold that it is utterly important to be able to make a distinction between strongly edited digital photographs – let alone purely computer-generated pictures – and photographic images taken according to a conventional understanding (e.g. Mäenpää and Seppänen, 2010). Basically, we are interested in finding out if ‘the aesthetic qualities of photography are [...able] to lay bare the realities,’ as André Bazin (1980) might have suggested, or if the distinction between digital photographs and computer-generated imagery has truly become indistinguishable, not just for ordinary people but also for highly skilled professionals.

Therefore we showed 20 professional photographers and photo-editors 37 pictures on a computer screen and asked them to look at each picture and answer a simple question: “Do you think the picture shown is a photograph or is it computer-generated?” Due to their expertise, these people should be particularly suited in making a correct distinction, particularly since the majority of respondents were acclaimed professionals working in news and press photography.

To make the task somewhat more interesting, we did not choose just any pictures, but border cases, that is images which we found difficult to distinguish ourselves, thus acknowledging that there

continue to be a variety of computer-generated images, as well as photographs, which remain relatively easy to distinguish from each other. The computer-generated-images we chose looked very much like actual photographs taken with a camera, whereas some of the pictures recorded with a camera contained elements that an untrained eye might take to result from render engines.

After each decision we asked the research participants to justify their choices in writing, as well as later to answer to questions in a short interview. This material was analyzed by paying special attention to two aspects: 1) are the studied able to make a correct distinction between photographs and computer-generated images?, and 2) what knowledge of photography do they rely on when making their distinctions both in writing and the interview?

In the following, we will provide an overview of prevailing discussions about our themes, present our methodology, including the choice of images, the experimental setting, and the choice of research participants. In going through the results of their decisions, we discuss the rationales those studied gave for choosing between digital photographs made with a camera and photorealistic computer-generated-images. Finally, we will discuss the repercussions our results have on the practices of looking at photographic images, arguing for the need to develop a visual competence that understands the computational in digital photography, and grounds the use of digital photography among particular communities of practice.

2. Related research

Particularly in the sphere of photojournalism and news imagery, the question of objectivity and trustworthiness of the images published is paramount. Photojournalism as a profession is a precarious undertaking, with reports of mass layoffs in many media outlets, a shift to assigning freelance work (Thomson 2016), and increased buying of images from stock-photo agencies (Machin 2004; Frosh 2013) and citizen photographers (Andén-Papadopoulos & Pantti 2013) for press publica-

tion. Photojournalists face various risks in their day-to-day work, and, besides living a precarious existence economically, many fear physical harm during working hours (Hadland et al. 2016).

Photos, especially from conflict zones, often must also be visually dramatic in order to be published (Solaroli 2015). Professional photojournalists learn a way of seeing, becoming skilled in particular photo aesthetics, which they can distinguish reasonably well from other aesthetics, such as those of citizen photographs (Quinn 2015). When searching for the right kinds of images while trying to make a living, some photographers have cut corners and manipulated photos before sending them out for publication. Publication of fake photos remains a major reason for firing photojournalists, and these fake items are widely discussed in news media (Carlson 2009). As a complicating factor, in times of using digital photographic technologies, the rules of what counts as fake and what does not are not always straightforward. A rule of thumb adopted by many photojournalists and professional societies is that of the imaginary darkroom principle (Mäenpää & Seppänen 2010). In essence, the idea is that the kind of post-processing that could be performed in darkrooms during the film era and that was usual then is acceptable with digital photo-editing software. The imaginary-darkroom metaphor follows the broader logic of a conventional understanding of photography. Debates of this nature have arisen within photojournalism because they affect hiring decisions, publications, and the winning of prestigious prizes.

Since the early 1990s, media theorists of numerous stripes have asserted that digital photographs not only are easy to manipulate but differ significantly from analogue photographs, maintaining that digital photographs should be considered to be, at base, computer-generated imagery. The argument is made by highlighting the difference in which the image captured with a camera is processed from a latent image into a visible photograph. If the image is captured on a light-sensitive emulsion on film, its processing is seen as following a “continuous translation,” as, for example, Bernd Stiegler puts it, whereas capturing on a light-sensitive semiconductor, such as a CCD chip, “occurs within a fixed grid and graticulate pattern in which each individual point or pixel is determined by a

numerical value and may accordingly be arbitrarily processed and transformed” (Stiegler 2004, p. 108–109; translated in Schröter 2011, p. 51).

This focus on the material basis of the technologies used is evidence for even claiming that “[t]he pictorial evidence of photography is dead, [...] photography as an authentic document has played out its role” (Stiegler 2004, p. 109–110; translated in Schröter 2011, p. 51). Daniel Rubinstein and Katharina Sluis (2013) argue for a fundamental dichotomy between analogue and digital photography by suggesting that the “algorithmic image” is non-indexical, without a causal relationship to the objects depicted, and that the only reason images on screens look like photographs would be “because of algorithmic interventions that ensure that what is registered on the camera’s CCD/CMOS sensor is eventually output as something that a human would understand as a photograph” (location 897).

These examples show that digital photography is, in this line of thought, equated with computer-generated imagery. The reference to something “out there” seems to be lost and is mainly constructed within computing systems. As will become clear from the discussion later, our perspective suggests an alternative line of argumentation, suggesting a rethinking of the computational in digital photography, applying neither the darkroom principle nor the claim about non-indexical algorithmic images.

Meanwhile, photorealistic computer-generated imagery has been explicitly developed in computer science, gaining particular interest among those working with digital signal processing, computer vision, computer graphics, and digital forensics. Early on, specific computer-generated simulations were already able to trick the human eye, undoubtedly spurring research and development activity. Humans’ judgements surrounding photographs and computer-generated images have been studied experimentally with relatively simple objects under basic illumination and also, later, in somewhat more complex settings (McNamara et al. 2005). Recently, Shaojing Fan et al. (2014) asked participants in a study to compare photographed and computer-generated faces. Since their interest

lay mainly in understanding what parts of faces are important for judging whether images of faces are photographs or instead computer-generated, in order to enable creation of better computer-generated simulations, we know from their work primarily that distinguishing these classes of image from each other is not straightforward and at times proves especially difficult.

