

# A Visualization Interface to Improve the Transparency of Collected Personal Data on the Internet

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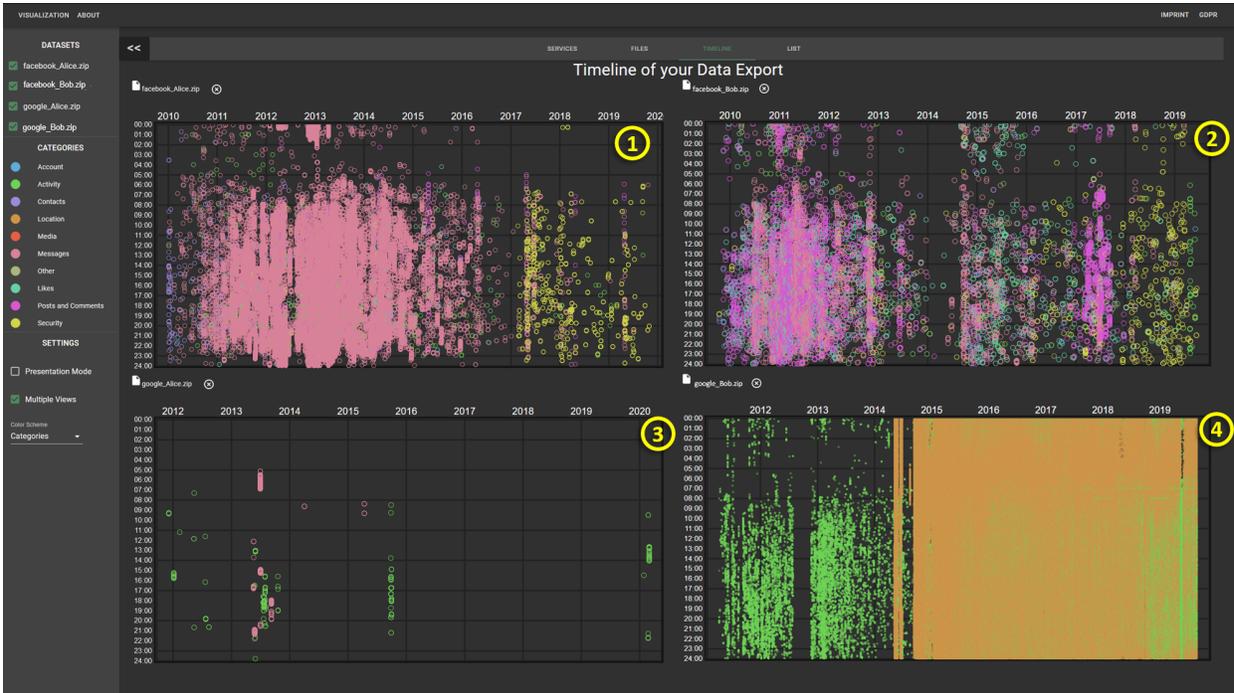


Fig. 1: The *TimeView* of the web interface *TransparencyVis* with *MultiView* mode on. The data elements from the GDPR data exports of two different users, each from *Google* and *Facebook*, are visualized in interactive scatterplots as circles over time. Different colors represent the categories of the data elements. Patterns can be detected and compared as described in use case 2 (see Sect. 5.2).

**Abstract**—Online services are used for all kinds of activities, like news, entertainment, publishing content or connecting with others. But information technology enables new threats to privacy by means of global mass surveillance, vast databases and fast distribution networks. Current news are full of misuses and data leakages. In most cases, users are powerless in such situations and develop an attitude of neglect for their online behaviour. On the other hand, the GDPR (General Data Protection Regulation) gives users the right to request a copy of all their personal data stored by a particular service, but the received data is hard to understand or analyze by the common internet user. This paper presents *TransparencyVis* - a web-based interface to support the visual and interactive exploration of data exports from different online services. With this approach, we aim at increasing the awareness of personal data stored by such online services and the effects of online behaviour. This design study provides an online accessible prototype and a best practice to unify data exports from different sources.

**Index Terms**—Information visualization, usable privacy, privacy awareness, transparency-enhancing technologies, user-centered design

## 1 INTRODUCTION

In the last few decades humanity has entered the digital age and became a modern information society. It is estimated that over fifty percent of the global human population is using the Internet nowa-

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days [21]. Online services are used for all kinds of activities, like news, entertainment, publishing content or connecting with others. But information technology enables new threats to privacy through global mass surveillance, vast databases and fast distribution networks. By using online services, data about users is collected on a daily basis. Companies collect data to offer more content, improve their services, gather insight about the users, or to increase the relevance of advertisements. A few major companies offer users to connect all devices to their accounts for free. This enables services to create an increasingly detailed profile due to the continued use of these services. Users are often unaware of the consequences of these choices and the amount of data that is collected from them as a result. A key point is that users lose control over the data that concerns them because they are not aware of the data that is distributed in different ways over multiple services.

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Furthermore, users cannot control exactly what happens with this data. Faced with this impotence, Internet users often develop an attitude of neglect of data privacy concerns. However, with regard to the inherent human right to privacy of each individual, as written in Article 12 of the Universal Declaration of Human Rights [52], the ability to control the provision of one's own data to different services on the internet is of utmost importance [37]. *Privacy* describes the right of individuals to decide how they seclude and expose information about themselves. In the context of this paper, the primary focus is on *informational privacy*. It can be described as "the right to select what personal information is known about me to what people?" [55].

People are using so many services today, that it is often challenging to keep track of the data they collect. People employ different tactics to preserve their privacy. Teenagers for example try to flood the services with random non-sensitive content [6]. Other try to denounce privacy threats by using common arguments such as "I have nothing to hide" [45]. We argue that the main reason for such arguments and tactics is the impotence to grasp the amount and value of the personal data being collected. Therefore, means to support the users mental access to these data collections are desirable. We argue that visualizing such data collections in a usable way can contribute to the situational awareness of the common internet user concerning the own personal data stored at different services. The data collection exports introduced by the GDPR, which was enacted in the European Union in 2018, proved to be a valuable resource for this aim. The GDPR gives more control to the users by regulating how companies can collect, store and use their personal data. It also enables users to download and access their personal data and transmit it to other services. However, the many files and the differences of formats between and within the data exports make it difficult for casual Internet users to get an overview of the content. Therefore, in this paper we present *TransparencyVis*<sup>1</sup>, an online accessible web tool to support a visual interactive exploration of such data exports. In a user-centered design process we identified the relevant users, data and tasks, which are also presented in this paper. We have implemented the tool experimentally for four of the most popular online services (Google, Facebook, Instagram, Twitter). However, the interface is extensible for other services. Therefore we share the generalization scheme for the data exports from different services, so that the community can contribute by parsing the data exports from further services. Our main contributions are:

1. A web-based prototype for a visual exploration of the data exports enabled by the GDPR, representing the data collections of the own personal data stored by different online services.
2. Characterization of the relevant users, data and tasks based on Miksch and Aigner [30], as appropriate for the presented challenge to raise the situational awareness concerning personal data.
3. A unification scheme to generalize the data exports from different services, to be able to merge and compare the various data sets in one visualization.
4. Evaluation of the usability and the appropriateness of the tool after the first design iteration and lessons learned and implemented changes in the current version.

