The Effect of Numerical and Textual Information on Visual Engagement and Perceptions of AI-Driven Persona Interfaces

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ABSTRACT

In an experiment, we present 38 marketing and data analysts professionals with two online AI-driven persona interfaces, one using numbers and the other using text. We employ eye tracking, think-aloud, and a post-engagement survey for data collection to measure perception and visual engagement with the personas along 7 constructs. Results show that the use of numbers has a mixed effect on the perceptions and visual engagement of the persona profile, with job role as a determining factor on whether numbers/text affect end users for 2 of the constructs. The use of numbers has a significant positive effect on user perceptions of usefulness by analysts but a significantly negative effect on user perceptions of completeness for both marketers and analysts. The use of numbers decreases the perceived completeness of the personas for both marketer and analysts. This research has both theoretical and practical consequences for AI-driven persona development and their interface design, suggesting that the inclusion of numbers can have a desirable effect for certain roles but with possible negative effects on user perceptions.

CCS CONCEPTS

• Human-centered computing ~ Laboratory experiments

KEYWORDS

Personas; information design; user study; experiment

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1 INTRODUCTION

Cooper [14] introduced personas for software development as a user-centric human computer interaction (HCI) technique for analyzing and communicating about the goals, attitudes, and needs of different user types [44, 47]. Since then, personas have been used by professionals, such as interface designers, software developers, public health professionals, marketers, and analysts [51, 52, 57, 66] toward the creation of a shared mental model of the users in an empathetic format (i.e., *another person*).

Despite the popularity of personas, it is not clear how to best create a persona profile and present it through a user interface that provides useful information in an engaging format for professionals using personas. The design of the persona's profile, perhaps surprisingly, has not been systematically examined, and there is little rigorous basis for guidelines regarding details of information presentation for persona end users [15].

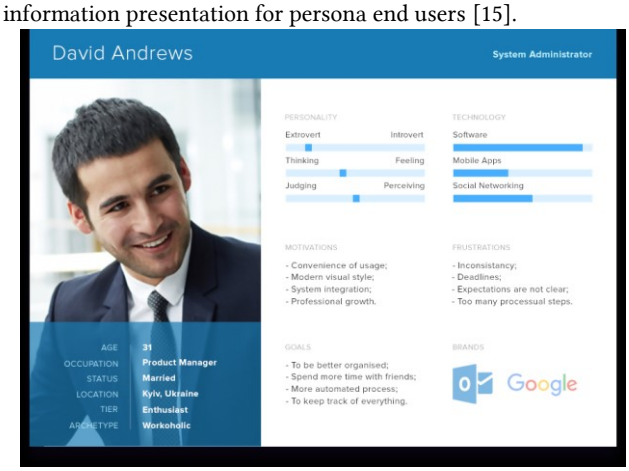

Figure 1: Example of a Typical Persona Profile.

A *conventional* layout has been developed for the persona profile [58], including some short textual descriptions and a photo within a 1- or 2-page layout (see Figure 1). Yet, rather than being the result of systematic research, this conventional layout has been adopted – with some degree of variation – from the early works illustrating persona creation (see [58]). The lack of systematic inquiry into the interface design of persona profiles

hinders their validity and applicability, as different designs should be tested for optimal persona user experience.

There are two important aspects to address in designing such "optimal" persona interfaces. First, the information design – that is, what information is selected for the profile and how it is arranged. Second, the end user goals, meaning the purposes for which the persona profile is deployed. While there is a tremendous "design space" of available alternatives to conceive and rearrange persona information, in this study, we focus on one aspect: the use of numbers versus text.

The potential of numerical information in persona profiles is tremendous. With the availability of online user data – often referred to as 'big data' [86] or 'aggregated user statistics' [35] – as well as the rapid development of online analytics systems and computational techniques and AI/ML algorithms for processing user data, there has been a growing interest in the creation of quantitative data-driven personas [5], where the persona profile is the user interface to an underlying data system. Because such approaches are fundamentally based on *numbers*, it is possible to include precise numerical information in the AI-driven persona profiles, addressing the widely acknowledged accuracy concerns of manually generated personas [13].

Numerical information may include, for instance, the probability of the persona being single/married, how large of a population the persona represents, how many minutes they watch online videos, and so on [5, 30, 34, 41]. Moreover, the data collection can be automated using application programming interfaces (APIs) that periodically retrieve refreshed user data from online platforms (e.g., YouTube Analytics, Google Analytics).

In sum, there is a growing interest in creating quantitative, data-driven persona profiles from numerical user data obtained from online analytics systems and social media platforms, but there is limited research concerning the use of numerical information in the design of persona interfaces. Despite the technological opportunities, it is not certain what numerical information should be included in persona profiles, how it should be conveyed to end users, and what the effects are for end users' perceptions towards and engagement with the persona.