Photorealistic images are widely used nowadays in advertising, catalogues, brochures, and news propaganda, and, interestingly, even some computer scientists have started becoming concerned about how to differentiate between photographs and computer-generated images. For example Lyu and Farid (2005, p. 845) cite as a motivation for their computational work: “If we are to have any hope that photographs will again hold the unique stature of being a definitive recording of events, we must develop technology that can differentiate between photographic and photorealistic images.” They have created computational techniques to distinguish the two kinds of images from each other, with a success rate of correct classification for approx. 67% of the photorealistic images tested and approx. 99% of the photographs in their test set. Others have followed the same path (for an overview, see Stamm et al. 2013), but, as far as we know, perfect computational solutions for differentiation are lacking. This is due to studies in computer science having to deal with a specific tension in the field: while some are especially interested in reliably distinguishing photographs from computer-generated images, others have the objective of creating photorealistic renderings for which this distinction cannot be made.

To the best of our knowledge, systematic judging between photographs and computer-generated images has not been explored among professional photographers and photo-editors, a group that should be especially well suited to distinguishing between these two kinds of images. Adding to the importance of studying photo professionals is their need to be able to note these distinctions in their everyday work, particularly in the field of journalism.

3. Methodology

In order to learn if professional photographers can tell by looking at pictures displayed on a computer screen if these are photographs or computer-generated images, we recruited 20 professional photographers and photo editors for an experiment, 8 males and 12 females, born between 1958 and 1991. All had experience with photo editing software, such as for example Adobe Photoshop and Lightroom. Only two of the researched had experience with rendering photorealistic images. All worked in Finland, and mainly within photojournalism, although some worked (additionally) in other areas, such as e.g. advertising.

The experiment consisted of showing the research subjects 37 pictures one at a time, displayed on a 29.7 inch Apple Cinema Display from an adjustable viewing distance, basically a chair in front of a work desk. The research laboratory had ordinary office lighting in order to simulate an encounter with these kinds of visualizations when working on one's own computer screen. The experiments were conducted in a research laboratory of the [blinded for review] by one of the authors and a research assistant.

Each image was shown once for as long as the research participants needed, in sequential order.

The respondents were asked to decide while looking at each picture revealed if the picture shown is a photograph, or if it is generated with a computer.ⁱⁱⁱ We asked the respondents to mark each decision on a separate laptop and to justify the decision in writing. After that they could select the next picture and repeat the procedure. After the respondents had gone through all pictures, they were asked oral questions about this differentiation, based on semi-structured questions that focused on the importance of this differentiation, its facility, the criteria that other people use for this distinction, and their definitions of photography and that of computer-generated images. The interviews were recorded and transcribed for analysis. After analysing our findings, we organized a meeting with the participants to discuss them. Of all researched, seven were able to participate in this latter meeting.

The pictures displayed were collected by two authors [blinded for review] using Internet search tools, focusing on a pre-selected photographic genre, landscapes and sceneries. The most important criteria for choosing computer-generated images was that they looked like photographs taken with cameras and fitted the selected genre. Photographs again only had to meet the criterion to be landscapes. Landscapes were chosen as a motif because software render engines are already very good for creating computer-generated landscapes, and pictures were widely available. Sources for pictures collected include image galleries from software developers (e.g. <http://planetside.co.uk/galleries/terrigen-gallery>) and online photo-sharing sites (e.g. <https://www.flickr.com/> and <http://www.deviantart.com/>). After we had collected the pictures, two of the authors went through all of them separately choosing only those computer-generated images that were hard to distinguish from photographs.

In order to test the feasibility of our setting, we conducted a pilot study with nine participants, including mainly psychology students and research colleagues. Encouraged by our initial results we contacted our networks for help to recruit research participants. In very much the vein as has been identified in science studies, we worked long in advance in order to create a setting that would, at least hopefully, provide interesting results vis-à-vis our research question (Latour, 1999).

Research subjects were searched via a personal visit to a major Finnish daily, by posting announcements to message boards and e-mail lists frequented by photojournalists, and by asking colleagues to help in recruitment.

The material collected for analysis consisted of the choices between a photograph and a computer-generated image, the written justifications for the selection, and the oral interviews conducted, which were transcribed for analysis. The analysis of the material collected is explained as we go through the Findings.

4. Findings

4.1. *Distinguishing photographs from computer-generated images*

We received a total of 725 answers to the selection task, of which 371 opted for “photograph” and 354 for “computer-generated image.” Of the possible 740 answers (37 pictures seen by 20 research participants) 15 are missing because one research participant was not able to finish the experiment in the time he had allotted to it, and two researched seem to have inadvertently skipped answering one question each.

None of the respondents was able to categorize all images correctly, the best result was 10 mistakes out of 37, while the worst result was 23 mistakes out of 37. This means that the success rate varied between 37.84% and 72.97%. When we averaged the ratings over the whole experiment, the mean percentage of correct answers was 55.49%, which is near guessing rate. For photographs and computer-generated images the percentages were 55.85% and 55.02%, respectively.

In order to see the statistical significance of our findings, we conducted a logistic regression analysis to the results with R statistical software. Logistic regression analysis is particularly suitable for analysing frequency data. The results show that the image type did not predict the participant categorization performance (Chi-square = 0.0384, $p=0.84$ with $df=1$), in other words the participants could not differentiate between photographs and computer-generated images. On the other hand, image contents predicted the categorization performance (Chi-square = 105.00, $p<0.001$ with $df=35$), which means that some images were easy and some images difficult to categorize. This is why we compared the odds ratios of the images (for odds ratio, see Peng et al., 2002). In Table 1. are presented the results for the photographs displayed. A small odds-ratio indicates that the photograph was more commonly mixed with a computer-generated image. A large value indicates that the photograph was often recognized as a photograph. The table has been sorted by the odds-ratio and the statistically significant odds ratios have been indicated by bold text. From the table it can be seen that there were seven photographs that were very often thought to be computer-generated images (images 4, 5, 7, 10, 17, 18, 30). This means, that in addition to not being able to

categorize these images correctly, in seven cases the respondents confused images from one category (photographs) with another category (computer-generated images).

