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An Exploration of the Feasibility of Using Google Glass for Dietary Assessment

Leonie Mauerhoefer, Pia Kawelke, Ivan Poliakov, Patrick Olivier and Emma Foster

**TECHNICAL REPORT SERIES**

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### **Abstract**

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## Bibliographical details

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To test the feasibility of Google Glass as a tool for dietary assessment, two studies were conducted. The first study consisted of a one-day trial (N=7) in order to capture food intake over a day and create a memory aid for food recalls and revealed, in addition to information about usability and privacy issues, that only 0.7% of all pictures taken were food related and that the images didn't capture every intake that took place in the observed time span. In a second study these results were further explained in a controlled feeding context, in that just 22.1% of the pictures allowed food identification due to partly visible food components and even fewer, only 1.3% of all pictures, showed the full plate, good enough for identification and estimation of portion size. To sum it up, without modification in the field of privacy protection, comfort and an adjustable prism, Google Glass in its current form is not feasible for dietary assessment research.

### About the authors

Leonie Mauerhoefer is a visiting researcher from Germany. She got her Bachelor degree in "Applied Cognitive and Media Science" at the University Duisburg-Essen in 2012. Her main focus is psychology in connection with new media and technology.

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### Suggested keywords

GOOGLE GLASS  
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PRIVACY  
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FOOD  
DIET

# An exploration of the feasibility of using Google *Glass* for dietary assessment

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## ABSTRACT

To test the feasibility of Google *Glass* as a tool for dietary assessment, two studies were conducted. The first study consisted of a one-day trial (N=7) in order to capture food intake over a day and create a memory aid for food recalls and revealed, in addition to information about usability and privacy issues, that only 0.7% of all pictures taken were food related and that the images didn't capture every intake that took place in the observed time span. In a second study these results were further explained in a controlled feeding context, in that just 22.1% of the pictures allowed food identification due to partly visible food components and even fewer, only 1.3% of all pictures, showed the full plate, good enough for identification and estimation of portion size. To sum it up, without modification in the field of privacy protection, comfort and an adjustable prism, Google *Glass* in its current form is not feasible for dietary assessment research.

## Author Keywords

Google *Glass*; wearable camera; dietary assessment; automated imaging; food photographs; privacy, health eating behavior; food; diet.

## INTRODUCTION

The assessment of dietary intake is one of the major aims of nutritional research, as food intake is a strong indicator for performance, disease and general health. Over time different methods of collecting data on eating behavior and the consumption of foods have been developed [1]. The traditional and most commonly used methods include food diaries, food frequency questionnaires and (24-hours) dietary recalls, which are all based on self-report [2]. One problem associated with self-reports is the underestimation of the true energy intake, especially by people, who are overweight and obese [3, 4]. Furthermore people may feel under social pressure to report a diet, which is healthier than what they usually consume [5]. Recently studies have expanded the traditional self-report methods using technology with the aim of improving the accuracy and precision of dietary assessment.

Due to the progress in technology, various approaches using food image capturing with mobile phones and wearable cameras have been developed to capture dietary intake in a more objective way.

## WEARABLE CAMERAS

Whereas in the past many of these devices needed to be triggered intentionally and didn't offer any advantages over traditional methods [6], significant interest in objective and passive food capturing methods has increased [7] due to the improvement of device technology and data storage. These small wearable tools offer the possibility to improve the accuracy of dietary assessment [2]. One of the main challenges in this research field is the development of precise working, small devices that reduce the effort of the participants to a minimum. Some examples are WearCam, a head-mounted video camera [8], StartleCam, a camera connected to a computer housed in a rucksack [9] and the eButton, a wearable camera integrated into a badge [10]. One of the most popular wearable cameras is Microsoft's SenseCam, a small digital 3 MP camera worn on a lanyard around the neck. With the construction of SenseCam, the developers tried to fulfill the challenges of the research area of wearable cameras by designing an easy to use, low-battery consuming and comfortable wearable camera device [11]. It has a wide-angle fisheye lens, which maximizes the field of view, an integrated timer enables the camera to record pictures automatically every 30 seconds, sensors perceive changes in light level or body heat to trigger a picture and a specific button for the user to take pictures intentionally [11]. Having already been used in the context of tourism [12], education [13] and as a clinical memory aid [11, 14], SenseCam could show promising results in dietary assessment research. By combining the photos of SenseCam with a conventional food diary, the participant's estimation of food intake could be improved due to the further information about portion sizes, forgotten foods, leftovers or brands, extracted from the pictures [2]. This is also supported by the study results of Gemming et al. (2013), where SenseCam was combined with a 24-hour dietary recall. By going through the pictures 17.0% more additional items were revealed and the mean reported energy intake increased by 12.5%. The results indicate that this method helps to reduce underreporting [15].

