

# An Interactive Visualization Interface for Studying Egocentric, Categorical, Contact Diary Datasets

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**Abstract**—Contact diaries are interpersonal communication logs which are obtained in sociological and epidemiological studies. These logs can be used to study the social patterns of communities over a period of time. A dataset composed of diaries maps well to a set of one-tiered, categorical, independent and egocentric networks. This paper presents an interface for visualization and analysis of contact diaries datasets using an interactive radial mapping scheme, with case studies illustrating a standard workflow using the application. We facilitate individual diary analysis, multi-dataset comparison, and an overlay interface for investigating a set of many diaries in a singular space. With this interface, network researchers can utilize visualization to enhance their analysis of contact diaries.

## I. INTRODUCTION

Social networks study and visualization is a growing and wide-ranging area of research. Network visualization has traditionally taken the form of node-edge graphs, where actors are related to each other via links, forming a web like view. This allocentric view works well for visualizing generalized relationship networks, but custom views can be leveraged to enhance display of more specific datasets. One notable subset of social networks are *egocentric networks*, which are visualizations based around a central node (or cluster of nodes). The visualization of an egocentric network is derived from the prominence of this central node, and analysis of the network is based around this principle.

One form of study that generates egocentric datasets is *contact diaries* [1]. Along with direct observation and subject interviews, contact diaries are a major source of data collection in sociological studies. A single diary normally consists of a log of interpersonal contactees, called *alters*, filled out by a respondent, called an *ego*, over a period of time that he or she interacts with alters. By randomly sampling egos from a large and diverse population set, contact diaries are an effective method to generate comprehensive interaction datasets for populations. From diary datasets, records, trends, and patterns can be extrapolated about larger communities or cultures.

Contact diaries map well to a number of relatively small egocentric networks, where the alters of an ego form an independent, “one-tiered,” small world cluster specific to that particular diary. Because of this ego independence, along with a large set of categorical and boolean attributes contained in these datasets, display with simple visualizations such as

scatter plots and bar charts is difficult. This necessitates a specialized design tailored to the data. However, an overly complicated view would be bewildering to most users who are not familiar with graph design. A simple and straightforward mapping and interface can be leveraged with interactivity to generate an effective process for analysis and discovery.

This background gives the basic motivation for this project: to develop an intuitive and easy-to-use process for visualizing egocentric and categorical datasets. The visualization itself takes on a radial view to highlight relationships between egos and alters. The accompanying interface is designed for ease of use and gives a non-technical user the ability to tweak presentation of results on the fly, allowing flexibility and fine-tuning without having to reload the system. From this, we show how visualization is a helpful tool for network researchers analyzing contact diary datasets, and contribute a set of case studies to further research in this domain.

## II. CONCEPTS

### A. Contact Diaries

Contact Diaries are a major form of data collection used in social network research [1]. A single diary usually consists of a list of all persons with which a person has had interpersonal contact with over a span of time, and a dataset is composed of a large set of individual diaries. Data kept in the diary includes information about each contactee and the nature of their interaction(s) over the diary’s timespan. Contact diaries we used were collected with systematic probability sampling, while controlling for population representation.

The diaries used for this project come from a Taiwanese dataset [2] and two European countries (Great Britain and the Netherlands) taken from the Polymod study of social contact patterns [3]. All datasets were collected for investigating how interaction affects patterns of infectious disease spread.

Each dataset was collected in similar fashion, mapping the interpersonal contacts that a subject had over a 24-hour period, and controlled for the maximum number of alters (40 for Taiwan, 30 for Great Britain, 55 for the Netherlands). We map the following set of characteristics from these studies:

- Gender - male, female, unknown of the ego and alters.
- Age - the age of the diary keeper and his/her alters.

- Frequency of contact - categorical groupings differentiating the average amount of contact the ego has with the alter. Can be daily, weekly, monthly, yearly, or first time.
- Order - the order in which the ego met the alter over the course of their diary, starting from one.
- Touch - either yes, no, or unknown, denoting whether or not the ego had physical contact with the alter, such as a handshake or hug.
- Duration - the length of the interaction between the ego and alter, broken into one of five groups, from unknown to under fifteen minute to greater than four hours.
- Locations - three boolean attributes denoting if any contact took place at the ego's home, school, or workplace.

These attributes represent a fairly standard set of contact diary characteristics, and allow for a large degree of investigative freedom.

### B. Egocentric Networks

Egocentric networks are defined around a central node (or cluster of nodes) called an *ego*. All other nodes in the network, called *alters*, surround the ego.