Image	Total answers	Correct answers	Odds-ratio	z-value	p-value
10	20	3	0.05	-3.63	p<0.001
7	20	4	0.07	-3.41	p<0.001
4	18	5	0.10	-2.96	p<0.001
17	20	7	0.14	-2.65	p=0.01
30	19	8	0.19	-2.25	p=0.02
5	20	9	0.22	-2.11	p=0.03
18	20	9	0.22	-2.11	p=0.03
12	20	10	0.27	-1.84	p=0.07
32	20	11	0.33	-1.56	p=0.12
8	19	11	0.37	-1.37	p=0.17
31	20	12	0.40	-1.26	p=0.21
15	19	12	0.46	-1.06	p=0.29
20	20	13	0.50	-0.96	p=0.34
3	20	14	0.62	-0.64	p=0.52
26	20	14	0.62	-0.64	p=0.52
9	19	14	0.75	-0.38	p=0.70
34	19	15			
11	20	16	1.07	0.08	p=0.94
24	19	16	1.42	0.42	p=0.68
21	20	17	1.51	0.49	p=0.62

Table 1. Results for photographs

In Table 2. are presented the results for computer-generated images. A small odds-ratio indicates that computer-generated images were more commonly taken to be a photograph than a computer-generated image. A large value indicates that the computer-generated image was often recognized indeed as a computer-generated image. The table has been sorted by the odds-ratio and the statistically significant odds ratio has been indicated by bold text (image 28). From the table it can be seen that there was only one computer-generated image that was very commonly recognized as rendered, adding to our earlier conclusion that the respondents were in all other cases not able to distinguish between photographs and computer-generated images.

Image	Total answers	Correct answers	Odds-ratio	z-value	p-value
2	19	6	0.56	-0.86	p=0.39
23	19	6	0.56	-0.86	p=0.39
25	20	8	0.81	-0.32	p=0.75
13	20	9	1.00	0.00	p=1.00
35	20	9	1.00	0.00	p=1.00
33	19	9	1.10	0.15	p=0.88
1	20	9	1.10	0.15	p=0.88
27	20	10	1.22	0.32	p=0.75
19	20	10	1.22	0.32	p=0.75
22	19	10	1.36	0.48	p=0.63
37	20	11	1.49	0.63	p=0.53
36	20	12	1.83	0.95	p=0.34
29	19	13	2.65	1.46	p=0.14
6	20	14	2.85	1.58	p=0.11
14	19	14	3.42	1.79	p=0.07
16	20	15	3.67	1.90	p=0.06
28	20	18	11.00	2.75	p=0.01

Table 2. Results for computer-generated images

These results lead clearly to the conclusion that the studied image professionals, who work day-to-day with photography as photographers and/or editors, are unable to distinguish correctly between photographs captured with a camera and computer-generated images by looking at them on a computer screen. We believe this result to remain valid also within a wider population, since the respondents in our sample were explicitly selected to be among the most proficient people to distinguish photographs from other kinds of images. This is due to the importance of high standards in the ‘purity’ of photographs within their profession.

For aspects that remain today difficult to render photorealistically, as e.g. faces (Fan et al. 2014), the results would surely look different. Neither have we tested this categorization task with those creating explicitly rendered images that look like photographs to see if they would fare better.

Possibly working explicitly with render engines is helpful for learning more appropriate diagnostic criteria for distinguishing photographs from computer-generated images. Nevertheless, there is so much interest in advancing techniques for photorealistic rendering, that we are pretty sure that in

the future photographed faces will be as difficult to distinguish from computer-generated faces, as we found for landscape images among photo professionals. This is why our results have serious implications for our understanding of photography after its digitization, and particularly the work practices that photographs are embedded in.

4.2. *Justifying distinctions between photographs and computer-generated images*

Besides asking to choose if a shown image is a photograph or computer-generated, we asked our respondents to justify their decisions in order to discover how they understand photographs and computer-generated images. Additionally we were interested in the ways they distinguish these two. Using an open-ended semi-structured interview, we thus asked the respondents how they define a photograph, how they define a computer-generated image, how they think that others would fare in distinguishing photographs from computer-generated images, and if they think that this distinction is important.

The distinction was considered to be especially important particularly for those who work in photo journalism. The authenticity of photographs, and their connection to something out there in the vein of a conventional understanding of photography, was a dominant idea brought up by several respondents. Because the respondents worked with photography, and mainly had little or no experience with rendering engines for creating photorealistic pictures, the participants justified their distinctions mainly by comparing their knowledge of photographs to the pictures shown to them on a computer screen. Thus their idea of photography served as an orientational device for making their choices and justifying them.

The reasons given for deciding if the picture shown was a photograph or not can be divided into four types of rationales that focus on an understanding of 1) how photographs look like (their iconic quality), 2) how photographic equipment effects photographic imagery (the indexical quality of the

equipment), 3) what kinds of scenes exist “somewhere out there” and thus might be depicted as photographs (the indexical quality of the scenes depicted), 4) and what kinds of images photographs are, especially when contrasted to other kinds of images (the symbolic dimension of photographs). These categories are informed by a Peircean analysis of visual semiotics (Houser et al. 1992; 1998; Jappy 2013).

Taken together, these four rationales provide a core understanding of how the distinction between the photograph and a computer-generated image was assessed. Although the respondents differed in their evaluations of which picture shown would be a photograph and which a computer-generated image, they had both in written form and in oral interviews strikingly similar evaluations of what kinds of images photographs are. Thus, their understanding of photography seemed to follow a shared path.

4.2.1. *Is this distinction important?*

All interviewees, except for two, maintained that this distinction is especially important either on a general level when thinking about photographs, or then as part of contextual uses such as within journalism. For illustrative purposes, or in advertisements, this distinction was by many not considered to be as important, since the laying bare of realities is not considered to be a main task of pictures used for those purposes.