One of the newest and most innovative technologies in the field of wearable cameras is Google's wearable computer *Glass*.

## Google Glass

*Glass* [16] is more than just a wearable camera; it is described as an “eyewear computer” device, which is predicted to be a smartphone substitute. *Glass* combines a microcomputer, a front-facing camera, a microphone for verbal and a touchpad for gesture-based navigation, a bone-conducting speaker and a prism for visual display (see figure 3). It also has integrated measurement sensors including accelerometer, gyroscope, magnetometer, ambient light sensor, proximity sensor and GPS. 12 GB of the 16GB data storage capacity are available for personal use.

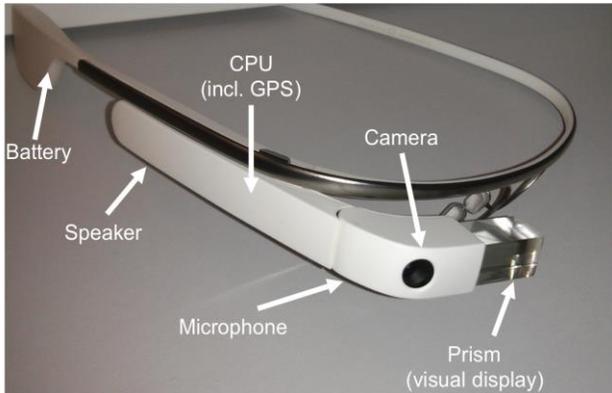


Figure 3. Image of Google Glass and description of its components

The user wears the device like spectacles and is able to navigate and interact with it by touch or voice command that enables them to e.g. browse the internet, send emails, make (video) calls, capture 5 MP photos and record 720p videos. Thus various applications already exist, self-developed programs can expand the *Glass* functions. In this context an application for automated picture capturing in self-adjustable time intervals was evolved. In contrast to the integrated photo application of Google, the display doesn't light up while taking a picture, so that neither the wearer, nor other people in the surrounding area, notice when it's taking pictures [17]. In addition to this lack of recording information, automatic image capturing methods mean a penetration into the privacy of the wearer and affected third parties can occur [18]. Those images may show unflattering or unwanted footage like sensitive information, private messages or passwords or reveal the identity of uninvolved bystanders. This is not a problem if the photos remain in possession of the user, but the moment they are inspected by independent researchers or professional crowdsourcing companies, precautions need to be taken. In this context a further exploration of the content of first person point of view images is necessary before privacy risk reducing techniques like the privacy-saliency matrix or Amazons Mechanical Turk can be developed further [19].

Due to its design, similar to usual glasses, its quite high photo quality and the possibility of collecting photo data

over the day automatically, Google *Glass* represents a new opportunity in first-person-point-of-view picture capturing for dietary assessment. Pictures can offer support in the estimation of portion size; accordingly the *Glass* pictures may have a use as memory and estimation aid for food reports. The main aim of the two conducted studies was to examine if Google *Glass* is feasible for use in this research area. In this context differences in the picture's quality and angle caused by different body heights or the wearing of glasses need to be considered as well as the required picture capturing frequency. Since privacy is a dynamic process that depends on social and cultural context, and is caused by the fast change of technology, a constant assessment of what is perceived as an attack in privacy is required [20]. These well known issues were considered in our study design. The studies should provide answers to the following questions:

1. What kinds of pictures are captured during a one-day trial?
2. Is (every) food intake captured over the day?
3. What is the best frequency to record food intake?
4. Are there differences in the quality of the pictures caused by different body heights?
5. What kind of pictures do the participants experience as sensitive data?
6. Are the pictures suitable for identification of the food type by third parties?
7. Can the pictures be used to estimate the portion size by third parties?