These questions are important because previous research postulates that the immersive properties of personas are, to a large degree, based on their human-like descriptions [12] rather than displaying raw (numerical) data. Therefore, while numbers can provide more accuracy and heighten the information value of the persona profile, it is unclear if adding numbers has negative side-effects; at worst, excessive use of numbers could draw attention away from human qualities of the persona, reducing the sense of immersion and empathy by the end user.

In general, user visual and search behavior to inform visual analytic system design has not been extensively studied [81] and user-adaptive support for textual documents with embedded visualizations, similar to persona profiles with quantitative information, is only now emerging [79]. As such, investigating the use of numbers in persona profiles is a contemporary design problem in HCI and visual analytic system design, further exacerbated by the rise of data-driven persona systems.

In this research, we address the lack of research in designing persona profiles by experimentally evaluating different interface layouts to assess their impact on user perceptions and engagement with persona profiles. We investigate an approach to persona development that includes the use of numbers in the profiles versus the use of primarily textual attributes. Our inquiry is focused on professionals, with job roles of marketing professionals and data analysts. We compare these two approaches (numbers vs. text) using a controlled within-participants eye tracking study in an organization that actually uses personas. Using these insights, we propose guidelines for the creation of personas as interfaces that can enhance the end user perceptions and engagement of marketing professionals and data analysts in workplace contexts.

2 RELATED LITERATURE

2.1 Persona Profiles and Numbers

There is little extant work on the use of numbers in persona profiles. In contrast, the *written* content of a persona description has been studied by several authors [26, 36, 58]; these studies point to persona profiles including information from (a) background information, such as name, age, gender, education, etc.; (b) design-related information, such as usage or behaviors; and/or (c) business- and marketing-related information, such as buying preferences. The studies looking at the textual information do not include investigation concerning the use of numerical information in these profiles. Rather, in HCI, personas are often seen as alternatives to numbers [5], with the premise that numbers are more difficult than verbal descriptions for efficient processing of user or customer information [80].

Information behavior research suggests that marketing professionals, one of the key groups of persona end users, are more critical of the quality and credibility of information in goal-oriented work tasks [17, 18]. Similarly, analysts' information-seeking is influenced by their perception of goals, which affects their selection and use of information [3, 77]. Within the space of intelligent user interface design, research has focused on the modeling of user interaction data, such as eye gaze and search behavior to predict user characteristics or individual differences for designing adaptive user interfaces [42, 74, 79]. As such, the question of how user perceptions of goals in work tasks influence their interactions with intelligent user interfaces remains.

Research investigating numbers and, more broadly, quantitative information in the persona context, tends to focus on the persona development stage where numbers are used as a source of information for persona creators, rather than perceiving numbers as a form of *information presentation* technique for the persona users. Even though the most prevailing methods for data collection for personas have been qualitative in nature [1, 14], the collection and use of numerical data in the creation of persona profiles have been suggested by various authors [10, 45, 53, 55, 73]. The focus of these studies tends to be the quantitative evaluation of persona-creation techniques, rather than the information presented for persona user experience.

There are some studies developing personas with quantitative information, though. Jung et al. [34] present persona profiles that include numerical information, such as the size of the audience segment corresponding to the persona attributes. Their personas have the underlying numbers available because raw numerical information has been utilized for their generation [71], making it possible to include various numerical information in the persona profile. However, it is not evident that adding numbers would improve the persona user experience. Previous user studies imply that any unconventional interventions in the persona profile risk creating confusion and worsening the user experience of professionals using the persona profiles [65, 68, 70].

A strong motivation for experimenting with the use of numerical information in persona profiles comes from prior work that revealed that the information needs of professionals do indeed include numerical information, as the participants repeatedly wished for more numbers to understand the relative importance of a persona to their overall audience population [68]. This suggests that numbers may belong to end users' information needs in the online analytics context, and, therefore, the effects of their use in persona profiles call for empirical investigation.

2.2 Professionals' Information Behavior

Research suggests that professionals' job roles affect the tasks they perform, which, in turn, influence how they perceive and seek information in the workplace [43]. Specifically, marketing professionals' information seeking is task driven and that work roles are critical for the perceived quality and credibility of information in goal-oriented work tasks [17, 18]. Studies of securities analysts' information seeking behavior reveal that institutional resources have a significant effect on the information sources and communication channels analysts use [7], and the years of experience are reflected in the use of information in research processes [39].

Prior work also shows that analysts' apply different information selection strategies when they deal with factual information [77], partly due to time pressures of the task at hand [46]. Studies of financial analysts' information behavior [3] show analysts' perceptions of information goals, such as identifying investment opportunities and addressing problematic situations, affect their information seeking and use. Moreover, visual stimuli can affect perceptions and attention to available information [33].