We quote a few interviewees in order to give a sense of the force of the felt importance for this distinction:

“It is important that photo professionals are able to distinguish these images from each other, so that we would not present computer-generated images in a wrong context.” R08

“Considering news imagery or journalism, then it is absolutely important. An image has to be authentic, if it is used to convey information, it is used in news, or it is used to convey facts. Then it is pivotal that the image is authentic.” R10

“Yes, definitely. Especially now that there have been several cases that manipulated imagery has been published as news images. It is very important to be able to differentiate these from each other.” R16

Since this distinction is considered to be especially important, we analysed closer the ways in which the research participants verbally explained on what grounds they had made their decision. By doing this, we wanted to know what the research participants used as their diagnostic criteria to assess how photographs look like.

4.2.2. *What do photographs look like?*

An important rationale given for deciding if a picture shown is a photograph or a computer-generated image dealt with qualities of the seen picture. For photographs, the amount of detail was of importance, the apparent randomness of the detail, a perceived natural rhythm, and at times an unsightliness became important diagnostic criteria. Computer-generated images again were thought of not being able to produce enough detail, creating predictable, repeated shapes, looking unnatural and at times too perfect, or then not good enough, displaying for example too many pixels.

In the following, these iconic criteria (following Peirce), have been marked in italics:

”*The amount of detail*, the variation in light and shadows. The patches and fallen trees in the forest, *the areas, where stone changes to forest.*” R10

”It might be a computer-generated image, but *since there are not too many recurring patterns*, I’d say it’s a photograph.” R6

”The clouds between the hills, *the amount of detail also there, where one’s look would not directly go to.*” R8

”The *amount of detail, the randomness and the ”mistakes” within the world of the image, bad lighting in the foreground.*” R5

These visual, iconic qualities give a sense of how the researched identified the particular visual characteristics of photographs. Many of these characteristics have fascinated photographers since the beginnings of the craft. The amount of detail, also in areas that one would not directly look at, as articulated by R8, is a good example of the special charm that many feel towards photography.

4.2.3 How does photographic equipment affect photographic imagery?

An important diagnostic criteria for distinguishing photographs from computer-generated images was to infer how the technical equipment used for creating images effects how the pictures displayed might look like. Here the professional photographers studied were able to infer a variety of possibilities in regard to photographic technology, even if they were not always correct in their assessments. They had prior experience of the effects that for example long exposure times have for resulting images, or how the use of different lenses affects for example the display of perspective. This inferred indexical relation between visual characteristics of an image, and how it has come about, was described repeatedly. Again, articulations relating to these criteria are shown in italics.

“you see *motion blurr*, and in the foreground a lot of details.” R17

“*Angle of view, distortion due to a wideangle lens* and the vanishing of the horizon.” R17

“A misty pineforest: *a flattened reality depicted with a telelens* – the tree trunks are precisely arranged but seem to be real.” R3

“*When taken with a long exposure during dusk*, a landscape can look like this as well.” R16

“depicted with *a small image sensor*” R9

In these examples, the descriptions explicitly relate to the assumed indexical traces marked by the equipment used for creating pictures. Photographic technology is considered to have affected the visual characteristics of the picture shown, even in cases of computer-generated images. Thus one’s knowledge of photographic technology, and of its possible effects, plays an important role in assessing the pictures.

4.2.4 *What kinds of scenes exist “somewhere out there”?*

For photographs of landscapes, the characteristics of landscapes are of obvious interest for deciding if a picture shown is a photograph or a computer-generated image. These are also indexical signs, referring in this case to the scenery depicted affecting the photographs. Here one’s own experience of particular places is used for assessing the credibility of the landscapes depicted, as well as one’s understanding of how light, water, rocks and similar aspects behave in landscapes. Although those studied refer at times explicitly to their own experiences, at other times they clearly indicate their reasoning referring to possibly existing places.

“I’ve seen once this kind of water. The variation between grass and stone in the forefront, the amount of details, plausible color range for that kind of weather and time of day.” R11

“I’ve taken once at the sea a similar kind of image.” R1

“Isn’t this a picture taken by me when flying over the Alps to Milan in autumn 2007?” R6

“A fell landscape: the weather phenomenon seems characteristic for the fell highlands.” R7

“somewhere on the Southside of New Zealand I’m sure you’ll find these kinds of places” R13

“It’s a possible morning fog.” R4

In these examples, the diagnostic criteria used refer to one's own experience, or an assessment of probability based on one's experience. The first three examples, "I've seen once this kind of water," "I've taken once at the sea a similar kind of image," and "Isn't this a picture taken by me" refer explicitly to personal, lived experience, that is used in assessment. The latter examples again are abductions, where the possibility of particular sceneries is evaluated vis-à-vis their existence on earth. Although the respondents do not claim to be sure of the existence of these places, they indicate a possibility that these kinds of sceneries actually do exist, and are not figments of imagination.

4.2.5. *Qualifying photographs*

An important set of justifications for deciding if a picture shown was a photograph or a computer-generated image did not deal with iconic or indexical signs, but with more general, symbolic signs. These are helpful for gaining an understanding of photography as articulated in the justifications, and contrast these with those given for computer-generated images.

The following symbolic qualities expressed have to do with understandings related to photography that expand iconic and indexical descriptions. Although how photographs look and what they refer to (the photographic equipment and the sceneries depicted) are of particular importance, we focus here on those descriptions that go beyond these categories.

"*a lot of life*" R4

"*believable, feels real*" R7

"I don't believe that a machine can create that *much life*" R1

"there's a kind of *natural line*" R3

“the image feels *natural*” R16

Here photographs are understood to show life, being real, authentic, natural or believable, thus in line with descriptions within the conventional understanding of photography outlined earlier, as well as with the reasons given by respondents why this distinction between photographs and computer-generated images matters. The symbolic dimension in the descriptions shows how the respondents use very abstract criteria (“life,” “real,” “natural”) for making their distinctions, qualifying photographic images as special in contrast to the pejoratively discussed computer-generated images.