The aim of the following two studies was to examine the above-mentioned questions concerning the feasibility of Google *Glass* as a dietary assessment tool.

## STUDY 1

This study focused on what kinds of pictures are captured with Google *Glass* during a one-day trial, in relation to both privacy concerns and potential for use in dietary assessment.

## Method

### Study population

Seven, male participants aged 21-25 years ( $M=22.86$ ;  $SD=1.574$ ) were recruited, six of British and one of Chinese origin. The average height was  $M=1.79$  ( $SD=0.085$ ).

### Study design

The study lasted two days (for each participant). On the first day the participant was instructed to wear Google *Glass* as long as the battery lasted. The recording started between 10:40 am and 11:30 am and ended between 2 pm and 6pm. This time span over lunch was chosen, as a

short pre-study indicated, that at least one chance to record food intake would occur as most of the people usually consume one meal during this time frame. On average the participants wore the *Glass* for 4 hours and 50 minutes, while a programmed app took pictures at different time intervals. This variation was necessary to determine the best image capturing frequency to capture every food intake over a day. Therefore the *Glass* took pictures every 15 seconds for three participants, for another three every 30 seconds and for two every 60 seconds. The second component of the study consisted of a four-part interview that was conducted the next day.

The first part of the interview consisted of questions regarding the usability and acceptability of wearing Google *Glass*. Afterwards the participants used Intake24 an online 24-hour recall tool to obtain a report of the foods and drinks consumed the previous day to enable comparison with the pictures that were taken with the *Glass*. In the context of privacy issues the participants got the chance to see all pictures and to remove those perceived as private to prepare the data for a joint analysis of the pictures between the participant and researcher. Furthermore they were asked questions about the amount and the kind of deleted pictures, as well as the reasons for deletion. Finally the participant and the interviewer looked through the remaining pictures and talked about the possible identification of food, the ability to remember every captured food intake and the resulting necessity to adjust the previous Intake24 input to enter forgotten meals or modify the estimations.

### Analysis

The interviews were transcribed and analyzed concerning their relevance for the research topic. Based on interest in privacy issues and food identification the captured pictures were divided into five categories: pictures displaying food were assigned to the first category, pictures containing the workspace e.g. computers to the second one and photos showing external surroundings without people in the third one, whereas the fourth included detailed images of faces and the fifth people or crowds of people in general. Some pictures were allocated to more than one category when the content showed more than one aspect. Two independent researchers performed the categorization with a good inter-rater reliability ( $\alpha = 0.85 - 0.89$ ). They agreed on a final data categorization.

## Results

### Photograph Analysis

In total the seven participants captured 3799 pictures, with the individual number of pictures ranging from 352 to 665. The low average duration of wearing the *Glass* (4 hours and 50 minutes) was caused by a low battery-life, various system crashes and the fact that the participants weren't willing to wear the *Glass* at home, because they didn't feel comfortable wearing it outside or recording

their roommates and friends. From the adjusted image capturing frequency and the period of wearing the *Glass* for each individual participant an overall number of 5260 pictures would be expected. The difference of -1461 photographs is the result of temporary system breakdowns and automatic and unintentional changes of the capturing

Participant	Duration (in min.)	Frequency (in seconds)	Expected number of pictures	Total number of pictures	Number of deleted pictures	Total after deletion
P01	300	30	600	605	92	513
P02	330	30	660	596	0	596
P03	350	60	350	352	13	339
P04	295	30	590	541	10	531
P05	200	15	800	489	15	474
P06	400	15	1600	551	0	551
P07	165	15	660	665	135	530
Sum			5260	3799	265	3534