Overall, these studies suggest that marketing professionals' and data analysts' (the two job roles of interest in this research) information seeking and use behavior are task driven, affected by information availability and individuals' years of experience. The use and interpretation of information for fact-checking situations are shaped by information goals.

2.3 Research Questions and Hypotheses

To bridge the knowledge gap between the implications of the use of numbers along with textual information in persona profiles and thereby information design of persona interfaces, we are interested in the following research questions:

RQ1: *Are there differences between the use of numbers and the use of text in a persona profile as perceived by professionals with different job roles?*

RQ2: *Does the use of numbers versus the use of text only affect end users' visual engagement with a persona profile?*

From these research questions, we formulate the following research hypotheses:

- **H1:** Using numbers increases the credibility of the persona perceived by marketers and analysts.
- **H2:** Using numbers increases the clarity of the persona perceived by marketers and analysts.
- **H3:** Using numbers increases the completeness of the persona perceived by marketers and analysts.
- **H4:** Using numbers increases the usefulness of the persona perceived by marketers and analysts.
- **H5:** Using numbers increases the consistency of the persona perceived by marketers and analysts.
- **H6:** Using numbers decreases the likability of the persona perceived by marketers and analysts.
- **H7:** Using numbers increases the visual engagement with the persona profile by marketers and analysts.

Previous research provides indications of what to expect when providing numerical information to end users in the persona profiles. Numbers are associated with various concepts, such as technical sophistication/technology, precision, anchoring of attention, and confidence [60]. In marketing, using numbers instead of imprecise claims tends to increase the perception of competence [84]. Researchers suggest that numbers add precision [85], which can be taken as a sign of expertise [50]. Following these findings, we expect that numbers increase *credibility* and *clarity* of the persona profiles (H1, H2). These perceptions matter, because decision makers are unlikely to adopt the personas for use if they have doubts about the personas' credibility [78].

There are other essential personas perceptions. One of these is *completeness* (referred to as "roundedness" by [58] of the persona profile), implying that it has all the necessary information for decision-makers. Therefore, adding numbers to the persona profile may increase the completeness perceived by end users. *Usefulness* [27, 31, 57, 63] has been identified as a key concern of persona applicability and an important dimension of user perceptions for information retrieval systems, particularly when users are domain experts [49, 75].

Consistency is highly relevant for personas, as the persona profiles may appear having been compiled from different sources and containing information pieces that conflict with each other [9, 13]. We expect the use of numbers to affect perceptions of completeness and usefulness (H3, H4, and H5).

Moreover, empathetic attitudes have been cited as key advantages of personas as a decision-making tool [11, 51, 54, 56]. It is, however, unclear what the effect of using numbers is for such impressions. We suspect that the use of numbers will reduce the *likability* of the persona (H6) because numbers are perceived to be more scientific rather than empathetic [84].

It has been found that numbers provide attention anchors [87], so the eye is drawn to numerical information, even with the presence of a large mass of textual information [61]. This leads us to expect that numbers will increase the level of visual engagement with the persona (H7).

Research on information behavior suggests that professionals are concerned about the quality-related attributes of information for goal-oriented tasks [3, 17, 18]. Specifically, data analysts work on the translation of business questions to low-level analytic tasks with marketing and other teams within an organization [38]. Data analysts engage with exploratory data activities that are characterized by the specificity of goals in the analysis process [4]. We consider these findings in H1–H7.

3 METHODOLOGY

3.1 Overview of Research Design

To address our research questions and associated hypotheses, we conduct a user experiment, specifically an experimental study using (1) eye-tracking, (2) think-aloud, and (3) post-experiment survey data. Eye-tracking provides information on the persona users' visual engagement with the treatment profiles and can be analyzed quantitatively. Think-aloud [2]— i.e., the participants explaining what sections of the persona profile they are gazing and why— yields insights into the information processing by professionals using the personas. The survey answers quantify the perceptions towards the tested personas.

Note that we use persona profiles derived from and presented by automatic persona generation (APG) [34], a system for data-driven persona generation from online analytics data. For this research, we use the focal organization's social media statistics, obtained via the YouTube Analytics API. Therefore, the created personas reflect the actual user population viewing the organization's YouTube videos, with the task also focusing on this channel. Refer to prior work for technical details of APG [5, 6].

3.2 Participants and Focal Organization

Our data collection site was a large non-profit organization, with employees of multiple nationalities, such as Egypt, Finland, France, Korea, Qatar, Turkey, and the USA. The organization uses personas for (a) better understanding their online audience, and (b) strategic planning, involving crafting agendas to serve the various stakeholder groups of the organization better.