## 2 RELATED WORK

A popular research field with the goal to increase the transparency of personal data is called Transparency Enhancing Technologies (TETs) [18, 22, 32]. They enable users to better understand the implications of disclosing personal data, to protect their privacy and to take an active part in the value creation of services [7]. TETs can be categorized into tools that enhance privacy before personal data is disclosed (ex-ante TETs) and tools that retrospectively enhance privacy once personal data has been disclosed (ex-post TETs) [15]. The approach provided in this paper can be classified as ex-post TETs. With this approach we aim to increase the situational awareness of common Internet users with respect to their personal data, which are stored by different online services. Thereby, the approach is to visualize the

current content of the data collections that have been collected so far. The goal is to help users reflect on their privacy attitude and their future behavior.

In our research of related work we have found a number of helpful approaches for visual interactive systems to increase the transparency of personal data. However, we have not found any approach, that addressed the visualization of the complete GDPR data exports from different services in a comprehensive view. Some approaches use parts of the download [49, 50] or are actually aiming to use a direct API of the service [15]. While there are some approaches, that provide the user with the accessibility to try the tools with their own data in their own environment [3, 15, 49], many of the approaches either require an implementation on the server side or are not designed for personal data at all [5, 15, 23, 39]. We have not found any approach, where the data from multiple services could be combined and explored in one tool. However, there are tools which support data from multiple sources [41, 49]. While many approaches extend their data by deriving or adding further information (e.g. by machine learning, statistical information or knowledge from the outside) [10, 41], our focus is mainly on depicting the collection as is. Most of the related work are appropriate for the use of a non-expert in IT. In the following, we present the most relevant groups of related work that we have found.

**Visualization of data flows** Related approaches that also aim to visualize personal collections of data with the goal of increasing the privacy awareness are *DataTrack* from Fischer-Hübner et al. [1, 15, 16, 24], *PrivacyInsight* from Bier et al. [5], *Privacy Dashboard* from Raschke et al. [39] and the online interactive tool developed by Kani-Zabihi and Helmhout [23]. These approaches are designed to be implemented on the server side and while they are also designed for personal data, the main focus seems to be on showing the data flows, who the data is shared with, and the details of the provided information. Our approach rather focuses on visualizing a collection of personal data to be viewed by a common internet user in an easily accessible way.

**Inferred data** The approaches of Do Thi Duc [10] (*DataSelfie*) and Rieder et al. [41] (*FindYou*) also aim at visualizing personal data and thereby increasing their transparency. Their main focus is to infer additional data using machine learning and statistical means to show what is possible to infer from the data. Do Thi Duc uses several bar charts that show the statistical information and also uses a time line visualization similar to the one in *TransparencyVis*, but only the last seven days are visible due to their focus of collecting the data in real-time. In *TransparencyVis* the whole time span of all available data is shown. *FindYou*, on the other hand, is a location auditing tool, thus providing a more specific service. Users can enter their own location data from three popular online services, including *Instagram*, *Twitter* and *Foursquare*.

**Visualizing privacy policies** There are also approaches, that visualize privacy policies, as for example Harkous et al. [19], Tesfay et al. [48], or Kelly et al. [25]. Some mentionable but not scientific web tools for this application area are *PrivacySpy* [29], *Trackography* [47], *Privacy Program* [9], *ToS;DR* [42] and *useguard* [38]. These approaches rate privacy policies based on different assessment schemes and while they help to support users in reflecting on their privacy attitude, they differ strongly from our approach by not visualizing the actual disclosed personal data.

**Personal visualizations** Some approaches visualize personal data for the purpose of reminiscing, self-reflection and self-expression rather than for privacy awareness. These approaches try to gain additional value of the collected data, whereas approaches for privacy awareness try to show the value of the data collection itself. One example for this category is *Visits* from Thudt et al. [49, 50], where personal location histories are visualized in an appealing and interactive way. Users can upload their location history from *Google* and three other location based services. Another example is *LastHistory*, a work of Baur et al. [3], which visualizes the music listening history from the Last.fm [27] service and context (photo and calendar streams) in a timeline. Both approaches visualize an already collected data set of the users and

<sup>1</sup><https://transparency-vis.vx.igd.fraunhofer.de/>

provide the possibility to use the service with personal data, even though for very specific data collections.

**Non-scientific tools** We found also some non-scientific online-tools, which are comparable to our approach. For example *myfbdata* developed by Do Thi Duc [12] and the *Facebook Analysis Tool* by Wolfram Alpha [57]. Both were designed to visualize personal data on *Facebook*, either from the data export or directly via an API. *myfbdata* provided a map and a timeline, while the tool by Wolfram Alpha let users gain insight by providing multiple visualizations about friend circles, distributions and others. Both tools allowed few interactions, no categorization of the data, and were designed for only one online service (*Facebook*). However, they became obsolete some years ago. Beyond that, there are several other online tools, which are designed to increase the transparency of personal data on the web. One category of these tools is the visualization of tracked user activity: e.g. *re:log* [35], *Vorratsdaten* by ZEIT Online [58], *vds-suisse* by OpenDataCity [36], *publicdefault* [11], *OnlineStatusMonitor* [28], *WhatsSpy Public* [59], *WhatsAppAll* [26]. They visualize one or multiple static data sets to show the sensitiveness of personal data. Other tools focus on the visualization of tracking behavior on websites, *Mozilla Lightbeam* [31], *Netograph* [33], *Trackography* [47].

Thus, to the best of our knowledge there is no other approach that can provide the means to analyze personal data collections simultaneously from more than one online service in a comprehensive and transparency-enhancing way.

