APPROACHABLE ANALYTICS FOR INDIRECT SAS USERS

Results of an Initial User Evaluation of SAS Report Visuals

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Executive Summary

These tests were conducted to measure the emotional approachability, usability, content and representation of a SAS Visual Analytics Report. The total number of participants in this study was 11. The study was not time-bound, but the total time taken for the participants to complete the test was monitored.

In this test, we took screenshots of an existing SAS Visual Analytics report and formulated tasks for our participants based on the information that could be perceived from the screenshots. Our goal was to evaluate the user experience associated with some of the report's data visualizations. In particular, our focus was understandability ("cognitive approachability") and emotional quality ("emotional approachability").

The results of the survey could be summarized as:

1. The usability of the report was hampered because of the sophisticated and aggregated display of information.
2. Complexity of the graphical components like bubbles confused and misled participants and steered them into the wrong direction
3. While, on the one hand, the report was found to be aesthetic appealing, the participants were overwhelmed and confused due to the excessive information branched and represented under one graph.
4. Some ways of displaying information in the report are not intuitive to participants, preventing them from retrieving such information
5. Participants' valence, mood and sense of control went down after performing the required tasks.

The main body of this report describes the project team's methodology and presents and discusses the evaluation results.

1. Introduction

SAS's Visual Analytics software products, including the the Visual Analytics Explorer (VAE) and Visual Analytics Designer (VAD), generate a wide range of visuals intended to communicate information and insights gleaned from large datasets in an understandable and appealing manner. Data analysts use these visuals to produce reports which they share via the SAS Visual Analytics Viewer with "indirect users" (i.e., those individuals who utilize the data represented in the reports but do not use the software, itself) who must understand and act on this information.

According to the SAS Institute (2013), "In reporting, the emphasis is on clear, compelling, and widespread communication" (p. 2). Although the goal is to enable individuals who aren't data scientists or analysts to quickly and easily discover patterns, spot inconsistencies, and ask questions of the data, such reports may be less than approachable, because the visuals themselves often require a certain level of expertise before they can be comprehended. As such, even highly educated viewers may find it challenging to understand these visuals.

This report summarizes the results from Phase 1 of a project that aims to make the data visualizations in SAS Visual Analytics Reports more accessible to indirect users. In Phase 1, we take screenshots of an existing SAS Visual Analytics report -- a report depicting data on the prevalence of Renal disease among patients with Type 2 Diabetes -- to evaluate the understandability ("cognitive approachability") and emotional quality ("emotional approachability") of the report's visuals. The results of the evaluation described in this report will be used to inform the development of a prototype which we hope will enhance the usability and appeal of the SAS report and overall user experience.

2. Methodology

The evaluation consisted of a series of task-oriented questions about the visualizations in the SAS report, preceded and followed by an evaluation questionnaire. The questions were formulated to go beyond standard measures of usability to assess experiential factors associated with using the report's visuals. In addition to recording task completion time and accuracy, data on relevant demographic characteristics, emotional state before/after task completion, anticipated/actual task difficulty, and subjective valuations of the understandability, impact and aesthetic appeal were collected.

2.1 Participants

The project team collected data from 11 participants (7 males and 4 females). 9 out of the 11 participants were in the age group of 21-25. They completed the evaluation between 4th– 5th November, 2013.

Due to external time constraints, we chose to use a combination convenience and purposive sampling method (Marshall, 1996). Potential participants were approached in person or by phone. Participation in the evaluations was strictly voluntary. Each individual session lasted approximately 30 minutes.

Prerequisites for participation included being age 18 or older, having basic English proficiency and some experience interpreting graphical representations of data but no prior experience with SAS Visual Analytics reports. This test did not require that participants be familiar with Diabetes or Renal Disease, however one domain expert was recruited so that the results could be compared and calibrated.

Figure 1 shows the age and gender distribution of our participants, while Table 1 lists their occupation and level of education. All student participants were enrolled in graduate school at the time of the evaluation and had some experience interpreting graphical representations of data.

Participant #	Occupation	Level of education
1	Student	Masters
2	Student	Masters
3	Student	Masters
4	Life Coach	Masters
5	Student	Ph.D.
6	Account Manager	Bachelors
7	Student	Ph.D.
8	Doctor	Bachelors
9	Student	Masters
10	Student	Masters
11	Student	Masters

Table 1. Participant background information.

Half of the participants have little knowledge about Type 2 diabetes or renal disease, as can be seen from the Disease Familiarity graph (Figure 2).

