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Data Visualization Experiences of People with Language Disability, a Qualitative Study

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Abstract

The accessibility of data visualization has been explored for people with visual and learning disabilities but not language disability. This exploratory, qualitative study invited adults with language disability to keep a diary of daily examples of data visualizations and then discuss them in an interview. Findings suggest people with language disability use data visualizations in everyday decision-making, but ease of use was variable. Future research could explore accessibility of different data visualization designs with this population.

CCS Concepts

• ***Human-centered computing*** → *Human computer interaction (HCI); Visualization;* • ***Social and professional topics*** → *User characteristics; People with disabilities;*

1. Introduction

Language disability affects a person's ability to understand language, speak, read and write. It ranges in severity from mild word finding difficulties to no verbal expression. Developmental Language Disorder (DLD) is a language disability from childhood with no obvious cause that persists into adulthood [RAD24]. It is estimated to occur in 7%of the population – 2 in every 30 people [NGW*16]. Aphasia is an acquired language disability that occurs after brain injury, most commonly stroke [BIW*22]. It is estimated that 350,000 people are living with aphasia in the UK [Ass16]. In DLD and aphasia, language difficulties are present in adults with no other cognitive or speech diagnoses and as such are the focus of this study. Accessibility in data visualization has considered the needs of people with visual impairment and learning disabilities, but there is no research exploring the needs of people with language disability [MLR*21]. To address this gap, we undertook a preliminary study to explore how people with language disability experience and use data visualizations in personal decision-making. It addressed the research questions:

1. How is data visualization used in this population and for what purpose or decisions?
2. How do people with communication difficulties experience everyday data visualizations?

2. Methods

A phenomenological qualitative research study explored the experiences of people with aphasia and developmental language disorders (DLD) in using data visualisation for everyday decision making (Fig. 1). Eight people participated in the study (n=4 with DLD, n=4 with aphasia); the number was determined so that a range of experiences could be shared within a pragmatic time constraint. Inclusion criteria were: adults (>18yrs); self-reported DLD or aphasia: score of >14/30 on Frenchay Aphasia Screening Test [EWWH]. All participants gave written informed consent after consideration of the participant information sheets. These were made accessible in line with published accessibility guidance for this population [RWHH12]. Ethical approval was gained from the University's research ethics committee.

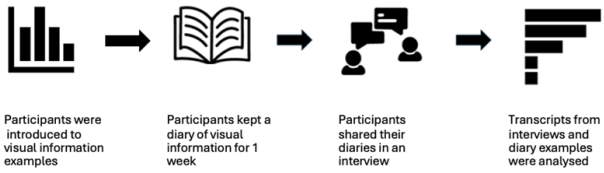

Figure 1: *Research process*

Participants were shown examples of visual information: a car dashboard, a display screen in a train that showed which carriages have empty seats, a personal health app and a route planner app (Fig. 2). They were invited to note any examples of visual information they came across in a typical week. They kept a diary of these visual information examples every day for 1 week and then discussed their experiences in a semi-structured interview. Diaries took whatever form participants were most comfortable with such

as paper and pen, photos/screenshot, WhatsApp messages, emails. Interview sessions then took place in person, in the University's speech and language therapy clinic, or online, as suited the participant.

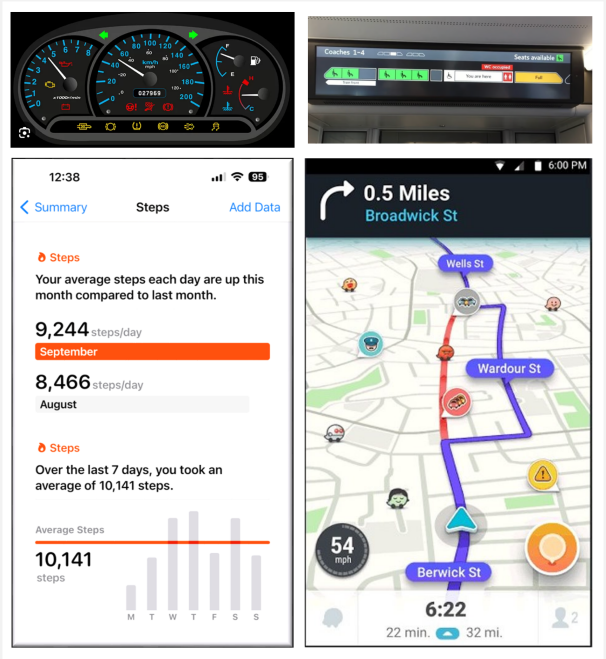

Figure 2: *Examples of visual data shown to participants. Clockwise from top left: train companies show us how busy each carriage is (image from greateranglia.co.uk); a car dashboard shows us how many revolutions per minute the engine is doing, how fast the car is travelling, how many miles the car has travelled in total, how full the tank us, how hot the engine is (image from www.f1autocentres.co.uk); a personal health app shows us how many steps we have taken today compared to our average step count (Health, Apple Inc.); traffic apps show us the quickest route based on current traffic (Waze, Alphabet Inc.)*

A topic guide directed the interview questions. The topic guide covered how participants experienced the data visualizations shared in their diary (easy/difficult), how they used them, the decisions they influenced, and the process of keeping a diary for the project. The researcher prompted the participant in order to elicit different examples of everyday decisions and visual data that were used to support decisions.

The eight diary records and eight orthographic transcripts of the interviews were analysed. Conventional qualitative content analysis [HS05] was used to extract the use of data visualizations from these data. Analysis began with immersion in the interview content, by the researcher listening again to all interviews to get a sense of the whole. Then participants' words were added to a spreadsheet for each example of visual data. Each example of visual data was then coded as either data visualization or visual information. Data visualization was defined as an idiom where more than one data value was visualised (e.g. heartrate values over time). Visual information was defined as a 1:1 representation e.g. symbol of camera on button represents the Zoom camera. Data visualization examples were taken forward for further analysis. Each data visualization was categorised by idiom type (e.g. histogram, map), category (e.g. finance, fitness) and characteristic (e.g. change over time).