### 3 DATA-USER-TASK

In this section we present the targeted data, user and tasks according to Miksch and Aigner's design triangle [30].

#### 3.1 Data

##### 3.1.1 GDPR downloads

In the scope of this research topic we are focusing on personal data that is collected on the Internet. Personal data is "any information related to an identified or identifiable natural person" [40]. It is primarily provided by users to online services simply by using them. In recent years, the Internet rights for users were strengthened by the introduction of the Californian CCPA or the European GDPR [40]. The latter provides European citizens with Article 15, the right of access, i.e. they can request a copy of their personal data, a *data export*. It also includes Article 20, the right to data portability, with which they can use their data export for their own purposes across other services. It also requires the service to deliver the data export in a structured, commonly used and machine-readable format.

During our research, we investigated the data export request on several services and found large differences among the retrieval process. While most services employ an automated data export, some require users to contact the support via email and identify themselves with an image of their passport. Further, the retrieval process varies in the duration of the time till the export is created. For some services the duration depends on the size of the data export or the current workload of that service, however, a few services need several days to weeks to generate the data export. Most data exports we encountered were available as a zip archive and contained many different file formats, including json, js, csv, html, tex, vcf, ics and others. As each file contained data about various topics, they all had an individual data structure and only occasionally used reoccurring data types. Some services used special encoding such as UTF-8 encoded strings, JavaScript files with an exported variable that contains the JSON data, or included data which purpose or context could not be identified. These files and data structures were almost never documented by the service, only the Twitter data export provided a documentation. It should be noted that some services allow choosing between multiple file formats, in most cases JSON and a HTML variant that allows for easier viewing. Some data that was available on the website of the service was not included in the data export, but it was mostly miscellaneous data or newer features which were not added yet. We selected services which are popular

among users, have an automated and simple data export request feature, have a short duration to generate the data export, and allow easy maintenance. We therefore decided for *Facebook* [14], *Google* [17], *Twitter* [51] and *Instagram* [20] in our initial prototype.

##### 3.1.2 Generalization

The data export comprises several folders that contain the data of certain parts or features of the service. In those folders are sub folders and files in multiple file formats. Some files are in a common data format, like json, while others can contain images, videos, documents or binary data which might not be known before. Due to the high variation of the content and the structure of the data exports, we defined a unification scheme with the goal to simplify the data and to make it comparable. The overall unification scheme is shown in Fig. 2. Based on our observations of the data formats we defined two types of data for our visualizations:

**File elements:** A file element represents files, which are contained in the data export. This can for example be a video, image, other archive or a machine-readable document. The files are categorized based on their file extension to make it easier for users to understand the files' purpose. The main attributes of this type of data are:

- **File Name** - messages.json
- **File Category** - Picture, Video, Audio, Text, Document, Other
- **Folder** - messages/
- **File Size** - 5 MB
- **Data Category** - Messages, Security ...

**Data element:** Data elements represents chunks of data, which could be identified in the machine-readable files contained in the data export. Most of the machine-readable data was given in a list or array with individual elements that contain multiple relevant attributes. Most elements are certain events that happen within the service. For example, account creation, password changes, sending messages, accepting friend requests, visiting an URL, using search, liking a page and others. After documenting several machine-readable files from multiple providers, we created the following attributes for this data type:

- **Time** - 2019-01-01 12:34:56
- **Text** - Person says: "Hello World"
- **Category** - Messages, Security ...
- **Subcategory** - Chat with Person B, Chat with Person C, ...

Finally - in order to support pattern exploration and a comparison between data sets from different online services or users, a set of ten categories has been derived so that each data element could be classified according to these categories (see also Fig. 2): *Account* (any data related to the users' account), *Activity* (any data that is collected passively from users), *Contacts* (any data that contains contact addresses or friends lists or similar), *Location* (any location-oriented data), *Media* (any data that primarily describes media data from the user), *Messages* (any communication data), *Posts and Comments* (any posts or comments from the user), *Security* (any security related data such as logins or IP addresses), *Other* (any data that does not fit the other categories). File elements which contain data elements have the same value for the attribute data category as the contained data elements. These categories can universally be applied for different services, so that a combination and/or comparison of data from different services is eased as well.

#### 3.2 Users: The ordinary Internet user

The proposed approach has primarily been designed with the ordinary Internet user in mind. For the user description in the design triangle, we characterize the user group by looking at two attributes: privacy concern and internet skills. With respect to the privacy attitude, Westin [56] defines three main groups of users based on their privacy concern index.

- **Fundamentalist:** A person that is distrustful of data collection by organizations and cares about privacy.

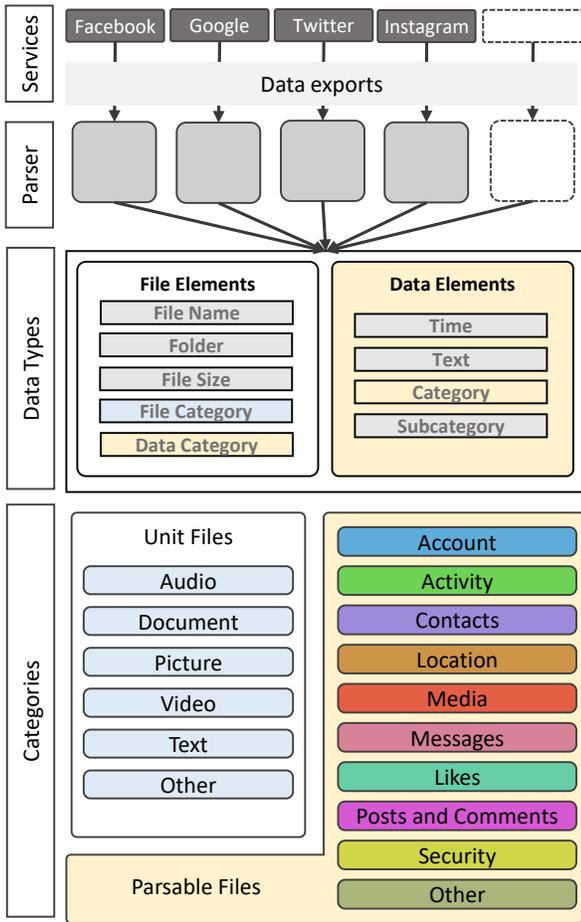


Fig. 2: Unification scheme: Data exports from different online services are unified to a defined scheme by a specific set of parsers. For each service an own parser must be defined. The unification results in two data types: *file elements* and *data elements* as well as an assignment of the elements to a category from the defined set of categories.