5. Discussion: The difficulty of telling photographs from computer-generated images

5.1. *Conventional understanding of the photograph*

Our findings show that, while the respondents were unable to distinguish photographs from computer-generated images, they did have a very particular understanding of photography. We call this understanding a conventional understanding of the photograph, because it is based on conventions and is conventional in the sense that it can be found in a variety of other settings as well – it is closely related to the darkroom principle outlined in our discussion of related research (Mäenpää & Seppänen 2010; Solaroli 2015).

The conventional conception of the photograph, as suggested by Florian Rötzer, relies on the indexical quality of the photographic representation, wherein a photograph is a combination of material traces left by light emitted or reflected from the photographed objects and an iconic picture that depicts, more or less accurately, the photographed scene. The material trace thus is seen as binding the photographic representation in time and space, working as an epistemological support for the iconic content. In addition, there is a time-space delay between the photographic representation and the represented scene with its objects. The delay is in accordance with the

fundamental *sine qua non* of the representation itself: for there to be a representation, there must be a difference between the represented and the representation. Hence, the represented precedes the representation chronologically and spatially. In a conventional understanding of photography, it is logically impossible for a representation to precede the represented by existing before it or by being situated at exactly the same spatial coordinates. Hence, their ontological status is different.

The particular power of photographic representation stems here from it being a representation that is created on the basis of traces, from surface markings made with light (Maynard 1997). The representation is deemed to give witness to an event that really has happened, even if the visual representation itself is blurry, underexposed, or even undecipherable. Therefore, in this understanding, photography provides a representation in which a trace of an actual event somehow has a presence in the picture taken. This is described very lucidly as the spectral, haunted, uncanny quality of photography by authors such as Walter Benjamin, Roland Barthes, and Susan Sontag.

In this light, the exclamation by one of the interviewees regarding the importance of a difference between photographs and computer-generated images echoes a discourse on photography that has been established since the beginning of the medium: “It is absolutely important [...]. I work with, and have always been interested only in, images that speak the truth. Speak or, rather, depict the truth” (R01).

The main understanding of photographs found among the individuals studied can be seen accordingly as an explicit continuation of this position: a photograph contains a seed of that which has really happened; it is a very particular kind of witness (Peters 2001; Greenwood & Reinardy 2011).

In contrast to this understanding, our findings problematize the ability of professional photographers to distinguish between pictures taken with cameras, fitting their idea of the photograph containing a trace of a scene out there, and those created with computers. By merely looking at images, our subjects could not assess correctly whether the representation contains an

indexical trace of the scene depicted. As the results show, the percentage of correct answers given is near guessing rate, meaning that extremely skilled professionals already have serious difficulties in distinguishing between these two kinds of images. Additionally, in some cases, those studied took pictures captured with cameras to be computer-generated images. We can only imagine how difficult the distinction will be to make for non-professionals, especially as computational tools for image rendering advance further.

At the same time, there is a profound desire for the kind of images in which “natural images [...] *imprint themselves durably*,” as Henry Fox Talbot (1980, p. 29) has already suggested. As our research material shows, the participants in the study felt that the difference between a photograph and a computer-generated image is of particular importance, and they had a surprisingly uniform understanding of what a photograph looks like. In contrast to the symbolic qualities attributed to photographs, such as looking natural, being plausible, having a lot of life, or being simply true, computer-generated images were characterized as inauthentic, simulations, artificial constructs, essentially artificial copies of an original they can never replace.

However, as our findings show, the difference between “an original” and “a copy” is increasingly difficult to pinpoint in the realm of digital photography. The difficulty of choosing between an idea of an authentic image, “a photograph,” and a computer-generated image underscores Hans Belting’s (2005) claim regarding images in general: We want to find images to trust, because we have never ceased to search for these kinds of images. Various kinds of images, long before the advent of photography, were considered to be authentic, true representations of a reality that had left its traces in the images.^{iv} It is often the case that the representational surface does not suffice for making a correct distinction between images created with different means, adding weight to the suggestion by John Durham Peters (1999, location 4413) that “[i]dentical objects invite radically different hermeneutic stances.” In our case, the images are interpreted in very different ways, depending on their categorization as either photographic or computer-generated images.

5.2. *The photorealistic computer-generated image*

In a contrast to the ways in which our research subjects spoke of photographs, computer-generated images were discussed particularly via opposition to any claims to authenticity. Whereas photographs were described with terms such as “authentic,” “natural,” “true,” and “trustworthy,” computer-generated images were considered to be artificial, unnatural, made, depicting a parallel reality, and too perfect. For the participants, computer-generated images therefore have little in common with photographs.

Interestingly, this position echoes important contributions to discussions on digital photography such as those introduced by Rubinstein and Sluis (2013), Stiegler (2004), or Ritchin (1991), who all maintain that digital photographs are fundamentally different from analogue, film-based photographs. Also, Rötzer suggests that “[d]igital photography provides images that only seem to be realistic, in which all kinds of image production techniques can be blended at will, in which there is no end to the possibilities of arbitrary manipulation: photography is the perfect painting of a digital surrealism, the image a naked surface on which the imagination can make subjective drawings” (p. 21).

Both among our research participants and in the work cited, the viewpoints are constructed in explicit contrast against a conventional understanding of photography, which thereby serves as a point of reference. Whereas among our participants the contrast was provided by descriptions of computer-generated imagery, in the works cited it is digital photography that in itself is considered to be suspicious. In both cases, the role of digitization and software in the creation of images is proof enough of surpassing the agency of any other kinds of mediations.

Now our inability to distinguish increasing quantities of photorealistic renderings from photographs created with a camera points to a need to take photorealistic computer-generated images seriously

and take into account that some of the images we see and use are not photography. Our results might be read also as confirming the role of algorithms and software in digital photography. We could conclude that, yes, digital photographs are unreliable, particularly when compared to their film-based, analogue predecessors, but the latter stance would remain unconvincing, also because there are diverse examples of manipulating film-based photographs.