**Table 1. Overview of the expected number of pictures in contrast to the actual amount and the adjusted number after deletion**

frequency, especially when the *Glass* was initially running at the 15 seconds rate. In total 241 pictures were deleted by the participants (Table 1). Only 28 pictures contained an indication of food or drinks. This is mostly the result of two participants who had 10 food (indicating) pictures in their data collection. In the context of privacy issues the results show that 280 pictures represented people's full face enabling identification of those people. Furthermore on 487 images, crowds of people or individual people in a distance or with the face turned away were visible. Based on those pictures the people captured can probably be recognized by those who know them. Due to 385 pictures, which represent the environment, it is possible to draw conclusions about private information like places the participant likes to go or eat. The majority of the pictures (N= 2543) show the participant's workspace especially the desktop computer.

### Interview completion

Six participants completed follow-up interviews, which explored the participant's experience of wearing the *Glass*, privacy issues related to the captured pictures and the comparison between the recorded food consumption and the food intake captured by the *Glass*.

### Experience wearing the *Glass*

The majority found Google *Glass* to be quite uncomfortable to wear because the *Glass* got "quite hot" and "the side hurts due to the bone conductor". One participant mentioned that while "walking around town it felt slightly uncomfortable", because you get "kind of self-conscious, when people start staring". On the other hand participants reported finding it "quite enjoyable" in the sense of doing something new and different. One participant felt uncomfortable because of not knowing when the photographs were being taken. He was "aware of wearing the *Glass*, whenever [he] was talking to anyone" and in so far he felt "kind of observed most of the day". Not all participants recognized a behavior change provoked by wearing Google *Glass* but four

admitted at least small variations to their usual behavior, like when “[one participant] was talking to people [he] didn’t look at them directly”. All of these four were “conscious what [Glass] was taking pictures of” owing to “the much wider view” and the difficulty to assess the “point of view of the camera” as it was “kind of above” their normal view. Furthermore one participant stated that he didn’t eat the chocolate bar that was lying on the desk because he felt kind of observed.

“One problem of social life and Google Glass” was the necessity when you “talk with other people you need to tell them that there is that machines that record something [...] you need to explain [that it will be] deleted later”. This might change if we “negotiate any sort of norms about what you should do when you wear this kind of device”. Especially people didn’t want to wear the Glass outside due to its “kind of funny look” as this was a reason to feel “a bit silly” as well as “pay more attention to how people think about you”. In addition one participant mentioned the security point of walking on the street with Glass, because it is an expensive device.

Two participants had controversial opinions about not knowing the exact moment of Google Glass taking pictures. While one participant would prefer to “know the moment, so that [he] could control it exactly”, the other one would consider a steady reminder as “uncomfortable”.

All participants took off the Glass to go to the bathroom and mentioned, “you can not wear it doing quite private things like talking to a specific person” or “having a meeting”. All of them noted to need short breaks from wearing it whether it was by reason of the uncomfortable fit or the limitations in concentration and creativity. One even described it as feeling observed by Glass. With his final statement, one participant gave a good summary of Google Glass’ actual state, as he called it a “cool device”, that “at the moment some people might sort of like and wear, but that would be a small minority”, he assumed that “when the hardware gets better, and they begin to look normal, they may be broadly accepted”.

#### *Content perceived as sensitive data*

Five participants deleted some of the photographs Google Glass captured during the one-day trial. Most of those pictures showed “working content or some details in [their] calendar [...] personal email, passwords that kind of stuff”. Although one participant deleted pictures of people he had a social interaction with, most of the deleted content of all participants were “websites, not really people”. They “could have deleted [those pictures] which involve anyone else because they didn’t consent to it but most were aware of them”, so they didn’t see the need to do it. But they stated also that this would probably be different when they were on the pictures themselves. One person mentioned that he didn’t have to delete more

pictures due to the fact that during some social interactions like one of his meetings the Glass crashed and therefore missed a lot. All in all they would feel more uncomfortable in a more private context and probably would delete a higher amount of pictures.