- **Pragmatist:** A person that weighs the benefits against the intrusiveness of data collection and believes that organizations should earn their trust rather than automatically have it.
- **Unconcerned:** A person that is trustful of organizations collecting personal data.

We see benefits from the ability to gain visual insight into their own data stored by different online services for each of these groups. Furthermore, we assume that all user groups have sufficient digital skills [53] to use online services such as Google, Facebook, Instagram and Twitter. The evaluation results show that the usability is appropriate for the evaluated user groups. However, an evaluation of privacy and visualization skills against the effectiveness of these tools would be a valuable future work.

### 3.3 Tasks

The main goal of our visualizations is to provide a comprehensive insight into the collection of personal data stored by different online services. This collection is represented by the data export, that can be requested from the services as guaranteed by the GDPR. With this we aim to support the situational awareness of one's personal data on the Internet. According to Endsley [13] situational awareness consists of three stages: *perception*, *comprehension*, *projection*. Applied to the context and data considered in this paper, the following three main goals can be defined.

- 1: **Support Perception:** Support the investigation of the distribution

of own data elements with regard to information type, time and the service by which it is stored.

- 2: **Support Comprehension:** Support the identification of possibly sensitive information
- 3: **Support Projection:** Increase the attention for the users current and future online behavior.

Based on these goals we have identified the following tasks, in that our approach should support:

- T1: OVERVIEW of all data elements contained in the exported data collection (*perception*)
- T2: INSPECT the details of each data element (*comprehension*)
- T3: RELATE the data elements to services (*perception and comprehension*)
- T4: RELATE the data elements to time (*perception and comprehension*)
- T5: COMPARE data between services and time periods (*perception and comprehension*)
- T6: EXPLORE possible patterns and information resulting from aggregation of the data (*comprehension*)
- T7: REFLECT on the personal value and perceived sensitivity of the revealed information (*projection*)

Through the overview of the whole data collection, the users should gain a first insight into the data. At this stage the users might have already identify unexpected data elements. Users can inspect the details of the data element to determine how confidential or critical the information really is to them. By relating the data elements to the context of time or exploring different services, the users should gain an additional perspective on the value of the provided data. Furthermore, patterns and unexpected information resulting from bringing together different data can be identified. Finally, the active reflection of users on the personally perceived sensitivity of the data should increase the awareness for the value of the stored data. While we defined the tasks mainly based on the three defined goals, we argue that the tasks are beneficial for all three user sub-groups. However, there might be different effects on the different sub-groups. For example, while the *Fundamentalist* might use T5 to detect sensitive information resulting from aggregation, the *Unconcerned* might use T5 to reminisce or self-reflect. On the other hand, the latter might lead to a higher awareness of their own data as a side effect.

### 3.4 Design Requirements

For the visualization solution itself the following requirements (R1-R7) have been derived based on the above data, user and task identification. To increase the willingness of the user to use our tool, we additionally added three system related requirements R8-R10. These requirements are in line with the requirements for privacy awareness supporting tools proposed by Pöttsch et al. [37]. With these we mainly aimed to ensure that the evaluated effect on the users experience results from the real inspection of the own data and not from a mockup, which we believe, makes a huge difference.

- R1: A view which shows all elements contained in the export at once (T1)
- R2: Zoom and filter, details for each data element on demand (T2)
- R3: Ability to upload data from different online services (T3)
- R4: Timeline layout for data with a time attribute (T4, T5, T6)
- R5: Visual categorisation by type of data to support the pattern exploration process (T5, T6)
- R6: Display multiple data sets at the same time (T5)
- R7: Functionality to evaluate the perceived sensitivity of a piece of information (T7)
- R8: Own data, not just demo data
- R9: No invasion to privacy by the prototype itself
- R10: Understandable for non-experts in IT and visualization

## 4 TRANSPARENCYVIS

In this section, we present our prototype *TransparencyVis*. First we will explain the infrastructure and the main technologies we used in our prototype. Then, we describe the visualization components and demonstrate how *TransparencyVis* can be used in practice along some use cases.

### 4.1 Infrastructure and Technology

*TransparencyVis* is implemented as a web application that primarily runs on the client side. The interface is written in *TypeScript* and *React.js*, and for the visualizations we use the JavaScript library *d3.js*. These technologies enable the implementation of an interface with interaction paradigms familiar to the common Internet user (R10). To meet R8 and to enable the users to explore the tool with their own data, we have implemented an upload and parsing mechanism for four exemplary, but well-known, services. To ensure R9 we decided to avoid any unnecessary connections to the server. Therefore, instead of uploading the data to a server, the processing is done in a web-worker thread in the browser to fulfill the privacy aspect while still being interactive. When a data export is selected, the contents are extracted and the service is automatically detected, to reduce the complexity for the user as far as possible. As defined in Sect. 3.1, each service has its own parser for each parsable file that is used to extract the relevant data from a JSON, or other, file to the data elements. The structure of JSON files is documented by *TypeScript* typings to facilitate the extension and maintenance of the application. Additional services can be added by implementing a parser for their data export structure.

### 4.2 Visualizations and Interactions

Based on the requirements stated in Sect. 3.4 we developed a collection of views (see Fig. 3) to support the users and their tasks. The two main views are the *FileView* (b) and the *TimeView* (c). They are complemented by the *Data Page* (a) and the *ListView* (d). The *FileView* is mainly based on a *TreeMap* [43] and is primarily meant to enable the user to get an overview of all file elements contained in the export at one glance (R1). The *TimeView* is mainly designed as a scatterplot [8] with the temporal aspect of the data elements. It contains time-dependent data and is primarily meant to explore patterns and time relations (R4). The *ListView* displays all data elements in a list. Additionally, users can rate the perceived sensitivity for each data element to support reflection (R7). The common process is as follows: The users start by retrieving their personal data from the online services and dragging the zip archive into the *Data Page*. Multiple zip archives from different services can be inserted at once (R3, R6). The user proceeds by going to the *FileView*, where the user can explore the files contained in the data export. Further they can explore the temporal data in the *TimeView* and finally have a look at the details in the *ListView*. However, the user can also switch between the views as desired. The sidebar contains the ten categories, as described in Sect. 3.1 with the mapped color (R5) which is the same for all views. The data in each visualization is mapped to the color of their assigned category. The *FileView* has an additional category *Files*. The legend list in the sidebar can also be used to filter each category (R2).