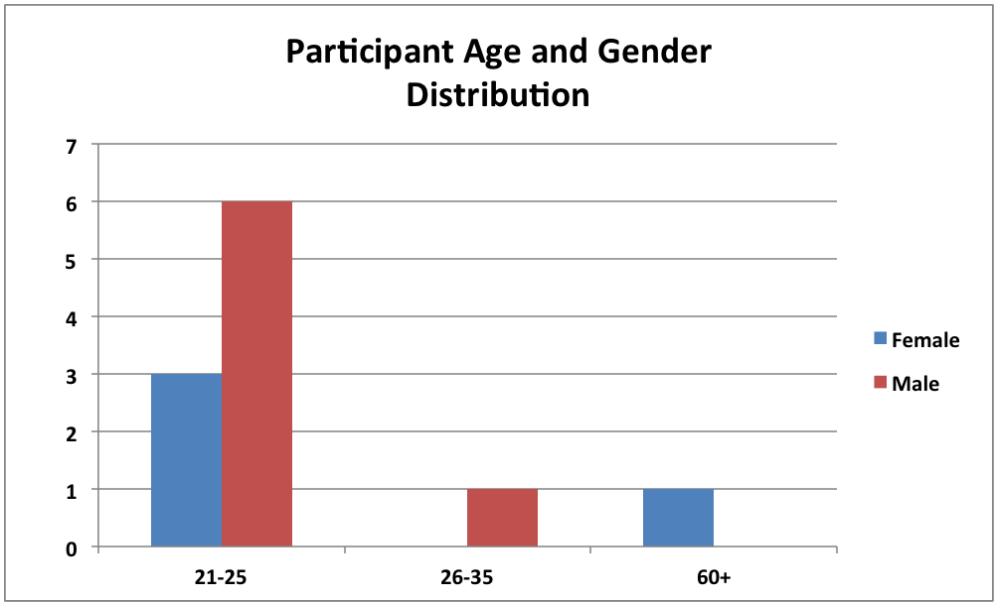

Figure 1. Age and gender distribution of the participants.

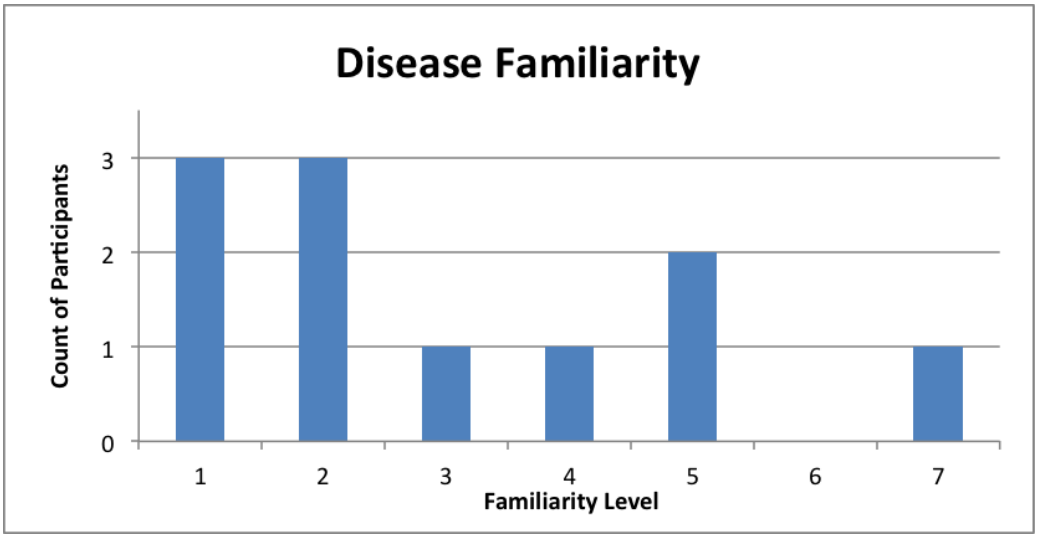

Figure 2. Participants' familiarity with Type 2 diabetes or renal disease

2.2 Sessions

During each session, the administrator (a member of the project team) explained the test session and asked the participant to complete three online forms (copies of these forms can be found in Appendices A, B, and C):

1) **Pre-Evaluation Questionnaire**: This form (Appendix A) captured demographics and participant background information, including their familiarity with the content of the report and with SAS Visual Analytics products. It also recorded their subjective emotional state (using Self-Assessment Manikins (SAM, Bradley & Lang, 1994).

2) **Evaluation Task Questionnaire**: In this form (Appendix B) participants were shown screenshots of first two tabs of the SAS report and were asked questions related to their understanding of the report and their interaction with it. The form was divided into two tasks, one for each screenshot. In each task, the participants were first asked to observe the screenshot (Overview tab of the SAS report for first task, and Type 2 Analysis tab of the SAS report for second task). They were then asked to describe what the report represented and how they would interact with the report to obtain specific information.