#### *Comparison of pictures and recall data*

The reason to have a look at the captured pictures and to compare those with the food intake entered into the Intake24 system was to reveal forgotten foods and to see how well the images from the Glass served as a reminder of the food consumed the day before. This comparison indicated that whilst one picture showed a snack, which was not entered during the food recall, whereas on the other hand, at least five meals that were consumed during the time span were not represented on any of the pictures. Furthermore the few food related pictures do not allow a statement concerning all meal components and the portion size, as most of the time just some parts of the foods were visible or the pictures were blurred.

## **STUDY 2**

This study’s aim was to use Google Glass to record food consumed in order to examine whether it is useful as a dietary assessment research tool under controlled conditions.

### **Method**

#### *Study population*

40 participants, 21 males and 19 females, aged 21-55 (M=30.98; SD=7.813) took part in the study. Employees and students of Newcastle University were recruited via mailing lists and offered a £20 reward for their participation. The average height was M=1.7318m (SD=0.088). 14 of the participants wore glasses.

#### *Study design*

Participation consisted of attending four different meals on non-consecutive days, which were freshly prepared by the two researchers. The meals were chosen to provide different food types with various morphologies (liquid, distinct pieces, amorphous, and mixed), in order to examine the capability to estimate portion sizes of foods with different consistencies [21]. The foods selected were baked beans with scrambled eggs, toast and butter (meal 1), fish fingers, peas and chips with mayonnaise and ketchup (meal 2), vegetable soup with bread and butter (meal 3) and spaghetti bolognese with grated cheese (meal 4). To ensure a controlled condition of intake, the exact portion size for each participant was recorded for later comparison with Google Glass pictures. Consequently every component of every portion was weighed before serving, as this has been shown as the most effective method to measure food intake [22]. Up to four people ate at the same time, while wearing Google Glass, which captured pictures automatically in the most

frequent imaging rate, every 15 seconds, to enhance the chance of capturing a good image of the meal. To protect people's privacy, they were located at different tables with their back to each other to reduce the probability of taking pictures of other participants. On every consecutive day of joining a meal, they were requested to enter their food intake of the previous day into Intake24 (an online dietary recall system).

### Photography

The captured pictures were categorized into three categories. The first category contained pictures, where the complete portion is recognizable, which may enable people to identify the food and to estimate the portion size (category 1). The second category allows the identification of foods thanks to a partly visible plate, whereas an estimation of the portion size is not possible (category 2). Pictures with no food detectable but parts of the empty plate were assigned to the third category (category 3), while the last one includes pictures where neither foods nor plates were detectable (category 4). Two independent raters performed the categorization with a good to excellent inter-rater reliability ( $\alpha = 0.915 - 1$ ) and agreed on a final data categorization.

### Results

Although Google *Glass* didn't capture any pictures in five cases due to technical problems, the participants captured a total of 4963 pictures. By reason of differences in the duration of food intake the amount of pictures varied between the four meals. Hence 1024 (20.6%) photographs were taken during the first meal, 1382 (27.9%) during the second, 1292 (26.6%) at the third and 1265 (25.5%) at the last meal.

The categorization by the two independent coders concerning the visibility of food on the Google *Glass* pictures revealed that just 1.3% of all pictures showed the full plate, good enough for food identification and portion size estimation. 22.1% of the pictures allowed at least food identification due to partly visible food components, whereas 76.7% were neither useable for food estimation nor food identification, because no parts of any food components were visible (Table 1).

	Category 1	Category 2	Category 3	Category 4	Sum	%
Meal 1	7	271	679	67	1024	20.63
Meal 2	14	300	891	177	1382	27.85
Meal 3	24	282	888	98	1292	26.63
Meal 4	19	242	700	304	1265	25.49
Sum	64	1095	3158	646	4963	100
%	1.29	22.06	63.63	13.02	100	

**Table 1. Distribution of Google *Glass* pictures across the categorization scheme and the different meals.**

Throughout the study a difference between spectacle wearers was noticed. As most of them took off their glasses for the study (further referred to as one glass), four wore the Google *Glass* above their own glasses