#### 4.2.1 Data Page

At first, the user is provided with an initial view that consists of a dropzone to enter the data export and an overview of the supported services. The *Data Page* (Fig. 3a) has a minimalistic design to reduce the users cognitive load. For each service, an instruction on how to retrieve the data exports from the services is provided. After the data export is loaded to *TransparencyVis*, the corresponding service field is colored and the inserted data set is listed within this field. After the data exports are processed they are kept in memory until the browser tab is closed or reloaded.

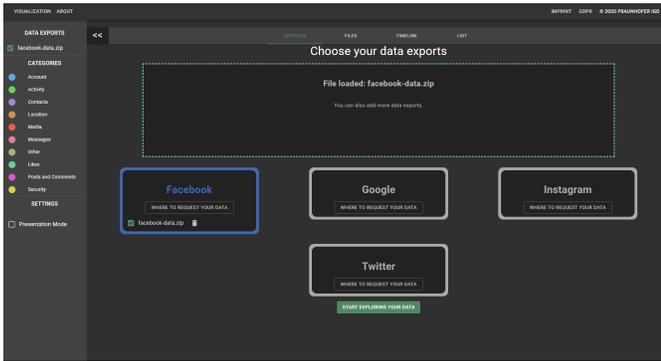
#### 4.2.2 FileView

The *FileView* (Fig. 3b) displays all files of the data export in a treemap (R1). We decided to use a treemap as our goal was to show an overview

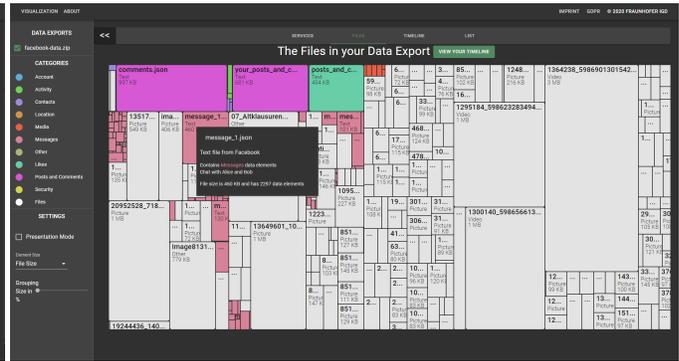
over all elements contained in the data export and to depict the proportions in the parts-to-a-whole relationship between the file elements and the whole export. Also we saw the metaphor of boxes, where the data elements are stored, as an appropriate representation for the file visualization. Because the amounts of files contained in the export can vary much from user to user we see the space-filling treemap also as a good choice to support the scalability. When choosing the treemap we also had the hierarchical data in mind. While the current version only displays the leaves, for future extensions we aim to emphasize the hierarchical structure of the data to increase the understandability. Each field represents a file which is contained in the export. There are multiple attributes for the scaling of the treemap slices which the user can choose from. As the main valuable options we see the file size and the amount of data points included in the files. While the first attribute can help to discover large (possibly) sensitive files, as for example videos or images, the latter can help to discover collections of many elements. This could for example be a conversation record or a search history with many items. Details can further be inspected in the *TimeView* or the *ListView*. Further possible but not yet implemented options would be to scale according to the sensitivity value. However this option depends on the input from the user. The color represents the category of the contained data (R5). Files which do not contain further data elements are colored white. In the treemap a user can compare the different categories to see which is prevalent and how much data is collected in each category. Users can inspect details about the files via tooltips and zooming (R2). Multiple data sets are merged in this view to one. This allows the user to combine the data from different services in one overview. However, in the sidebar the user can select and deselect the data sets to display.

#### 4.2.3 TimeView

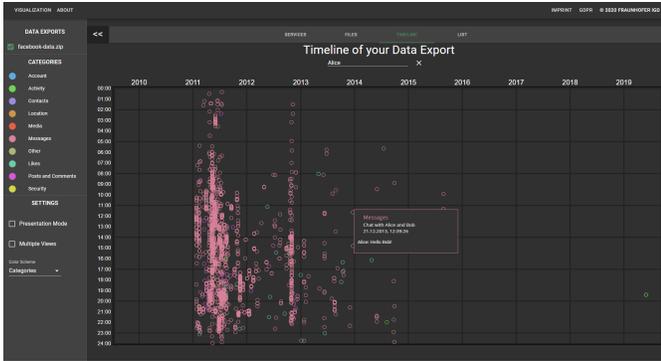
To support the exploration of patterns and trends, in this view, a timeline visualization (Fig. 3c) is used to display the temporal aspect of the data (R4). Therefore, a scatterplot was chosen. While time is one dimensional, the repetitive cycles are considered and split into two dimensions. The x-axis shows the years and months across the data contained in the export. The y-axis shows a single day. A grid allows for better orientation and comparability. Each circle in the visualization represents a data element. To reduce overplotting, only a border of the circle is drawn. The color indicates the category of the data elements. We decided to use a scatterplot to allow a display of each single data element, while being able to perceive general trends. Representing the data elements as units should support the perception of the possible relevance of every single data element. By assigning the data elements to a category and coloring them appropriately, the dense formation of the individual elements in the scatterplot additionally allows to observe patterns in groups of data elements. To fulfill R2 according to Shneiderman's Mantra [44] and support R10 the familiar interaction paradigm *zoom and pan* with the scroll wheel is implemented. Therewith users can look at specific time frames, like years, months, or weeks by zooming into the timeline. By seeing changes or deviations in the activity patterns it is possible for the users to identify certain important events in their life. The data elements can be filtered based on the categories. Therefore the user can click on the category filters on the left to hide irrelevant or overplotting data, such as the location history data from the Google service that is collected every few minutes on Android phones (Fig. 1, (4)). To inspect the details of each data element, users can hover over the circles to view a tooltip that shows additional information about that item. One extension of the current version after the evaluation was the search filed in *TimeView* and *ListView*. With it, users can search for specific terms or names and inspect the patterns in a specific context. Multiple datasets are merged by default and are shown in one timeline visualization. However, the *MultiView* option allows the user to plot the different datasets on separate time lines. This is similar to small multiples and can be used to compare the patterns between different data exports. This is shown in Fig. 1 and is demonstrated in use case 2 in Sect. 5.2. A combination of multiple sources increases the possibilities to detect patterns such as daily routines, deviations, sleep, holidays, moving to a new place and others.