3) **Post-Evaluation Questionnaire**: This form (Appendix C) captured participants' reviews about the report. Specifically, the form recorded their views about the usability of the report, how they felt about it and how this interaction impacted their subjective emotional state. The form also captured their feedback on how their experience could have been improved.

Sessions were recorded and analyzed along with the data from the questionnaires to identify potential areas for improvement.

3. Results

3.1 Expected versus experienced difficulty

Prior to seeing the Visual Analytics Report and tasks, participants were asked to rate on a 7-point semantic differential scale (1 = Difficult, 7 = Easy) how difficult they anticipated it would be for them to understand the SAS Visual Analytics Report. They were also asked to rate the anticipated difficulty of the evaluation tasks. The table below summarizes the average ratings.

	Report	Tasks
Expected	4	4
Experienced	3.82	4.18

Table 2. Mean expected and experienced difficulty.

3.1.1 Understanding the report

Comparing the expected and experienced difficulty of understanding the visualizations in the report, we can observe that the experienced difficulty was nearly the same as the expected difficulty for most of the participants, with the mean of 4 and 3.82, respectively. Figure 3 shows that 4 of the 11 participants reported above average difficulty understanding the visuals while 3 of them found it to be of average difficulty and 4 participants found it easier to understand, suggesting that overall the report was about as difficult to understand as was expected by the participants.

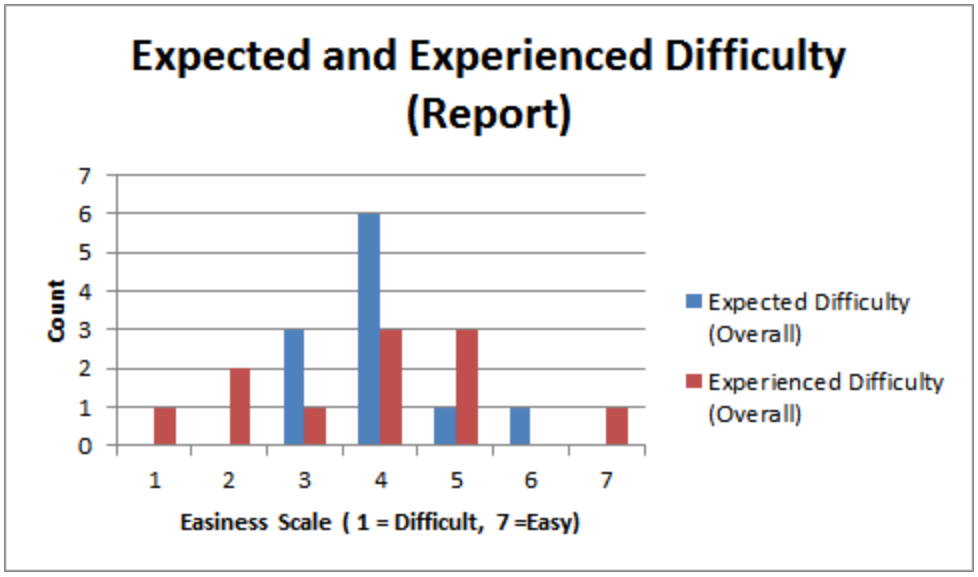

Figure 3. Expected and experienced difficulty in understanding the report

3.1.2 Completing the tasks

Similar to the ratings of report difficulty, it was found that the experienced difficulty level of completing the evaluation tasks were also close with pre-eval rating being 4 and post-eval being 4.18.