Instead, we want to point to another direction, suggesting a fundamental tension in how digital photographs are approached: on one hand, the digitization of photography has raised, with considerable force, questions about their status as particular kinds of pictures, while, on the other hand, they continue to be used and valued in accordance with a conventional understanding of photography. The claims as to a fundamental break between photography and digital photography have not been able to convince professional photographers, photo-editors, or the social settings in which images made with digital photographic equipment are used.

5.3. *Communities of practice and the computational in digital photography*

Instead of claiming an ontological break *per se* between images created with analogue and digital cameras, it seems more useful to acknowledge that the question of authentic vs. artificial images has been a constant companion in assessing photographs throughout their history, including analogue and digital. Just as the computer-generated image might seem suspect, it has long been suggested that photography, when in the wrong hands, might actually be a means against the truth. No matter the conventional understanding of photography, photographs have, in fact, always remained suspect. Have the scenes photographed been staged? Have people been cut out of the negatives produced? What has been left out of the images? Whose story is being told?

In contrast to reliance on a conventional understanding of photography or on claims of digital photographs being non-indexical algorithmic images, we suggest that the computational in digital photography should be assessed from a clearer foundation, while one takes into account the role of particular communities of practice in directing the use of specific digital photographs.

Here, two technical issues should receive particular attention, the first being the merging of consecutively taken images into a single picture file, as is the case when one uses high-dynamic-range (HDR) images, and the other being the status of RAW image files in assessment of photographic objectivity (Winslow 2009; Mäenpää 2014; Solaroli 2015). These have become prominent topics particularly because of decisions on including or excluding photojournalistic work from competitions. As Marco Solaroli (2015) notes, when Swedish photojournalist Paul Hansen won the World Press Photo of the Year award in 2013, Neal Krawetz, a computer scientist working in digital forensics, claimed that Hansen's picture was not a photograph but an HDR composite. These pictures are composites of several shots, taken with different lighting settings and merged into a single picture. This technique allows for creating pictures with a wider dynamic range than those based on one image alone, and the technique is particularly useful for difficult lighting conditions, as well as for creating visually dramatic images. While Hansen was allowed to keep the award and arguably benefited from the new visual aesthetics that HDR allows for, the example shows how digital photographic technologies not just are a faster, lighter, or more convenient way of doing photography but effectively change what can be done photographically.

The role of the RAW file in relation to assessment of images has sparked even more pointed criticism of the "imaginary darkroom" idea within photojournalism itself. As Jenni Mäenpää (2014) notes, photojournalist Klavs Bo Christensen contested a Picture of the Year decision against him after judges decided, upon seeing a RAW file, that too much editing had been done. This decision, based on a conventional understanding of photography, treats RAW files as digital negatives, in a view that is increasingly contested. Christensen, as both Mäenpää (2014) and Solaroli (2015) attest, said that "a RAW file [...] has nothing to do with reality and I do not think you can judge the finished images and the use of Photoshop by looking at the RAW file." Although this statement seems counterintuitive from the imaginary-darkroom perspective, from a computational perspective

it becomes understandable. After all, RAW files are unprocessed, latent images and can only be made visible for human eyes by the use of software (Munhoz 2014; Solaroli 2015). And the software for processing RAW images is rapidly developing. Francesco Zizola, a photojournalist, describes it:

When you take a photograph, the photo is there but – at the same time – isn't there. It's there but it cannot yet be seen [...]. The raw is the latent image of the digital age. It is a numeric record of light-generated data that are not yet elaborated. As such, it cannot be seen. When you "open" it in order to see it, you do it with a software [*sic*] that makes you see it on the basis of its own degree of technological sophistication. [...T]he raw remains the same, but software improves. Today we can't see everything in the raw. In six months we'll see more. In one year perhaps even more. (Zizola in Solaroli 2015, p. 523)

Zizola's assessment of the RAW file as "a numeric record of light-generated data that are not yet elaborated" opens up an alternative path between a view that dismisses the usefulness of digital photographs in photojournalism and that of treating digital photography in terms of an imaginary darkroom, fundamentally in line with a conventional understanding of photography. As a photojournalist, Zizola obviously will know whether he has been on location actually taking a photograph, affected by light, and whether he has tampered with the image and in which ways.

These records of light-generated data are ever more often visualized in computing environments not just as classic photographs, so-called simulative pictures, but increasingly also as heuristic pictures, visualized as, in essence, data visualizations, as Asko Lehmuskallio (2016) has shown with reference to work among computer scientists. Digital photography does not have to be presented in only one way, and numeric records of light-generated data allow for a wide variety of computational processes.

Our empirical findings show that our ways of differentiating various photo technologies from each other, such as analogue from digital or camera-based from computer-rendered, need to be

reassessed. Instead of being in stark contrast to each other, in practice they are much more entwined and entangled with each other than we would perhaps initially wish to acknowledge.

If they are to serve as records of events that really happened, their particular purity has to be painstakingly created, every time anew. Jens Schröter (2011) shows in relation to scientific imaging that the capture, development, and visualization of a photographic trace has to be carefully manipulated in order to assure its authenticity. The authentic trace is an accomplishment assured by codes of conduct, education, and peer review in particular communities. Our understandings of particular photographs are hence tied to the communities of practice in which they are used, and in this context it is seldom a technology alone that is taken as a guarantee for authenticity. As both our findings and the related work among photojournalists show, the mechanisms of authentication are difficult to keep pure.

6. Conclusions: A plea for photojournalism

Our results show clearly that the people we studied are unable to distinguish correctly between digital photographs and photorealistic computer-generated images. Since they, somewhat paradoxically, continue to hold to a conventional understanding of photography, we pay attention to this contrariness by turning to related literature on the digitization of photography in general and discussions surrounding their use in photojournalism in particular.