It is important to reiterate that the datasets for many contact diaries are *one-tiered*, which means that each alter has a direct relationship only to the ego; there are no direct connections between alters. Since egos are also independent from each other, a contact diary dataset can be thought of in an allocentric network view as being composed of many disconnected clusters. From this point, we can overlay diaries on top of each other in a singular mapping to analyze a large set of egos at once.

### C. Categorical Data

Some datasets have *categorical* distinctions, as opposed to degree or scale distinctions. An example of this is gender: the choices are from the set [male, female, unknown]. When not using clustering in a network graph setting, Venn and Euler diagrams are the common approach to set visualization [4], but can suffer from high complexity when groupings overlap and have elements that span many regions.

For example, a grouping by gender overlaid on a grouping based on age ranges could have both male and female elements in each range. This paper takes a hierarchical approach to classifying data, pushing elements with the highest priority (which we call *ranking*) to an initial positional range, and recursively subdividing within these ranges among the lesser ranked attributes.

## III. RELATED WORK

As network visualization is a major area of computing research with a long history, there is a robust set of research on the topic. Many approaches to social network visualization are based on edge-node graphs, displaying people as nodes and relations between them as edges. [5] gives a good overview of the history of social network visualization. Vizster [6] is one notable example of an application for node-link graphing

social networks. It also implements clustering and force direction to assist users with readability, although it is not meant for rigorous analysis.

While graphs are the traditional way to represent nodes, high complexity in large networks can lead to reduced readability via edge crossings and nodes that span multiple clusters. As such, various network implementations have been studied to reduce complexity, including methods that abstract away edge clusters altogether. Two proposed solutions are representing graph clusters in condensed formats, such as matrices [7], or using node duplication to reduce link density and so-called cluster ambiguity [8].

As a subset of generalized graph networks, egocentric networks are more concerned with how to arrange nodes in relation to a centralized node. Some graph views remove edges then, and rely entirely on node position and proximity to other nodes to infer relationships [9]. This approach can work particularly well if, as in our case, each egocentric network is independent. Many user-centric visualizations are concerned with communication over time [10], and make use of circular displays for their implementation in the form of hyperbolic planes [11] or other radial metaphors [12], tree rings [13]. We are similar to these too in adopting a circular structure to show node relationships to a central actor.

Regarding the issue of categorical data display (or set visualization), Euler and Venn diagrams (and their various evolutions) are traditionally the more popular visualization implementations [14]. Many papers focus on ways to visualize datasets with complex components that span multiple groups. [15] and [16] use discontinuous shapes to form their visualizations, while [17] uses overlapping linked sets and element duplication to form their views.

For viewing hierarchical classification, various implementations have been proposed, although tree-based views and hyper graphs [18] [19] are the most common. [20] is based on modified Euler diagrams. Integrating hierarchical classification into graphs views leads to display paradigms such as hierarchical edge bundling [21], knowledge graphs [22], and compound graphs [23].

Finally, we note that many social scientists use simple and straightforward visualizations to display their results, such as scatter plots or bar charts. These are available in many visualization packages (Tableau [24] is one example) or even as Excel exercises. While views such as these can be rather limited, they can be customized to give higher dimensionality or granularity. Recent work with scatter plots, for example, has regarded displaying higher dimensionality [25] and density [26], and using shadings for more clarity [27].

## IV. AN INTERFACE FOR ANALYZING CONTACT DIARIES

### A. Motivations

From discussion in the previous sections, we are motivated to many design choices. Since contact diaries are based on egocentric networks, alters can have a *closeness* factor to the center, making a polar mapping design suitable. We remove edges, since alters are not directly connected except to the