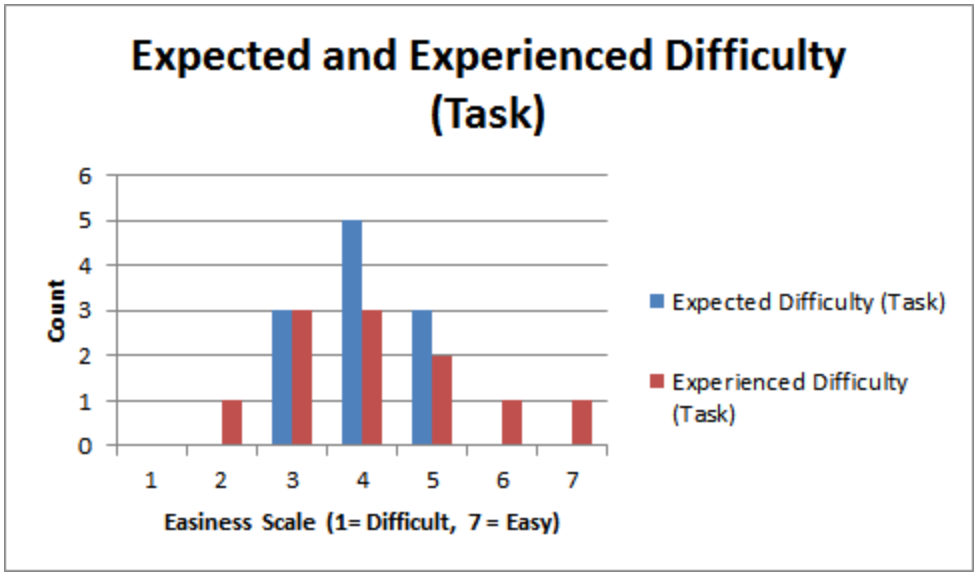

Figure 4. Expected and experienced difficulty in completing the tasks

3.2 Pre-evaluation versus post-evaluation emotional state

In order to evaluate the emotional approachability of the report, we asked participants to report their emotional status before and after evaluation using the SAM (Self-Assessment Manikin) scale. SAM allows us to evaluate emotion along three dimensions viz. Valence (happy versus sad), Arousal (excited versus bored) and Dominance (dependent versus independent). Overall we noticed decreased pleasure and excitement, and increased dependence. This hints towards poor emotional approachability of the report.

3.2.1 Valence

Figure 5 compares the valence for each participant before and after evaluation. We can observe that most participants reported a decrease in valence after evaluation indicating decreased pleasure levels post evaluation. This is also evident from decrease in the mean valence from 6 before evaluation to 5.18 after evaluation.

3.2.2 Arousal

Figure 6 compares the arousal for each participant before and after evaluation. We can observe that majority of the participants reported same or decreased arousal after evaluation indicating decreased excitement levels post evaluation. This is also evident from decrease in the mean arousal from 5.09 before evaluation to 4.90 after evaluation.

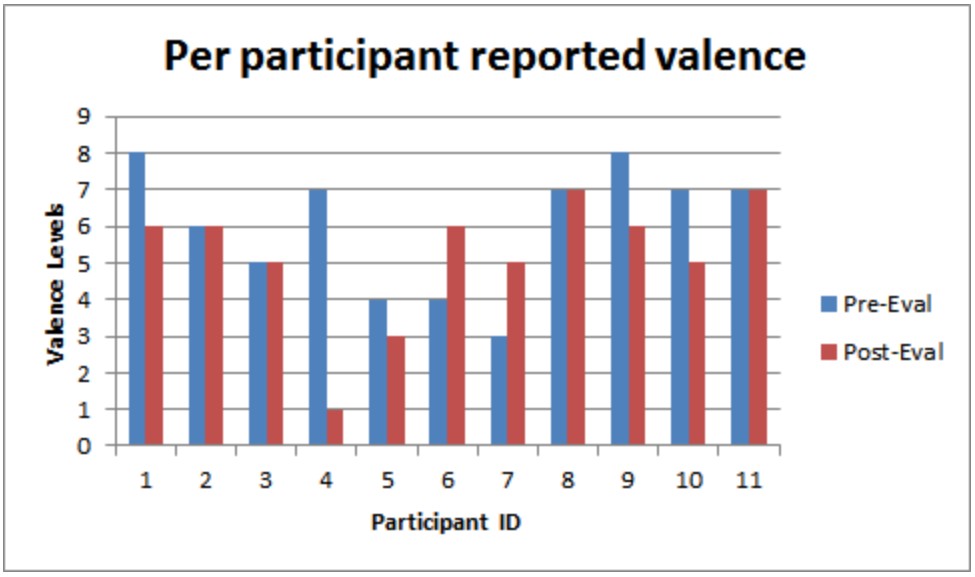

Figure 5. Valence levels as reported by participants before and after evaluation. Valence: 1 = sad, 9 = happy.