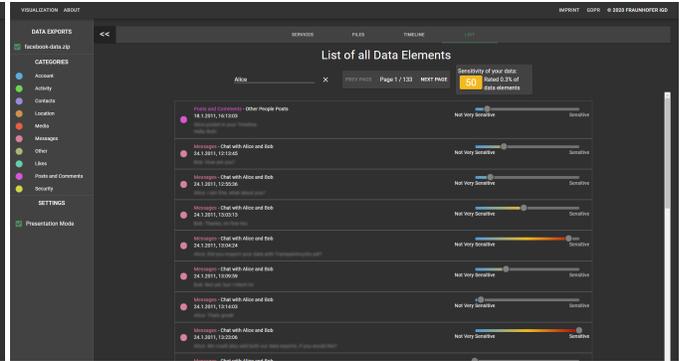
(a) Data Page



(b) FileView



(c) TimeView



(d) ListView

Fig. 3: The four views of *TransparencyVis*, (a) *Data Page* where the user can drag and drop his data export folder to, (b) *FileView* gives an overview over all files contained in the export, (c) *TimeView* with categorized data elements to explore temporal trends and patterns, (d) *ListView* for details on each data element and the possibility to reflect on each data element by rating the perceived sensitivity.

#### 4.2.4 ListView

The *ListView* (Fig. 3d) is meant to support the user in inspecting the data elements in detail (R2) and in reflecting on the perceived sensitivity of this data, as required by R7. It consists of a chronologically sorted scrollable list of the data elements from the selected data exports. It displays the date, category and the contained text of each data element. Further, the user has the possibility to rate the perceived sensitivity of each reviewed data point by interacting with a slider. The slider allows to choose a value between *Not very sensitive* and *Very Sensitive*. The average of the sensitivity rating over all elements is calculated and displayed to the user. This way the motivation to inspect and reflect on further data elements should be increased. A search field can be used by the users to search for specific terms and thereby to inspect particular questions in detail. The last two features are improvements based on the the evaluation results.

### 5 USE CASES

In this section, we demonstrate two use cases that show how *TransparencyVis* can be used. We do this by imaginary scenarios based on real data.

#### 5.1 Use Case 1

Bob has uploaded his data from *Facebook* to *TransparencyVis* by dragging and dropping the received zip archive into the *Data Page* (Fig. 3a, T3). In the *FileView* (Fig. 3b) he can see all the files and folders contained in the data export (T1). While hovering over the boxes and revealing the names of the files (T2), he wonders about some files, which he has sent to friends years ago and which seem to be still stored on *Facebook's* servers (T7). He also wonders about the large amount of images stored there, which he did not expect (or forgot about). Then he spots the - in comparison to the others - relatively large message file (the big rose one). By inspecting the details in the tooltip, he learns

that the file contains the conversation with Alice. Having detected this, Bob might goes on to the *TimeView* (Fig. 3c) and search for all data elements, which contain “Alice”. In the timeline he can, for example, see that the conversation has mostly taken place around 2011 (T6). But he also can explore further patterns of the conversation. Bob might go also to the *ListView* (Fig. 3d) and search for “Alice” in the search field. There he would get all messages which he has exchanged with her and could inspect, whether there is especially sensitive information, which he probably would like to delete.

#### 5.2 Use Case 2

Fig. 1 shows how four different datasets can be compared (T5) with each other in one view. Alice (left) and Bob (right) have both provided their personal data sets retrieved from *Facebook* (top) and from *Google* (bottom) - (T3). Compared to Bob, Alice seems to have used *Facebook* mostly for private messaging (rose circles in (1)). Hovering over the circles reveals the communication partner as well as the full message text of the message item (T2). According to the data, Alice primarily used *Facebook* (1) rather than *Google* (3). She seems to have some messaging data on *Google* around 2015, but then she seems to have avoided using her *Google* account (T6). In contrast to this, Bob’s *Google* dataset (4) reveals a large amount of tracked activities (green). Beginning in 2014, his location is tracked constantly (orange). Each circle reveals the concrete stored information in a tooltip, like actual location coordinates, search terms, seen videos or visited webpages. Bob has an *Android* phone, which is connected to his *Google* account, while Bob’s privacy settings allow *Google* to track all of his activities on the platform. Alice on the other hand was surprised to discover that the green activities around 2015 hint at her *Youtube* history of videos she had watched at that time. Thinking about how her taste and interests have changed over the years, she caught herself at the thought, that she would feel uncomfortable to share part of the history with others (T7). Both Bob and Alice noticed that security related data in

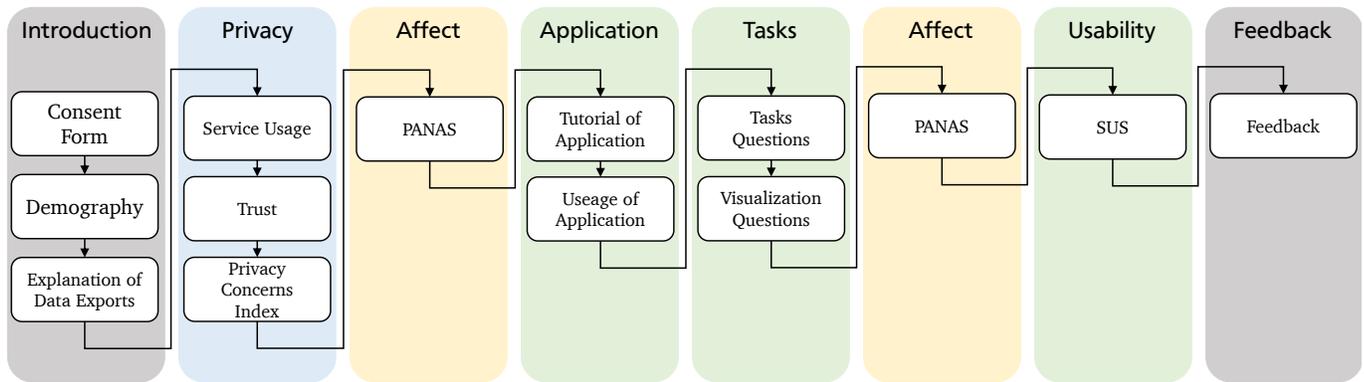


Fig. 4: Evaluation proceeding - Questionnaire to receive feedback about *evaluated user group*, *appropriateness of TransparencyVis*, *effect on the privacy attitude* and *usability*. The online evaluation started with an introduction part and followed by a questionnaire to derive users attitude to privacy. A PANAS questionnaire has been used to examine the participants emotional affect of seeing the data in *TransparencyVis*. The participants could explore *TransparencyVis* with their own data. The evaluation conclude with questions regarding usability and general feedback.

the collections of *Facebook* has increased since around 2016. While the scenario that two users would provide their data to merge them in one visualization, seems quite unrealistic, we decided for this use case to present the possibilities of the tool and to present the difference of data sets between different personalities. However possible applications of this scenario might be, the combination of data sets of members of a family or the comparison of own data with exemplary average datasets.