In contrast to recent lamentations of the demise of the photojournalistic profession, listing various threat scenarios due to editorial use of stock-photo agencies' work, citizen photographers, changes in business models, or the further digitalization of the profession, we are positive that professionals in visual cultures are increasingly needed. Photojournalism has always been reacting to societal and technological changes, and this proactive stance is needed as we start to uncover the various ways in which digital photography may be thought of. In underscoring also the future need for photojournalists and professionals in visual cultures, we maintain that photographic images are not

trustworthy simply because they have been taken with particular equipment; rather, they are made trustworthy by being embedded within conventions of communities of practice in which people strive to create images with a particular representational logic, as is the case in photojournalism. Since, as our results show, it is increasingly difficult to assess how images in digital environments originally were created by merely looking at them, we cannot rely on our understanding of digital photography resting on a darkroom principle. Instead, we have to develop a visual literacy that acknowledges the difficulty of separating digital photographs from computer-generated images. When seeing photographs on screens, in journals, at exhibitions, or in newspapers, we might actually be looking at computer-generated simulations, and the reverse applies for images that we might expect to be computer-rendered. At the same time, we must be aware of the myriad forms that digital photographs may take in visualization of numeric records of light-generated data, all of which make distinctions in how photographs have been created even more difficult.

We always have to negotiate the delicate equilibrium between representation and belief, but our task is made easier if we can rely on communities of practice with solidly established criteria for doing so, even if these criteria, as we suggest, do have to be changed.

7. References

- Andén-Papadopoulos K and Pantti M (2013) Re-imagining crisis reporting: Professional ideology of journalists and citizen eyewitness images. *Journalism* 14(7): 960–977.
- Baer J (2010) Introduction: Photography's "And/Or" Nature. *Visual Resources: an international journal on images and their uses* 26(2): 89–93.
- Bazin A (1980) The Ontology of the Photographic Image. In: Trachtenberg A (ed) *Classic Essays on Photography*. Stony Creek, CT: Leete's Island Books, pp.237–244.
- Belting H (2005) Einleitung. In: Ibid. *Das echte Bild. Bildfragen als Glaubensfragen*. München: C.H. Beck, pp.7–44.
- Carlson M (2009) The Reality of A Fake Image: News norms, photojournalistic craft, and Brian Walski's fabricated photograph. *Journalism Practice* 3(2): 125–139.
- Fan S, Wang R, Ng T-T, et al. (2014) Human Perception of Visual Realism for Photo and Computer-Generated Face Images. *ACM Trans. Appl. Percept.* 11(2): 21 pages, <http://doi.acm.org/10.1145/2620030>.
- Frosh P (2013) Beyond the Image Bank: Digital Commercial Photography. In: Lister M (ed) *The Photographic Image in Digital Culture*. London: Routledge, pp. 131–.
- Greenwood K and Reinardy S (2011) Self-trained and selfmotivated: Newspaper photojournalists strive for quality during technological challenges. *Visual Communication Quarterly* 18(3): 155–166.

- Gursel ZD (2016) *Image Brokers: Visualizing World News in the Age of Digital Circulation*. Berkeley: Univ of California Press.
- Hadland A, Lambert P and Campbell D (2016) The Future of Professional Photojournalism: Perceptions of Risk. *Journalism Practice* 10(7): 820–832.
- Houser N and Kloesel C (1992) *The Essential Peirce: Selected Philosophical Writings (1867–1893)*. Indiana Univ. Press.
- Houser N et al. (1998) *The Essential Peirce: Selected Philosophical Writings (1893–1913)*. Indiana Univ. Press.
- Huang ES (2001) ‘Readers’ Perception of Digital Alteration in Photojournalism. *Journalism & Communication Monographs* 3(3): 147–182.
- Jappy T (2013) *Introduction to Peircean Visual Semiotics. Kindle Edition*, London et al.: Bloomsbury.
- Latour B (1999) Circulating Reference. Sampling the Soil in the Amazon Forest. In: *Ibid. Pandora’s Hope. Essays on the Reality of Science Studies*. Cambridge/London: Harvard University Press, pp.24–79.
- Lehmuskallio A (2016) The camera as a sensor: The visualization of everyday digital photography as simulative, heuristic and layered pictures. In: Gómez Cruz E and Lehmuskallio A (eds) *Digital Photography and Everyday Life. Empirical Studies on material visual practices*. New York/London: Routledge, pp. 243–266.
- Lowrey W (2003) Normative Conflict in the Newsroom: the case of digital photo manipulation. *Journal of Mass Media Ethics* 18(2): 123–142.
- Lyu S and Farid H (2005) How Realistic is Photorealistic? *IEEE Transactions on Signal Processing* 53(2): 845–850.
- Machin D (2004) Building the world’s visual language: The increasing global importance of image banks in corporate media. *Visual Communication* 3(3): 316–336.
- Mäenpää J (2014) Rethinking Photojournalism: The Changing Work Practices and Professionalism of Photojournalists in the Digital Age. *Nordicom Review* 35 (2014)(2): 91–104.
- Mäenpää J and Seppänen J (2010) Imaginary Darkroom. Digital photo editing as a strategic ritual. *Journalism Practice* 4(4): 454–475.
- Maynard P (1997) *The Enginge of Visualization: Thinking Through Photography*, Ithaca, NY: Cornell University Press.
- McNamara A, et al. (2005) Exploring perceptual equivalence between real and simulated imagery. *Proceedings of the 2nd symposium on Applied Perception in Graphics and Visualization*: 123–128.
- Mitchell W (2001) *The reconfigured eye: Visual truth in the post-photographic era. Fourth printing*, Cambridge, MA/London: MIT Press.
- Munhoz P. (2014) Manipulation, professional practices and deontology in informational photography: identifying new parameters. *Brazilian Journalism Research* 10(1 EN): 210-237.
- Peng CJ, Lee KL and Ingersoll GM. (2002) An Introduction to Logistic Regression Analysis and Reporting. *The Journal of Educational Research* 2(1): 3–14.
- Peters JD (1999) *Speaking into the Air. A History of the Idea of Communication. Kindle Edition*, Chicago and London: The University of Chicago Press.
- Peters JD (2001) Witnessing. *Media, Culture & Society* 23: 707–723.
- Quinn S (2015) A question of quality: how research participants described photographs in the NPPA study. *NPPA*: <https://nppa.org/news/question-quality-how-research-participants-described-photographs-nppa-study>.
- Reaves S (1992) What’s Wrong With This Picture? Daily newspapers photo editors’ attitudes and their tolerance toward digital manipulation. *Newspaper Research Journal* 13/14(4/1): 131–155.
- Reaves S (1995) The Vulnerable Image: categories of photos as predictor of digital manipulation. *Journalism & Mass Communication Quarterly* 72(3): 706–715.