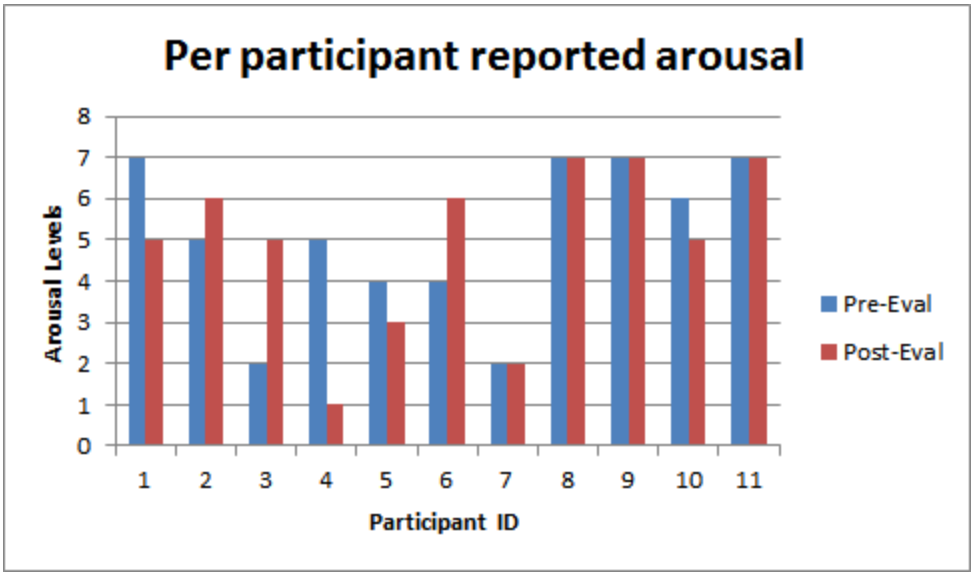

Figure 6. Arousal levels as reported by participants before and after evaluation. Arousal: 1 = bored, 9 = excited

3.2.3 Dominance

Figure 7 shows the dominance levels per participants before and after evaluation. It can be seen that along with decrease in valence and arousal after evaluation (Figure 3 and 4), there is marked increase in dominance after evaluation. This is in tune with our observation that the the evaluation was taxing on the participants' mood. We observed that the mean of dominance went up from 4.82 before evaluation to 5.55 after evaluation (more dominant).

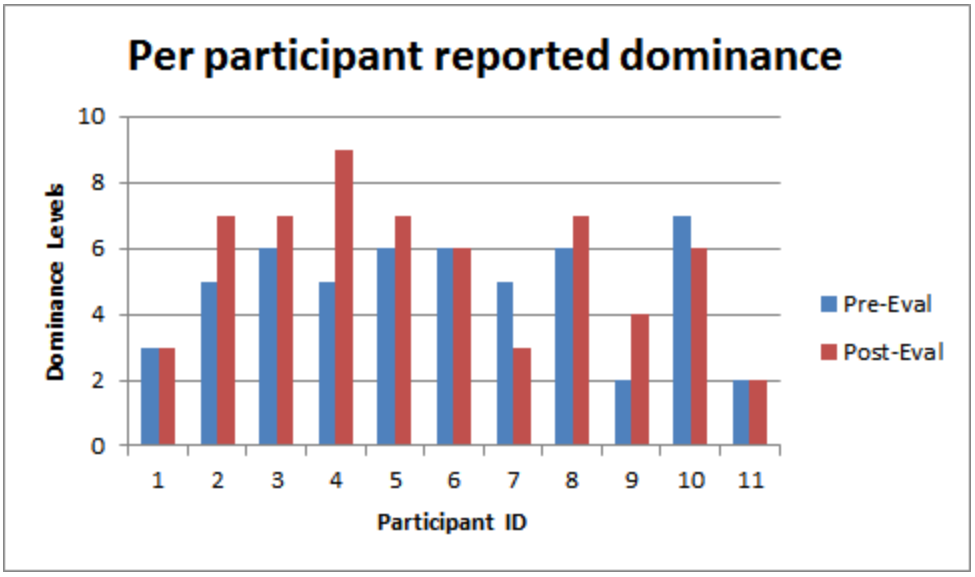

Figure 7. Dominance levels as reported by participants before and after evaluation. Dominance: 1 = independent, 9 = dependent

Apart from evaluating the emotional state of the participants on the SAM scale, we also asked the participants if they they would recommend using the report (or similar one) to others, and if required whether they would buy the product. They were asked to answer these questions on a 7-point semantic differential scale (1 = Unlikely, 7 = Likely). The mean of responses for the former question was 4.54 while for the latter was 4.27, suggesting a moderate likelihood of the participants using or suggesting the use of the report to others. Also, the mean of overall experience of the participants recorded on a 7-point semantic differential scale (1 = Displeased, 7 = Pleased) was found out to be 4.91, again suggesting a moderate experience with the report.

3.3 Participants' responses to evaluation tasks

We observed that there were many interaction techniques/styles that were common across participants, irrespective of their background, which suggests that certain interaction styles are more commonplace than others. We also observed that certain interaction styles that the participants intended to use were non-existent in the current version of the report. For example, many participants reported that they would click on a legend entry in a graph in order to filter data (Task 1), a feature that does not exist in the current (interactive) version of the report. Also, it was assumed that the table containing patient information would allow for sorting on multiple columns. This too is a feature that is not currently available in the interactive report.