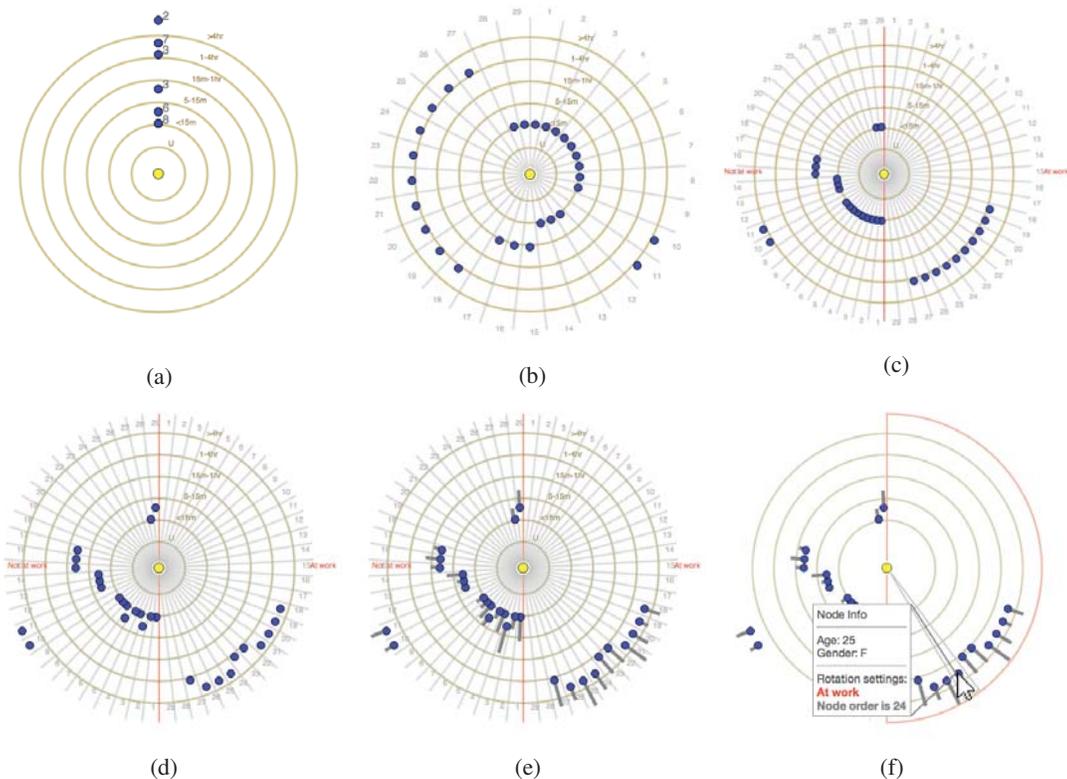


Fig. 1: Six initial radial views showing how interaction quickly builds a highly dimensional mapping for a single ego. (a) Initialize the display by setting alters on tan-colored rings based on their duration attribute (grey text notes duplicate nodes at a position), where there are six possible values. (b) Apply a rotation based on contact order, showing the timeline of interaction for the diary. (c) Update the rotational hierarchy to “work + order,” meaning alters are first classified by whether they interacted with the ego at work, then order in which this happened. (d) Apply a secondary radial ranking on gender (without adding gender step guidelines). Female alters are incremented a half step away from the center of the mapping. (e) Apply a set of line tags showing the frequency of each contact, where longer tags show more frequent contact. (f) Use mouse over to highlight a particular node’s classifications and rotational slots.

ego, and egos are not interconnected. We also implement a hierarchical classification system for higher dimensionality and categorical groupings.

The framework is highly interactive and updatable, allowing for quick view generation and updating. It should be intuitive and reproducible over different data sets, since social scientists will be the primary users. We design a view with both overlay and side-by-side comparison, giving the option for viewing single diaries or an entire dataset in a single, consistent display.

### B. Radial Mapping

Our basic mapping for our panel and singular views is a multilevel circular layout that positions alters around a centrally located ego. The basic idea is that a user selects two ranking layouts: one assigns each alter to a ring, the other rotates each alter a certain degree.

Each layout classifies nodes according to user-selected attributes from the dataset, and each attribute has a rank associated with it (either radial or rotational). These ranks establish the positioning priority of the alters. We define the hierarchy of ranks via the formalism “rank one + rank two...” to show which attributes define the primary positioning of the

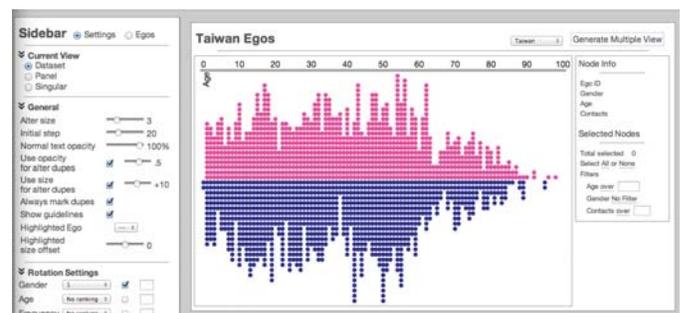


Fig. 2: An overview of the interface, showing the Taiwan dataset’s ego histogram and the control panel sidebar.

ring or rotation, and which are recursively applied within the space already established by higher ranked attributes.