- Ritchin F (1991) Photojournalism in the Age of Computers. In: Squiers C (ed) *The Critical Image. Essays on Contemporary Photography*. London: Lawrence & Wishart, pp.28–37.
- Rubinstein D and Sluis K (2013) The digital image in photographic culture: algorithmic photography and the crisis of representation. In: Lister M (ed) *The Photographic Image in Digital Culture. Second Edition, Kindle*. New York/London: Routledge.
- Rötzer F (1996) Re: Photography. In: von Amelunxen H, Iglhaut S, Rötzer F, et al. (eds) *Photography after photography. Memory and representation in the digital age* Amsterdam: G+B Arts, pp.13–25.
- Schröter J (2011) Analogue/Digital. Referentiality and intermediality. *Kunstlicht* 32(3): 50–57.
- Schwartz D (1992) *To Tell the Truth: codes of objectivity in photojournalism*, Minneapolis, MN: Gordon and Breach.
- Solaroli M. (2015) Toward A New Visual Culture Of The News: Professional photojournalism, digital post-production, and the symbolic struggle for distinction. *Digital Journalism* 3(4): 513–532.
- Stamm MC, Wu M and Liu KJR (2013) Information Forensics: An Overview of the First Decade. *IEEE Access* 1(2013): 167–200.
- Stiegler B (2004) Digitale Photographie als epistemologischer Bruch und historische Wende. In: Engell L and Neitzel B (eds) *Das Gesicht der Welt. Medien in der digitalen Kultur*. München: Fink, pp.102–128.
- Talbot WHF (1980) A Brief Historical Sketch of the Invention of the Art. In: Trachtenberg A (ed) *Classic Essays on Photography*. Stony Creek, CT: Leete's Island Books, pp.27–36.
- Thomson T (2016) Freelance Photojournalists and Photo Editors: Learning and adapting in a (mostly faceless) virtual world. *Journalism Studies*: 1–21.

- Funding: This research has been funded by the Academy of Finland projects Mind, Picture, Image (MIPI) and Digital Face (DIFA).
- Acknowledgements: We would like to thank for assistance in conducting the empirical work Milla Huuskonen and Hannu Alén, as well as in helping recruiting participants Anna-Kaisa Rastenberger, Hanna Weselius, and Matilda Katajamäki. Additionally we have benefitted from discussing the research with Kari-Jouko Räihä, Göte Nyman, Poika Isokoski, Jenni Mäenpää and Erhard Schüttpelz.
- Contact details for the corresponding author: Dr. Asko Lehmuskallio, asko.lehmuskallio@uta.fi, +358-50-3187013, Finland.
- Asko Lehmuskallio, University of Tampere
- Jukka Häkkinen, University of Helsinki
- Janne Seppänen, University of Tampere
- Author biographies: Asko Lehmuskallio (PhD) is a University Researcher at the Faculty of Communication Sciences, at the University of Tampere. His research focuses on media anthropology, visual studies, and digital culture. Lehmuskallio is founding member of the Nordic Network for Digital Visuality (NNDV), and chair of the ECREA TWG Visual Cultures. His recent books include *Pictorial Practices in a 'Cam Era'* (2012, Tampere Univ Press), *#snapshot. Cameras amongst us* (co-ed with A. Rastenberger, 2014, Finnish Museum of Photography) and *Digital Photography and Everyday Life* (co-ed with E. Gómez Cruz, 2016, Routledge).
- Jukka Häkkinen (PhD) is a University Researcher at the Institute of Behavioural Sciences at the University of Helsinki, and Principal Investigator of the Visual Cognition Research Group. He works on perceptual psychology, particularly image perception, and has studied the use of a wide range of image technologies, including sickness symptoms with various consumer head-mounted displays. His work is widely cited, and he has a h-index of 23.
- Janne Seppänen (PhD) is a professor at the Faculty of Communication Sciences, at the University of Tampere. He has been pivotal in advancing research on visual cultures in Finland, and works additionally on photojournalism, advertising and psychoanalysis. His recent books include *Levoton valokuva* ('The unruly photograph', 2014, Vastapaino), *Mediayhteiskunta* (with Esa Väliverronen, 'Media Society', 2013, Vastapaino), *The Power of the Gaze* (2006, Peter Lang) and *Visuaalinen kulttuuri* ('Visual Culture', 2005, Vastapaino).

Footnotes:

ⁱ See e.g. <https://www.theguardian.com/artanddesign/photography-blog/2014/jan/23/associated-press-narciso-contreras-syria-photojournalism> and <http://www.dailymail.co.uk/news/article-2544662/Pulitzer-Prize-winning-photographer-fired-admitting-doctored-Syrian-war-rebel-picture-photoshopping-camera-original-image.html>.

ⁱⁱ See e.g. <http://www.worldpressphoto.org/activities/photo-contest/verification-process/what-counts-as-manipulation>

ⁱⁱⁱ The experiments were conducted in Finnish, and the participants were asked to answer the following question: "Onku kuva mielestäsi valokuva vai tietokoneella tehty?"

^{iv} Belting (2005) discusses the problematics between trace and simulacrum in 'true representations of Christ' as an example that might be helpful for elucidating a broader issue with representation within a so called Western history. The Mandylion of Edessa, as well as the Shroud of Turin provide only two examples in a rich history of searching for the authentic image.