(further referred to as two glasses). Due to the assumption that this behavior has an impact on the camera angle, various calculations concerning distinctions in the amount of pictures that show food were performed. In general the people with two glasses ( $M=144$ ;  $SD=31.337$ ) took a higher number of pictures than the people with just one glass ( $M=121.861$ ;  $SD=119.083$ ). This is attributed to the number of pictures representing no food (two glasses:  $M=94$ ;  $SD=38.401$ ; one glass:  $M=77.278$ ;  $SD=42.022$ ) or just empty plates (two glasses:  $M=20.5$ ;  $SD=16.217$ ; one glass:  $M=15.667$ ;  $SD=12.147$ ) as both groups took approximately the same amount of pictures displaying parts of food (two glasses:  $M=27.25$ ;  $SD=18.301$ ; one glass:  $M=27.389$ ;  $SD=24.009$ ). Considering all meals the people with two glasses took  $M=2.25$  ( $SD=1.708$ ) pictures of the full portion on average (category 1) and the others  $M=1.528$  ( $SD=1.630$ ).

Additionally a calculation concerning the relation between height and quality of pictures was conducted. A positive correlation between height and the amount of pictures with the whole display of the food ( $r=0.497$ ;  $p=0.001$ ) was found.

### DISCUSSION

Based on participant's statements, the categorization and the analysis of the captured pictures, it is possible to draw conclusions about Google *Glass*'s feasibility as a dietary assessment tool as well as aspects concerning the experience of wearing Google *Glass* and privacy.

#### Experience with wearing the *Glass*

All participants noted some aspects concerning the experience with *Glass* that needed an improvement in later versions. In general the design needs to be revised so that it offers a comfortable fit and a more unobtrusive appearance, as a more simple design could promote a higher acceptance in society. The controversial discussions in public about using Google *Glass* leads to a skeptical and defensive attitude in the general public, and therefore influenced the participants to feel uncomfortable wearing it outside, and concerned about how they are being perceived by other people. The current high cost of *Glass* causes further concerns, due to fear of theft. If Google *Glass* becomes an everyday device in future and behavioral norms develop, these problems will be reduced or at best resolved.

In particular, the installed picture-capturing app evoked uncertainty and discomfort among the participants in the context of social interactions. Because they didn't know the exact moment pictures were captured, their conversations were not relaxed and natural as they tried to avoid eye contact and to inform their dialogue partner about the recording. This uncertainty was enhanced because the angle and the point of view of the camera could not be assessed. This may be improved through familiarization over a longer period of time. The

impression of two participants that their concentration was interrupted may be attributed to the running app as they may have felt observed and paid more attention to how they behaved, rather than to wearing the *Glass* in general. Nevertheless these findings are not generalizable to the whole population due to the small sample size of seven participants.

In the second study changes in the recording angle could be observed because people wore the Google *Glass* above their own glasses and also due to differences in the participant heights. The fact that people who wore their own glasses during the study captured more pictures of full plates may indicate, that an angle directed downwards would lead to better picture results in the context of dietary assessment. A possible explanation for the significant positive correlation of height and pictures representing full portions is, that the actual angle and the position of the prism is better for taller people because they may need to tilt their head further towards their plate while eating.

### **Privacy issues**

As it is known, that wearable cameras cause privacy issues when pictures are taken automatically while wearing the camera in a public space, one aim of the first study was to examine on an objective level how many of the captured pictures violate privacy. Additionally the personal evaluation of the participants about what they experience as sensitive data was of interest. 20.2% of all captured pictures violated the privacy of uninvolved third parties as they show full-face portraits (7.4%) or identifiable crowds of people (12.8%). This is quite a high amount when taking into account that most of the time the participants were working without a lot of social interaction. Some of them even took *Glass* off to go outside. A possible explanation of the high number of these pictures is the wider angle and the superior height of the camera's point of view in combination with human head movements. As people don't tilt their whole head to focus something but for example just look with their eyes down on the computer, it is still possible that the forward oriented camera records the people in front. The participants didn't delete pictures featuring third parties, as they didn't perceive them as relevant to their own privacy. This may indicate irresponsible handling of this type of data especially as they deleted or would have deleted images of themselves. 10.0% of the captured pictures allowed conclusions about specific whereabouts like shopping malls or restaurants and therefore could be abused for observation and acquisition of habits. Since all recorded pictures are generally stored on the Google servers it is imaginable that this kind of information could be profitably used by Google to adjust the personal customer profile. According to the statements made by the participants most of the 241 deleted pictures showed a computer screen with private messages, passwords or