Figure 1 illustrates how to iteratively build a mapping by applying ranked attributes. By iteratively adding and ranking attributes, a classification hierarchy for both ring position and rotational placement is made, creating a mapping that lets us view multiple dimensions of attributes, with focus on attributes that we consider most important. Guidelines and text tags denote the edges of classifications. We also give the option

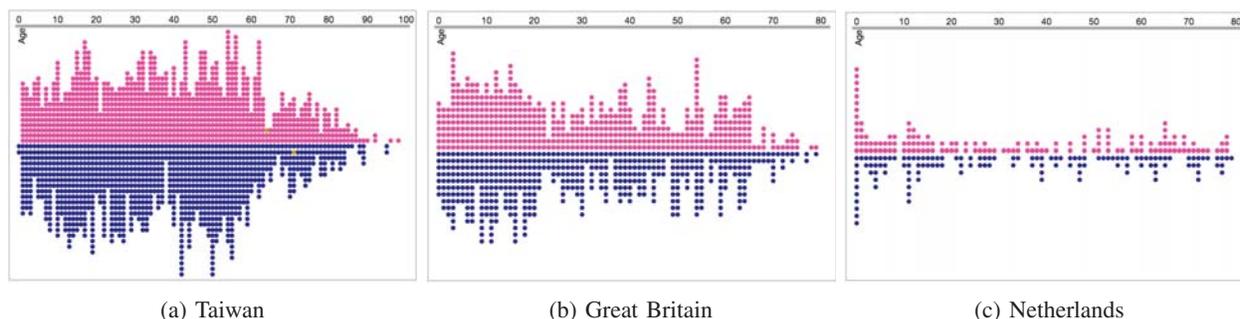


Fig. 3: Histograms showing age distribution and gender coloring for egos of each country. The points are colored by gender and arranged by number of contacts (y-position) and age (x-position). Taiwan is the large dataset with 1,954 egos, while Great Britain and the Netherlands have 1,012 and 269 egos, respectively.

to add *line tags* to the view (Figure 1e), which are radially outward line segments with a length according to a defined attribute, giving an extra degree of dimensionality for nodes at a position. Finally, we add in classification highlighting to show the recursive classification of a particular set of nodes when they are hovered over. Figure 1f shows this.

### C. Overview of the User Interface

Here we give an overview of the interface we implement. It is presented to a user in a single browser page, for ease of navigation, and contains the following components:

- A histogram plot view for viewing and switching between contact diary datasets.
- A sidebar control panel for setting layout classifications and views.
- A panel view for showing individual ego mappings.
- A singular view for manipulating individual egos in detail or viewing multiple diaries overlaid on top of one another.

The following subsections detail what each component does, and describes the radial mapping we implement for the panel and singular views. The initial loading of the page brings up only the sidebar and histogram (see Figure 2). As the user selects components to analyze on, the views toggle from the histogram to the appropriate panel and singular views.

1) *Histogram*: This displays the egos for a specific dataset. It is categorized horizontally by age, vertically by number of alters, and colored by gender. For this paper, we have contact diary datasets from three countries: Taiwan, Great Britain, and the Netherlands. The individual histograms for each country are displayed in Figure 3. The egos and alters counts for each country are shown in Table I. In this view, user selects a set of egos, uses the control panel to set up his view settings, and clicks a generate button to go to the panel view.

TABLE I: Egos and alters by country

Country	Taiwan	Great Britain	Netherlands
Egos	1954	1012	269
Alters	24265	11876	3726

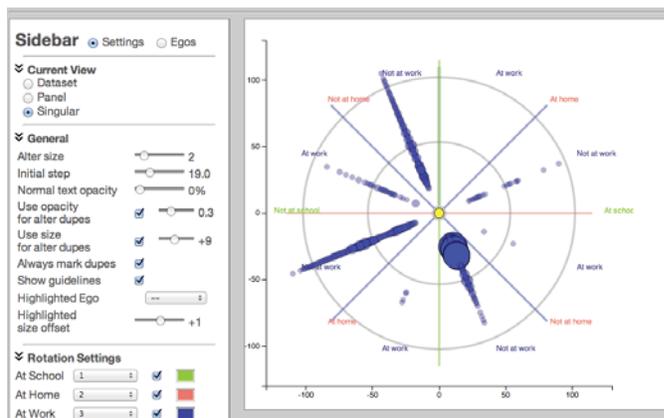


Fig. 4: An example of overlaying multiple egos and rotating on multiple attributes. Radial distance is determined by age of alter, and the rotational rankings are done by the classification “school + home + work” booleans, which lead to eight possible rotational slots for each alter. The fourth slot (from clockwise top) is the most densely populated, which represents interactions “at school, not at work, not at home,” and is composed mostly of students, particularly small children and teenagers.