We further observed that participants faced difficulty in analyzing data represented in the scatter plot (Task 2). More specifically, they were confused with the use of varying size and color of bubbles in scatter plot to represent multiple dimensions.

3.3.1 Most appealing features

The participants found the following features to be most appealing.

1. The participants found the report to be aesthetically appealing.
2. The participants found the presentation of information to be terse and intuitive.

However, the latter can be argued since the participants assumed interaction styles that are not supported by the report.

3.3.2 Least appealing features

The participants found the following features to be least appealing.

1. The participants reported that it was not very easy to obtain summary information like sum, average and count.
2. The participants observed that because multiple dimensions were presented in a single graph, they couldn't simply glance at the graph to ascertain what information was represented in the graph.
3. Almost all participants complained about getting confused with the use of concentric pie charts.
4. The participants found it distracting to have data points from multiple series plot on the same graph.

3.4 Participants' feedback and suggestions

After completing the tasks, the participants were asked to suggest any modifications they would make to the visualizations they believe would have made the report more approachable or provided them with a better User Experience. They were also asked if the Addition or Removal of any component in the Report that would make the Report more usable and approachable. The responses were evaluated and aggregated and it was seen that most of the modifications, additions or deletions border on the concept of "Simplifying Data" .

3.4.1 Modifications

Participants identified two modifications to the SAS report visuals:

1. Size of the the bubbles in "Type 2 Analysis" section should be easily distinguished. The graphs seemed to concentrate a lot of information, and a better way would be to distribute information over multiple graphs for simplicity.
2. Patients list at the bottom of the page could just be a button or a pop-up, which should hide the table until it is needed.

3.4.2 Additions to Current Report

Recommended additions to the report included:

1. Sorting and Filtering could be done on multiple columns, making it easier to find relevant piece of data and make sense of it.
2. The graphs could have help section, giving an overview or context or external links of the data and terms used in the report.
3. Patient count could be displayed inside the bubbles in the "Type 2 Analysis" section of the report.

3.4.3 Eliminations from the Current Report

When asked what they would delete from the report, eight of the eleven participants responded by saying there was nothing they would remove or that they could not think of anything. Three participants had specific recommendations, primarily reflecting a desire to reduce the complexity and density of visual content in the report:

- P4: Stop trying to fit so many variables into each dimension.
- P6: Blank columns in the patient list (table view) shouldn't be displayed.

- P10: Patient list (table view) at the bottom ended up not being of any help, could be moved to a separate screen or as a pop-up.

4. Conclusion

In this phase of our project, we examined a demo report generated by SAS Visual Analytics to assess its understandability and emotional quality. To conduct our evaluation, we took screenshots of the Disease Management report and formulated interactive tasks for our participants. Participants were asked to report their emotional state before and after the evaluation, the anticipated and actual difficulty associated with understanding the report visualizations and completing the tasks, and also provide their feedback on the hedonic aspects of the report. While the report was observed to have overall low emotional approachability (based on low post-evaluation SAM ratings), it was perceived to have moderate to high aesthetic appeal. The report was also found to have low to moderate cognitive approachability. Participants noted that the report was slightly difficult to understand due to aggregation of lots of information in a limited space. Also, certain graphical elements, such as bubbles of varied sizes, were reported to be confusing and misleading. This could be explained in part by humans' general difficulty in accurately judging relative volume and area in graphs, particularly when objects do not share a common base position (Cleveland & McGill, 1985). An interesting observation was that although the participants found the report to be aesthetically appealing, they also found the report to be overwhelming due to representation of data in more than 2 dimensions on a simple 2-D graph, which is contrary to the one of the facets of effective Information Visualization, i.e., representing multidimensional data in fewer dimensions (Novotny, 2004). The goal for the next phase of our project is to develop a prototype with better emotional and cognitive approachability. It should not only address the identified issues but also be at least as aesthetically appealing as the current report.

References

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Appendix A. Pre-Evaluation Questionnaire

Pre-eval questionnaire (SAS Visuals)

* Required

Age *

- 18-20
- 21-25
- 26-35
- 35-45
- 45-60
- 60+

Gender *

- Male
- Female

Highest level of education or degree obtained *

If currently enrolled then please select the degree currently you are pursuing

- No schooling compeleted
- High School
- Bachelors
- Masters
- Ph.D
- Post-Doctorate

Occupation *

Describe your familiarity with details about Type 1/2 diabeties *

You needn't be a diabetic yourself.