confidential program code. This distribution may be caused by the choice of the sample, as they are all programmers who try to protect their intellectual property. In summary many of the captured pictures contained content that can be perceived as sensitive data in so far that they enable an identification of innocent bystanders, they reveal the places the wearer goes or private (working) information. Therefore responsible handling of Google *Glass* and in particular the images captured is necessary and essential [18]. But as it emerged from the interviews, participants evaluate sensitive data as just related to their own person instead of considering and protecting the privacy of others. Nevertheless it cannot be deduced from these statements that the participants have this understanding of privacy in general, as the small number of deleted pictures may be due to the fact that the investigation was performed as a feasibility study among colleagues. They may think it is not necessary to delete those pictures as the photos remain within the same research group.

### **Feasibility of Google *Glass* for dietary assessment**

During the one-day trial 0.7% of all pictures revealed hints of food or beverage intake. As this seems like a really small quantity it should be qualified by the fact that in general just a small amount of time is spent on food intake. Nevertheless *Glass* didn't catch the whole food intake of the recording period for any of the participants. This indicates that it is not feasible to capture all food intakes over one day using Google *Glass*, so the received information is not reliable. However not all participants ate a proper lunch during Study 1 and as they were not willing to wear the device at home, a controlled feeding study (Study 2) was conducted to ensure that food consumption occurred. Concerning the aim to investigate if Google *Glass* could capture pictures of a meal, which would allow identification and estimation of food, the following results were found.

Out of the 4963 pictures captured during the second study 22.1% revealed parts of the served foods which may be sufficient to allow independent third parties to identify the meal or separate components. Based on some of those pictures the meal could only be partly identified e.g. that the meal included tomatoes. Only 1.3% of all pictures were usable for identification of the food type and an estimation of the portion size, because the full plate was visible. 3804 (77.0%) pictures showed parts of the environment like walls, windows and tables. These pictures do not support either food identification or an estimation of the portion size. An independent crowdsourcing study was planned to verify whether the Google *Glass* pictures would allow food identification and accurate estimation of the portion size by third parties. But due to the poor quality of the food pictures taken crowdsourcing would not provide any added value.

The results indicate that the unmodified Google *Glass* is not a feasible tool to assess diet, as it is not able to record food intake. It is not possible to catch every food intake over a day as a reminder and support for keeping a food diary or to complete a 24-hour recall interview. Moreover it does not reliably capture useable pictures of meals in a controlled food consumption situation.

## CONCLUSION

These studies investigate the feasibility of Google *Glass* as a tool for dietary assessment in a select volunteer population. The findings showed that the technical requirements of Google *Glass* like an extended battery life, technical stability of the system and the general comfort of wearing need to be improved. In addition to privacy issues, public awareness needs to be raised and common rules for the use of head mounted displays need to be developed.

As the picture-capturing app does not meet the Google policy of ensuring that the display is active when the *Glass* is active, it is not officially permitted for distribution among other researchers or for use in public. This is in agreement with some of the participant's opinions about giving the wearer and the people around information about the recording. But a continuous reminder would impede an objective acquisition of dietary intake by possibly causing a behavior change, as well as being annoying. Therefore the image capturing process needs to be irreproducible for the wearer, but in concerns of third parties' privacy, a REC light on the outside of the *Glass* could advice the environment of the recording.

The ability to adjust the prism downwards or attaching a mirror in front of the camera would probably enable Google *Glass* to catch every food intake over a day for identification of consumed foods and the estimation of the portion size in addition to improving the protection of privacy of all parties concerned. But still there has to be the opportunity to remove or pause the *Glass* for private activities like changing clothes or using the bathroom.

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