3. Results

Participants were an equal split of men and women, between the ages of 33 and 70 years. Four participants had DLD, established by an adult DLD screening tool, and four participants had aphasia as measured by the Frenchay Aphasia Screening Test [EWWH]. All participants had typical nonverbal reasoning skills as measured by a score of more than 2 standard deviations below the mean for their age group on the Ravens Coloured Progressive Matrices [MZC*93].

People with language disabilities are using data visualisation it their everyday decision making. They shared 43 examples of data visualization in interviews. These were coded as 12 categories using the categories for developing apps (https://developer.apple.com/app-store/categories/). Participants used visual data for navigation (traveling to a destination), travel (planning or purchasing for travel), monitoring (checking the status of a measurement), health and fitness, weather, productivity, shopping, business (resource management), finance, education, and food and drink (See Table 1, page 5).

Characteristics of the data relationships in the examples shown from diaries were largely spatial, with examples of magnitude, deviation, part-to-whole, change-over-time, correlations, ranking and flow.

Idioms seen in the data diaries were connection maps, dot maps, bar charts, histograms, line graphs, radial bar charts, illustration diagrams, candlestick charts, span charts, stacked bar charts, timelines, heatmaps and pie charts.

The most represented categories in the data were navigation and travel with over 20 examples of data visualisation to support decisions. People use large data sets of spatial data represented as connection or dot maps via apps such as google or apple maps, bus apps, trainline, and city mapper and well as graphics like the tube map or hospital colour coding of zones to find a route and/or make decisions about the quickest route or cheapest travel option. There were a range of experiences in accessing travel visualisations with some participants finding travel data easy to use and useful and others finding it difficult to access. One participant described the use of a travel app to explore available options, compare timings and make a decision to wait for the reduced train service on a strike day:

> "I came down into the platform and it was like 'strike action'. So, then I was like, shall I get the bus into (place name)? How long is it gonna take? And I was like, well, 21 minutes actually and probably traffic is worse maybe than it's predicted to be. So, I think I'll just stay here" (P07).

This contrasts with participants who found travel visualisations difficult to access, relying on others to complete the travel task. One described being unable to navigate to a new destination on google

maps "I don't know what to do ... I call my daughter" (P03). Another found the London underground map and City Mapper inaccessible:

> "My niece met me 'cause, on the way there, to help me through the tubes because I can't do the tubes. And then on the way back, I didn't. I thought I was being a burden, so I didn't ask her, and I got myself in a muddle" (P10).

Participants shared examples of using travel data but not for its intended use. In this example a participant used the Waze app but did not drive:

> Interviewer: "So, you use it for the map?" P03: "Thank you. Yeah." Interviewer: "Do you ever use it to find a route?" P03: "Nope."

Participants reported variable experiences regarding ease of use of data visualizations. Some visualizations were given low scores for ease of use but were still used daily, "They're horrendous" (P12 discussing charts of stock market trading). Others were so difficult to use that they were prohibitive, "no, I can't do that" (P10 discussing the London Underground map).

4. Discussion

People with language disability use data visualization in everyday decision making. Existing data visualizations vary in their accessibility for this population, with some participants unable to understand or use some visual data and others using complex visualization in day-to-day decisions.

The variability in use is perhaps unsurprising given the heterogeneity within language disability profiles. There are eight language profiles within people with aphasia, some with opposite patterns of function i.e. you can have fluent speech and poor understanding or good understanding and non-fluent speech [SS21]. Equally, DLD has wide variation, multi-factorial aetiology, and a high overlap with other conditions [Bis17]. This indicates a need to consider the experiences of a broad range of people with language disability. This range of experience was evident in this exploratory pilot and needs consideration in future research.

Accessibility refers to something being 'available to and usable by people with disability' [EBM22]. Communication access ensures linguistic information in conversation, documents and environments is accessible [PPH06]. Guidelines for communication access include simplifying language (use short, active sentences) and supporting verbal language with written keywords or symbols [WGR*16, SJ17, RWHH12]. No such guidelines exist in data visualization design as yet.

5. Conclusion and Future Work

Access to information and data can be empowering and support social participation [WTP*23]. Visual resources are used to make conversations accessible in people with language disabilities so it follows that visual data may be used and useful in this population, however, to date this has not been investigated. To our knowledge, this is the first study exploring data visualization for language disability. It marks the beginning of a programme of work to explore accessibility of data visualization for personal decision making in people with language disability.

6. Acknowledgements

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Category (Number of Examples)	Example Visual Information	Example Decision(s)
Navigation (13)	Map apps	Choose the quickest route to a destination
Travel (8)	Bus app	Whether to wait for the next bus
Monitoring (6)	Dashboard information e.g., on a car or work appliance	Fill up with petrol
Health and Fitness (6)	Apps that track health metrics e.g., steps, heart rate	Choose the activity with the highest heart rate
Weather (3)	Weather apps	What clothes to wear (e.g. hat and gloves?)
Productivity (3)	Digital work diary	Amount of time available to complete a task
Shopping (2)	Reviews star ratings	If the item is worth the cost
Business: Resource Management (1)	Whiteboard timetable in for school staff	Which room to go to
Finance (1)	Charts that track trading	When to sell shares
Education (1)	Word cloud	Supported the interpretation of information
Food and Drink (1)	Colour coded nutrition information	Influences what to buy

Table 1: *Visual data instances coded with examples*