2) *Sidebar*: The sidebar contains a control panel for setting rank layouts for ring and rotational positioning, as well as guideline colors and a number of general settings. The two notable general settings we utilize in our case studies relate to the number of alters occupying the same position in a mapping: we use their density to determine opacity and size of the node for positions where multiple nodes occupy the same space.

3) *Panel View*: When a set of nodes is picked in the histogram and the “generate multiple view” option is selected, the display toggles from the histogram to a panel showing all the selected egos and their mapping, based on ring and rotation classifications chosen in the sidebar.

The panel is the starting point for analysis. The sidebar toggles to an ego listing, where individual egos may be selected for loading into the singular view.

4) *Singular View*: After selecting a set of egos in the panel view, an update button closes the panel view and opens the singular view. This view presents a larger circular mapping,



Fig. 5: Using the panel view to compare a nine year old female to a 63 year old male based on contact duration (radial distance) and age (rotational position). The female ego (the left mapping) has a cluster of alters to the upper right, which shows she has contact with many young alters under the age of ten years that she interacts with for long periods of time. The male ego's (right) grouping in the lower half of his mapping indicates contact with many middle aged alters from moderate to extended periods of time.

and will display multiple selected egos overlaid on each other. This view is intended for analysis of large sets of egos, although small sets of nodes can be loaded for comparison (as in the Section V-A).

This view can facilitate analysis over entire contact diary datasets or between datasets from different locations or times. Figure 4 show an example of the singular view for overlaying a large set of egos. Enlarged node size based on duplication is enabled, meaning nodes with a high number of duplicated alters at a position will be larger. This lets us more easily discern patterns and traits about our datasets, such as alter density or ratios of alters between other classification regions.

## V. WORKFLOW AND CASE STUDIES

This section discusses how a basic workflow using our interface can be leveraged to explore and analyze our three datasets. We do so by walking through three basic case studies that a scientist might perform in analyzing a set of contact diary datasets. We note that each study is performed using the same radial view, demonstrating the flexibility and adaptability of our interface.

### A. Comparing a young and an old contact diary

We initially explore how two different diaries are represented using the same classification rankings. We randomly take two egos from our Great Britain dataset: one that is a nine year old girl, and one that is a 63 year old male.

We set our rotation layout to “age” and our radial layout to “duration,” so each dimension only classifies with one attribute. Switching to the panel view gives us Figure 5. The two mappings are quite different, as the left one (the female, denoted by the pink ego in the center) has most of her alters in the upper right quadrant, and the older male has the majority of his alters positioned to the bottom half of the circle.

Even without age guidelines turned on, we can tell from rotation that the female ego interacts with mostly young alters while the male ego interacts with more middle aged alters. Enabling age and duration guidelines and switching to the singular view overlays the two mappings on one circle, as in Figure 6a. For clarity, we also highlight the female ego so its

alters are orange in color. Now we can directly see how the two egos compare to each other.

The highlighted female ego has most of her alters in the upper right quadrant, radially located farther away from the center. These alters have an age of eight years or less, with contact duration of fifteen minutes to four hours. This infers that the female ego was in a school or group setting of similarly aged alters for a significant span of the day. There are two sets of alters, grouped around age thirteen to nineteen, and 35 to 42, that have a duration of greater than four hours. We can surmise that it is that her parents or school teachers in this latter group, while familial siblings or schoolmates are in the former.

This contrasts to the male ego, which has no alters younger than sixteen. Most of this ego's alters range from 35 to 60 years old and have a duration of less than four hours. The initial thought might be that these are alters encountered during the male ego's work day, so we update the view to investigate this. We keep the “duration” setting for the radial distance the same, update the rotation classification to be “school + work + age,” and reload the view (while disabling the age guidelines to keep our visualization less cluttered).

The updated view is in Figure 6b and reveals that the hypothesis about the male ego having interactions at work was wrong. Neither ego has any work contacts, which would go in the upper right or lower left quadrants of the display. This makes sense for the female ego, as she is only nine years old, but it was unexpected for the male ego. Instead, the male ego has a number of alters he interacted with at school, and a number he interacted with outside of school, but no alters he interacted with at work. Further, all alters at school that the male ego interacted with were in the middle of the age spectrum. Perhaps they were teachers, or he attended an adult education class composed of people moderately younger than him.