## 6 EVALUATION

We evaluated the first iteration of our prototype *TransparencyVis*, with regard to the three goals defined in Sect. 3.3. The evaluation focused on four main aspects: (1) *evaluated user group*, (2) *appropriateness of TransparencyVis*, (3) *effect on the privacy attitude* and (4) *usability*. We have used the results to improve *TransparencyVis* into the version presented in this paper.

### 6.1 Methodology

As detailed in Sect. 4, the prototype is a web interface that can be used with personal data. Therefore, we have conducted an online study with 37 users (14 f, 21 m, 2 other) and their own personal data. The age ranged between 20 and 64 years with a predominance on the age group of 20-34 years (30/37). Most participants were either students (12) or employees (24). All participants were from Germany. The study ran for 21 days. The average duration of an evaluation session was about 30 minutes. Only the participants that reached the last page of the evaluation were recorded. The participants were led through a fixed process by the evaluation tool [46] without the need for an instructor. Therefore, participants could conduct the evaluation on their own, in their own pace and in their familiar environment. This way the usage of the tool during the evaluation leaned on the natural context of an every day situation, in line with the targeted user group. The process of the evaluation is shown in Fig. 4. The questions of the evaluation can be found in supplementary materials. The evaluation started with the introduction, which consists of a consent form, a questionnaire on demographic data and a data preparation session. Then, the participants had to fill out a questionnaire about their attitude towards privacy. This questionnaire was inspired by the works of Cabinakova et al. [7] (trust), Westin [56] and Bergmann [4] (privacy concern index). Furthermore, we asked the participants to fill out the PANAS questionnaire [54] before and after the actual interaction with the tool. This was used to measure the possible emotional affect caused by the exploration of the own data as provided by *TransparencyVis*. After using the tool, some questions regarding possible discoveries were asked, followed by a questionnaire about the perceived appropriateness of *TransparencyVis* for some selected tasks, primarily concerning the goals to support *perception* and *comprehension*. Then we checked the overall perceived usability with the SUS questionnaire [2]. Finally,

we asked the participants for their subjective opinion, if and how the insights in the data have changed their attitude towards privacy and gathered more general feedback.

## 6.2 Results

### 6.2.1 Evaluated user group

In the set of participants were 9 *Unconcerned*, 17 *Pragmatics* and 11 *Fundamentalists*, which goes along with the distributions observed by Bergmann [4], that unconcerned users are usually underrepresented. The users' trust in services was measured with two questions from Cabinakova et al. [7]. The answers were converted from their Likert scale to a score from 0 to 100. The mean of all participants was 68.2 with a standard deviation of 26.5. Most users had an account on the *Google* platform with 33 out of 36 participants, *Facebook* with 30, *Instagram* with 22 and *Twitter* with 12 participants (see Fig. 5). Participants from the *Unconcerned* group used the most services with 2 to 5 services. The *Pragmatist* group used between 2 to 4 services. The *Fundamentalists* group used the least with 1 to 3 services. The *Unconcerned* had the least amount of hours used with an average of 15 hours weekly across all services. The *Pragmatists* group had an average of 32 hours, and the *Fundamentalists* an average of 16 hours. In conclusion, the participants of this survey are well distributed in their privacy attitude and users of multiple services.

### 6.2.2 Appropriateness of the tool

Overall, we have received much appreciation by the participants as well as from informal presentations of the interface. Nine participants expressed their praise explicitly in the feedback section with an appropriate comment. Several participants asked if they could forward the link to friends.

**Support perception of data:** The questionnaire supports the appropriateness of the tool for the perception of the *amount of data* (28/37 agreed), the *type of data* (25/37 agreed) and *trends and patterns* (18/37 agreed). These are the main aspects with regard to the goal to support *perception*

**Support comprehension of data:** To determine whether the participants were able to bring the perceived data in context with their meaning, we asked what they saw during the exploration phase. This way we wanted to estimate the effect with respect to the goal to support *comprehension*. In particular we asked about the patterns or insights that participants have gained from their data. Interestingly, the ability to find patterns seems to relate with the privacy concern group to which the participant belonged. This is shown in Fig. 4. While the majority of the *Fundamentalists* (7/11) reported about exciting trends, only 3 of 9 *Unconcerned* have claimed to see any trend. For the *Pragmatists* it appeared to be half-half. We received reports about some identified trends, which we have clustered in the following groups.

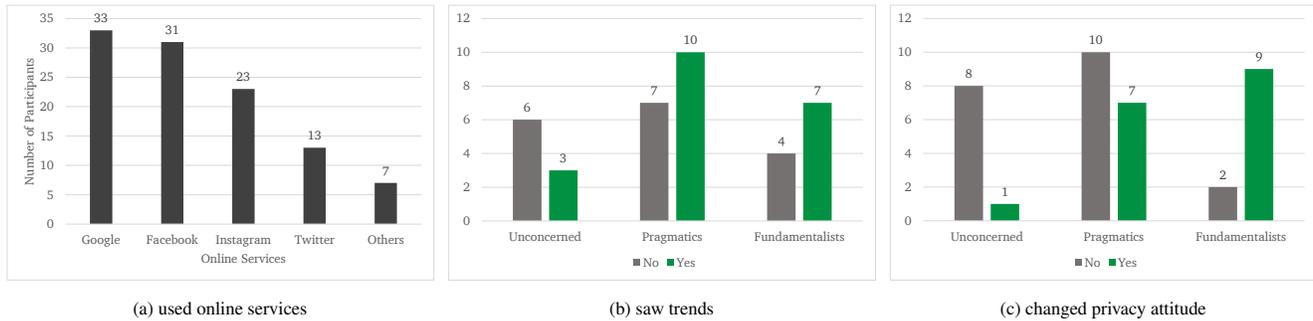


Fig. 5: Evaluation results. (a) Amount of participants using each online service, (b) Amount of participants that claimed to have seen any trends in their data, differentiated according to the privacy attitude groups, (c) Amount of participants, who claimed to have changed their privacy attitude after having seen their data through *TransparencyVis*

- Usage patterns regarding the platform:** e.g decreased activity on *Facebook*, changes from one platform to another
- Changes in online behavior:** Periods of a high amount of messages or friends requests, last deletion of the browser-history and similar
- Changes in location:** Changes of place of residency, change of workplace, holidays, location change from working day to weekend
- Changes induced by the platform:** For example increase of security elements from *Facebook* in recent years
- Personal events and patterns:** Sleeping patterns, online times, holidays, birthday congratulations, or change of jobs

### 6.2.3 Usability and improvements

The SUS revealed an average score of 65.4, which is a good value for the first iteration. There was nearly no difference between the different user groups. We further clustered the textual answers from the feedback section and derived the following main points for improvement, which we have adjusted in the version presented in this paper.