	1	2	3	4	5	6	7	
Completely Unfamiliar	○	○	○	○	○	○	○	Completely Familiar

Have you ever used SAS Visual Analytics software *

- Yes
- No

Have you ever seen a SAS Visual Analytics report *

- Yes
- No

How difficult do you think understanding the report is going to be *

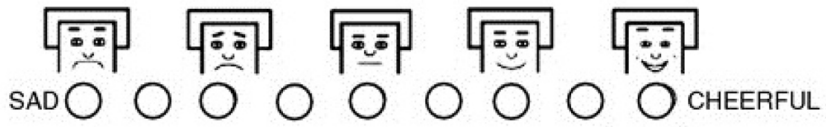
	1	2	3	4	5	6	7	
Very Difficult	○	○	○	○	○	○	○	Very Easy

How difficult do you think the tasks are going to be *

	1	2	3	4	5	6	7	
Very Difficult	○	○	○	○	○	○	○	Very Easy

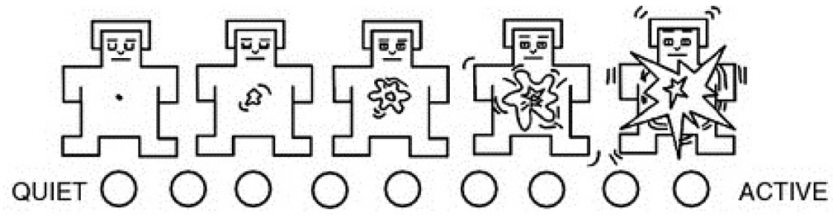
Please rate your current level of pleasure based on the following scale *

	1	2	3	4	5	6	7	8	9	
Sad	○	○	○	○	○	○	○	○	○	Cheerful



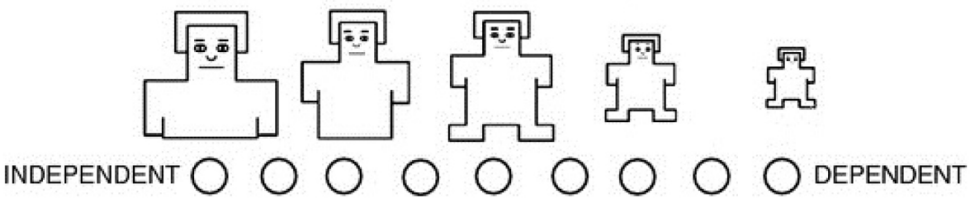
Please rate your current level of excitement based on the following scale: *

	1	2	3	4	5	6	7	8	9	
Quiet	○	○	○	○	○	○	○	○	○	Active



Please rate your current level of control (dominance) based on the following scale *

	1	2	3	4	5	6	7	8	9	
Independent	○	○	○	○	○	○	○	○	○	Dependent



Appendix B. Report Evaluation Questionnaire

Evaluation Tasks (SAS Visuals)

* Required

Task 1

Based on the screenshot of a report provided below, please answer the following questions.

Describe what the report is about. *

This is a required question

Using this report, describe how you will find patients suffering from Type-2 diabetes who do not have any renal disease? *

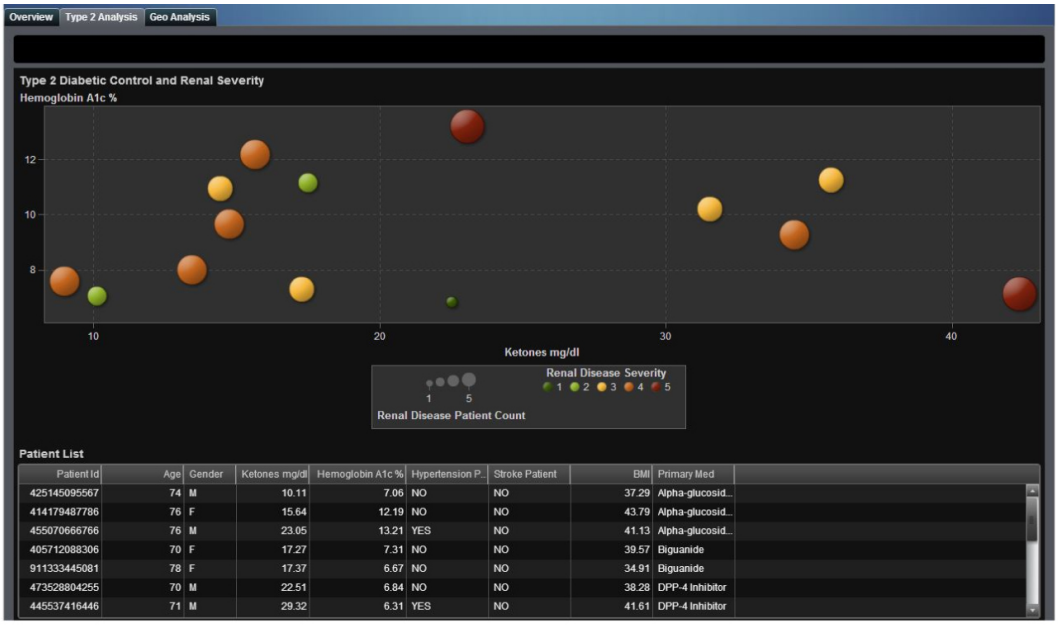
Assume all widgets in this screen allow you to filter based on selection, how will you identify the number of people in the age group 65-70 whose blood urea nitrogen/creatinine ratio is above 80?