Since the work attribute is not needed, we update the view again by removing that classification and only rotating based on “school + age” attributes. This is shown in Figure 6c. We can now clearly see that both egos spent an amount of time in school, where about half of their contacts are. The female ego interacted with a number of alters for a long duration near her age outside of school, as well as alters older than her (again, probably her parents). The male ego interacted with only a narrow age group of alters at school, and a larger range outside of school, though mostly for short durations. The exception here is a female alter (which we know from mouse hovering over the node in Figure 6d) near his own age with a duration of over four hours. We can guess this is his wife.

### B. Comparing physical touch between countries

Physical touch is an important attribute for studying the spread of infectious diseases. For our second study, we will validate claims from earlier reports about physical touch. Namely, various studies have found that physical touch in interactions is higher in European societies when compared to Asian countries [2] [3] [28], especially when correlating to

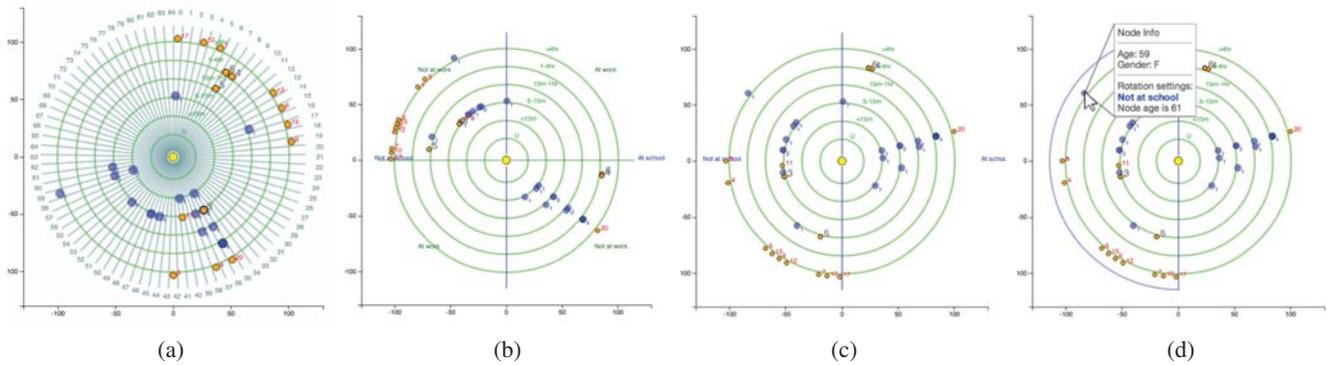


Fig. 6: Using the singular view’s overlay and highlighting to compare a nine year old female to a 63 year old male. The female ego’s alters are highlighted orange, and the male’s are blue. (a) Shows an initial ranking, with radial mapping on duration and rotation on age. We can see that the female ego has mainly young alters with long durations, while the male ego has more middle aged alters. (b) The rotation classification is updated to “school + work + age.” We see that neither ego has work contacts (upper right and lower left quadrants), and both have school contacts. (c) Simplifying the view removing the unnecessary “at work” rotational attribute. (d) Attributes of specific nodes can still be explored by mousing over them.

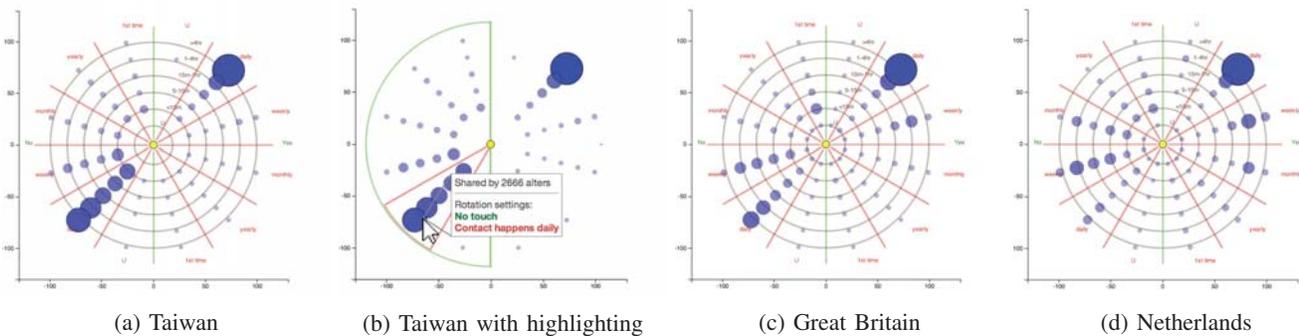


Fig. 7: Showing the breakdown of touch (right side) to no touch (left side) based on the frequency (rank two rotation) and duration (radial distance) of contacts. In (b), node highlighting helps us quickly see what rotational slots have high variability between the datasets.

the frequency that the ego comes into contact with the alter (which would be emphasized with alters like family members, work associates, or schoolmates that often interact with egos). We can map our three entire datasets to see if they conform to this trend.