- Zoom function:** Adding a zoom function or a selection of a time-period to the TimeView
- Filter improvement:** Improve the filter option, e.g. filtering on the categories, reducing the overload
- Tooltip improvement:** e.g. format, details, position
- Search function:** Improving the support for pattern detection by adding a search capability to the timeline

Furthermore, *FileView* and the *ListView* turned out to be complicated to understand for the participants. We have implemented some improvements for the current version. For the *FileView* we have simplified some interactions and improved the tooltips. We further classified the files (white) additionally according to the type of file, which is displayed as a label and in the tooltip. We also have simplified the layout of the *ListView* and added the average rating value as a feedback for rating of the perceived sensitivity. Additionally we added a search functionality to filter the elements.

Summarized, the main extensions we have implemented after the evaluations are: Support of multiple data sets simultaneously, filter by categories, zoom and pan, feedback for the sensitivity rating, improved tooltips and layout simplifications.

### 6.2.4 Effect on privacy attitude

With regard to the goal to support *projection*, we wanted to know whether the use of *TransparencyVis* had any effect on the privacy attitude of the participants. The results of the PANAS questionnaire revealed a significant increase of the negative attributes *Upset* (+0,78) and *Scared* (+0,65) and a marginal significant loss of the positive attribute *Determined* (-0.41). With one of our goals being to trigger more attention for the effects of online behavior, an increase of a slight

alertness based on the insights can be seen as success. However, while this evaluation only meant to get a trend about possible effects, further studies should conduct deeper evaluations on the effects and their reasons.

**Support projection:** 17 participants confirmed that the use of *TransparencyVis* had an influence on their privacy attitude. Interestingly, most of these participants belonged to the group *Fundamentalists* (9/11), while only one *Unconcerned* (1/9) was affected in a similar way (see Fig. 5b). Further we clustered the answers to the questions about which kind of influence has been experienced. Overall, we derived the following clusters of answers to the questions on privacy attitude:

- More attentiveness:** Many anticipated on more attentiveness for their own personal data handling and online behavior (8 participants)
- Checking settings:** Some intended to check and change privacy settings, maybe switch to more trustful platforms (4)
- Deletion:** Some stated to delete their data, the entire account or avoiding such platforms (4)
- Gain of Confidence:** Selected participants increased their confidence in treating their personal online data (2)
- Surprise:** Some expressed surprise about which data actually has been collected (2)
- Curiosity:** One expressed curiosity about what the exported copy might not include (1)

## 7 DISCUSSION

With our design study, we have gained several insights into the understanding of personal data stored by online services. First, the idea and the current implementation have received much approval and interest from the targeted user group. We have observed, that especially the inclusion of the usability requirements **R8-R10** had a strong influence on the positive feedback. This is especially true, because the users could use the tool with their own personal data at their own pace in their own private environment. The evaluation showed good results when reflecting on the effect on the privacy attitude and perceived appropriateness of the tool for the intended purposes. However, the obviously subjective answers with regard to the change in privacy attitude should not be seen as possible trends in changed behavior. Therefore, long-term studies have to be applied on improved versions of the interface to examine the significance of the effects. During the evaluation we have also gained valuable feedback, on how to improve the usability of the interface, which we have partly integrated into the version of the tool presented in this paper. Some implications will require further research. This is especially true for *ListView* and *FileView*, which purpose seemed to have not been understood very well by the participants. Additionally to the optimizations in this paper, a stronger improvement of the rating functionality and the appropriate feedback of the *ListView* should be carried out in future work. Especially the calculation of the perceived sensitivity should get a stronger attention. While the concept of the

treemap in the *FileView* seems to be not very intuitive for the common users, it has many advantages with regard to the data of the exports, as described in Sect. 4.2.2. Future work, however, should take the optimization of the treemap visualization for non-experts into account. One of the challenges, which is also related to the *FileView*, is the huge variance in the formats of the data exports between different online services as well as between different users. This complicates the development of appropriate parsers for the proposed unification scheme. The problem of the huge variance in formats and content also leads to the open challenge, to achieve a comprehensive overview for the user. Additionally the communication of the difference between *files* and *data elements* to the user still needs to be improved.

Overall, we are encouraged by the results of the evaluation of the first iteration of the tool and are more confident that tools of this type have the potential to receive attention by a broad range of Internet users. While the current version is primarily designed as an independent interface for the individual, the application of such a visualization by online services is another possibility. Such functionality could increase the users' trust in the services, which is an increasingly important factor for the willingness to share personal data with an online service [7, 34]. As an extended stand-alone application, the interface could, however, also be used as a management tool for online data by bringing the exports of all used online services together.

## 8 CONCLUSION AND FUTURE WORK

In this paper, we have presented our design study on increasing the attention and awareness of the common internet user for their own personal data that are stored by different online services. We have presented the targeted user group, which we differentiated by the privacy concern index together with the used data source. We also have provided a unification scheme based on two defined data types and ten plus one categories, which can be used by other researchers to develop new parsers for further services. We have also presented the tasks which we have derived based on the theory of situation awareness applied to stored personal data. Based on the derived requirements we have implemented the online accessible prototype *TransparencyVis*, which can be used with own real personal data. We have evaluated this tool with 37 targeted users and have elicited important insights with regard to the tool's appropriateness, usability and effect on the participant's attitude towards privacy. The evaluation of this first iteration has led to many ideas for improvements of the approach. The main next steps would be to improve the *FileView* to enhance the overview of all data contained in the download at a first glance. Further we want to investigate how an active reflection on the presented data can be supported more effectively. A possible approach could be to connect a users rating of the sensitivity to an active learning approach to support the visualization of the results. A remaining challenge for any new ideas is our effort to preserve the privacy of the user by not using a server-based approach. Further potential improvements include the employment of additional analysis methods, including other services, and further optimizations of the data parsing.

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