How would you interact with the report to show just the female patients? *

How would you interact with the report to show male patients from NC in the age group 71-75? *

Task 2

Based on the screenshot of a report provided below, please answer the following questions.



Patient Id	Age	Gender	Ketones mg/dl	Hemoglobin A1c %	Hypertension P...	Stroke Patient	BMI	Primary Med
425145095567	74	M	10.11	7.06	NO	NO	37.29	Alpha-glucosid...
414179487786	76	F	15.64	12.19	NO	NO	43.79	Alpha-glucosid...
455070666766	76	M	23.05	13.21	YES	NO	41.13	Alpha-glucosid...
405712088306	70	F	17.27	7.31	NO	NO	39.57	Biguanide
911333445081	78	F	17.37	6.67	NO	NO	34.91	Biguanide
473528804255	70	M	22.51	6.84	NO	NO	38.28	DPP-4 Inhibitor
445537416446	71	M	29.32	6.31	YES	NO	41.61	DPP-4 Inhibitor

Describe what the report represents *

Does the scatterplot that you see display data in more than one dimension? If yes, how many and what are these? *

How will you identify the hemoglobin % levels for patients with renal disease severity = 3? *

How will you use the graph to determine the number of patients suffering with renal disease severity = 3? *

The scatter plot displays patient data in 4 dimensions, viz. Hemoglobin %, Ketones level, disease severity level and count of patients. What would be the best way to add a 5th dimension to the scatter plot that you see here? *

Appendix C. Post-Evaluation Questionnaire

Post-Eval questionnaire (SAS Visuals)

* Required

How difficult do you think understanding the report actually was *

1 2 3 4 5 6 7

Very Difficult ○ ○ ○ ○ ○ ○ ○ Very Easy

How difficult do you think the tasks actually were *

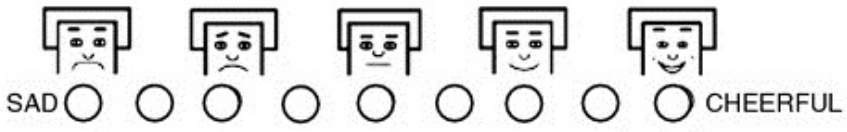
1 2 3 4 5 6 7

Very Difficult ○ ○ ○ ○ ○ ○ ○ Very Easy

Please rate your current level of pleasure based on the following scale *

1 2 3 4 5 6 7 8 9

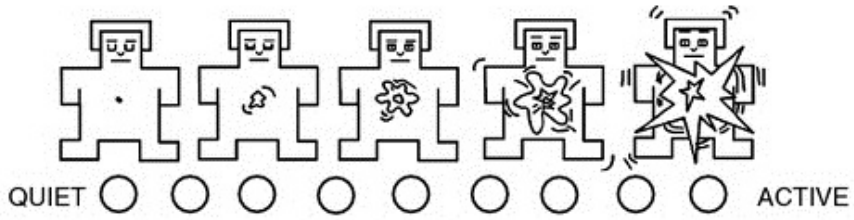
Sad ○ ○ ○ ○ ○ ○ ○ ○ ○ Cheerful



Please rate your current level of excitement based on the following scale *

1 2 3 4 5 6 7 8 9

Quiet ○ ○ ○ ○ ○ ○ ○ ○ ○ Active



Please rate your current level of control (dominance) based on the following scale *

1 2 3 4 5 6 7 8 9

Independent ○ ○ ○ ○ ○ ○ ○ ○ ○ Dependent

What frustrated you the most *

What were the most positive aspects of the report *

What were the most negative aspects of the report *

If there was one addition you would make to the report, what would that be *

If there was one deletion you would make to the report, what would that be *

If there was one modification you would make to the report, what would that be *

For examiners only

Time taken to finish Task 1 *

Hrs : Mins : Secs

Time take to finish Task 2 *

Hrs : Mins : Secs

Total time taken (1+2) *

Hrs : Mins : Secs

The participant finished task 1 *

- ○ Completely
- ○ Partially
- ○ Didn't attempt

The participant finished task 2 *

- ○ Completely
- ○ Partially
- ○ Didn't attempt