We generate three views, one for each country, with the following rankings: rotation is based on “touch + contact frequency.” Since touch is a yes/no attribute, alters will go to either the right or left side of the mapping based on their touch value. There are six categories for contact frequency, from unknown to daily contact to a first time interaction, giving each side of the mapping six possible rotation “slots,” for a total of twelve slots. The ring ranking is based on the duration attribute, where a closer-to-the-center ring means a shorter duration of interaction. We also tweak the opacity and node duplication size settings to highlight alter density ratios.

The mappings for the three datasets are in Figure 7. We can draw the following observations from these views:

- All three datasets show a high density of alters where physical touch is true (right side), the frequency of interaction is at a daily level (second rotational slot), and the duration of the contact is at least one hour or more

(the two most outer rings).

- The Taiwan dataset has a much higher ratio of contacts without physical touch at a daily level (Figure 7b highlights this), for all interaction durations, as compared to the two European mappings. The Netherlands mapping has a very low density of contacts in this position, while Great Britain is in between.

This quick and simple mapping confirms that our datasets conform to what other studies have found.

### C. Comparing interactions by age, gender, and location

In this case study, we use a complicated mapping view and compare its output using four different sets of egos based on age span and gender combinations. While straightforward and readable, this type of mapping allows us to do an in-depth analysis with regards to many attributes. Each mapping compares location, age, gender, and average frequency interactions for a set of egos, and we choose four sets of egos based on the combinations possible from two age ranges (under 18 and 18-35) and the genders of the egos (male or female).

The classifications for the mapping are defined radially as “gender”, with line tags enabled to show the average contact frequency of the node(s) at a position. Rotationally, the

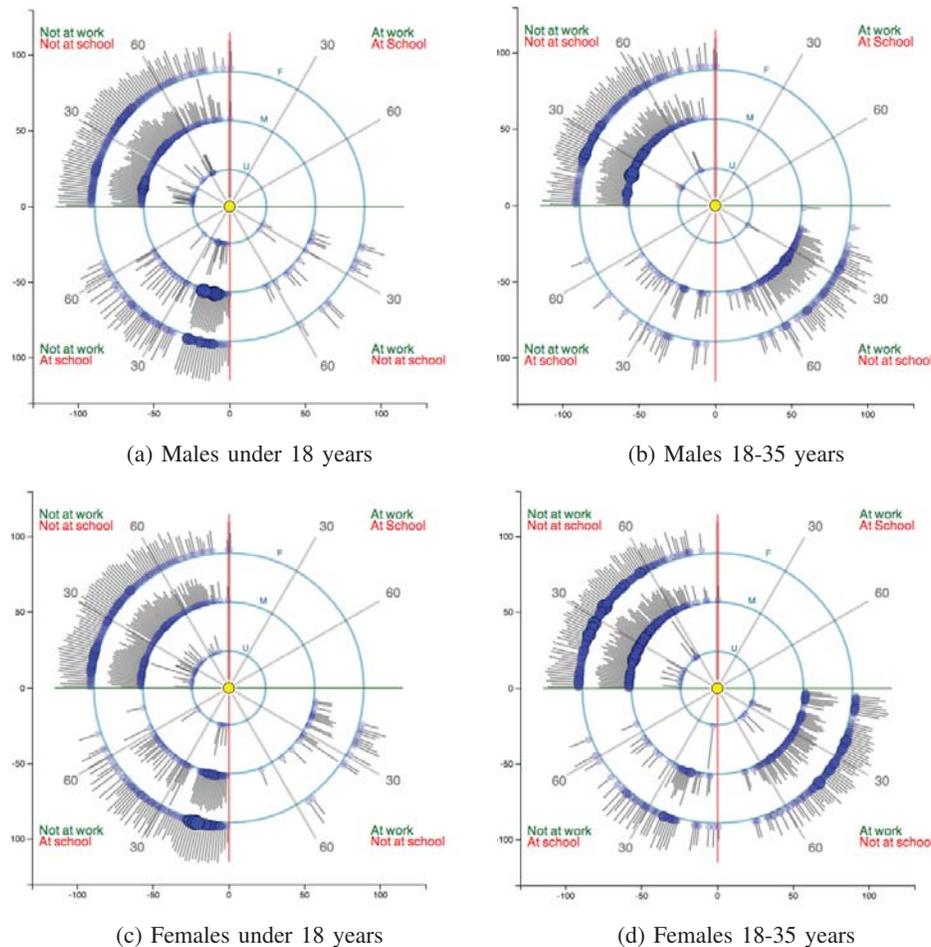


Fig. 8: These four mappings show location, age, gender, and average frequency distribution of contacts over four ego combinations. (a) and (b) show male egos in two age ranges, while (c) and (d) display the corresponding sets of female egos. The radial classifications used is “gender” with line tags enabled for the average frequency of the nodes at a position (there are three potential contact genders: unknown, male, and female), and the rotational position is defined by “at work + at school + age.” Note that guidelines are turned on for the two boolean location attributes, effectively breaking each view into four quadrants, depending on whether the contact happens at work, school, both, or neither.

classifications are “at work + at school + age.” To emphasize areas of high contact density, we turn on node opacity and size enlargement (but only slightly, so as not to occlude other nodes from view) for our dually positioned nodes.

The resultant four figures are shown in Figure 8. Radially, there are four main quadrants for contacts, based on their location of interaction with an ego, which are easily discerned with guidelines and text tags turned on. In clockwise order, the quadrants show interaction happening “at work and school,” “at work only,” “at school only,” and “at neither work nor school.” We can refer to them as quadrants one to four. Inside each quadrant slice, the age of the alter follows a clockwise path around the center, denoted with grey guidelines for showing 30 and 60 years of age.

Radially, there are three main rings denoting the alter gender (from unknown to male to female, going outwards) shown by a blue guideline. For each node (or set of nodes) at a point, a grey line tag shows the average contact frequency for the

node(s) at that position, where a longer line outwards indicates higher average frequency of interaction.

We can draw many conclusions from these plots, such as:

- Males and females under 18 years of age interact mostly with alters of similar age at school with high average frequency (Figures 8a and 8c, quadrant three), and to a lesser extent with middle aged contacts in the “neither school nor work” quadrant four. Many contacts there are probably parents or other family members.
- Females 18-35 are more likely to attend a school (Figure 8d, quadrant three), either for their children or as students themselves, compared to males (Figure 8b), as they have higher ratios of interactions there. Note though, that when comparing the average contact frequencies for adult females at school in 8d to male and female children at school in 8a and 8c, the average frequencies are much less uniform for adult females. This indicates their average interaction at school is less routine than younger egos.

- Males and females 18-35 (Figures 8b, and 8d) are more likely to interact with alters of the same sex “at work but outside of school” (quadrant two). For males, this shows high density of contacts on the middle gender ring; for females it is the outermost ring. Outside of school and work (quadrant four), both male and female egos displayed a high amount of interaction for all ages and genders up to about 60 years of age, where the amount of interaction starts decreasing for both genders.

## VI. CONCLUSIONS

Contact diaries are an important method of data collection for social network and epidemiological research. As they map well to a set of independent, egocentric networks, we argue that a simple, concise, and efficient mapping and accompanying user interface is a productive way to interact with this kind of data. We put forward such an interface, tailored for high responsiveness and quick multi-attribute analysis, with a simplicity that is suitable for non-technical scientists. We base our mapping design on a multi-level circular layout, with freedom along radial and rotational axes, and allow for a highly configurable design suited to interactive discovery.

Based on a set of case studies using three datasets, we show that our system is quick and adept at generating results, even when performing different tasks such as viewing only one or two diaries at a time, or scaling to analysis between entire datasets. Since our design and interface are both informative and straightforward, they are useful to network researchers and epidemiologists studying contact diary datasets.

Future work with our system includes updating the implementation to be more robust with regards to display and analysis, such as adding more view features (like clustering, hyper graphs, or complex set visualizations). We also wish to generate a packaged application for general distribution. Our mapping itself need not apply only to contact diaries, as many social networks can be viewed egocentrically and investigated with a similar approach to ours. Therefore, another option for future work is incorporating other egocentrically viewable networks into our system and workflow, making our application more widely usable for a general purpose audience.

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