In total, there were 38 participants, of which 15 (39%) were females. The average age of the participants was 33.4 years (min. 21; max. 57; SD=9.6). The participants' earlier experience of personas ranged from "Not experienced at all" (33%), "Slightly experienced" (33%), "Moderately experienced" (3%), to "Highly experienced" (31%). Participation was voluntary, and the participants were not financially compensated. All participants were explained what personas are to ensure a foundational level of understanding.

The participants held a variety of job positions within the organization, ranging from data analysts, engineers, editors, social media managers, copywriters, project managers, and content specialists. As the participants all worked in either research division (focused on data analytics projects) or marketing division (focused on communication activities, such as newsletters, social media, internal stakeholders, PR), we categorized those working in the research unit as 'Analysts' and those working in the marketing department and related tasks as 'Marketers'.

3.3 Experiment Design and Data Collection

Two personas were created ("Anar" and "Yvette") from the organization's YouTube data using the APG methodology. For each persona, a Text and a Number version were created (see Figure 2 and Table 1). The text versions showed the persona attributes as text, while the number versions showed the attributes as numbers. This resulted in four treatments: (1) Anar-Text, (2) Anar-Numbers, (3) Yvette-Text, and (4) Yvette-Numbers.

Each participant was shown two treatments (personas) during the session with closely matching information, but one treatment included text while the other treatment included numerical data in the place of the text (see Figure 2).

For counterbalancing the treatments, we created four different sequences in the eye-tracking software (e.g.., one sequence showed Anar-Text first and then Yvette-Numbers, while another sequence showed Yvette-Numbers first and then Anar-Text). We assigned an equal number of participants for each sequence to mitigate possible order effects [72].

The experiment was conducted in the participant's workplace, with each participant individually participating in a session. One session took approximately thirty minutes. We instructed all participants in the same way at the beginning of the experiment about the usage of the devices and the procedure. To begin each trial, we welcomed the participant, introduced ourselves, briefly explained the study, and answered any questions. After completing an institutional review board (IRB) consent form, each participant was assigned a unique ID. After calibration of the eye-tracking device, the participant was presented the following scenario and shown one of the treatments:

> Your task is to create an interesting video that will be posted on your organization's YouTube channel. To create this interesting video, you decide to use personas to better understand your core online audience. The persona you are about to see describes one of your organization's audience groups on YouTube. It is based on real data.

3.4 Use of Eye-Tracking

To conduct the eye-tracking sessions, we employed two research stations (two identical HP Studio G4 laptops with 15" screens) equipped with the MyGaze eye-tracking device (sampling rate: 30Hz, accuracy: 0.4°, spatial resolution: 0.05°, calibration: 9-point) and software for logging the visual engagement of the participants. The device is designed to be portable and uses a built-in head movement compensation algorithm that is intended for improving the measurement accuracy in live systems.

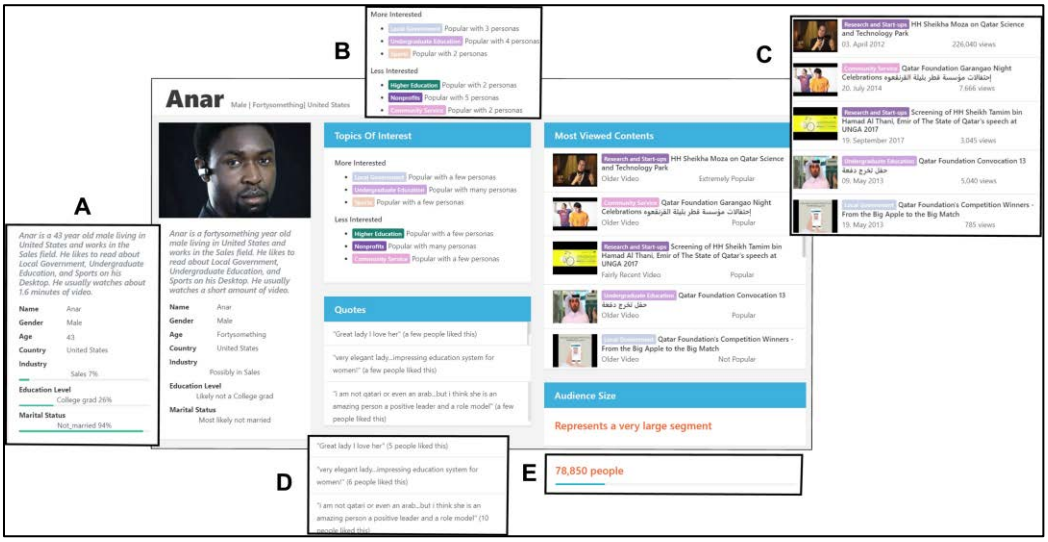

Figure 2: "Anar", one of the two personas tested (the other one being "Yvette"). The figure shows the text version, with numerical attributes presented as text (e.g., "fortysomething" vs. "43 years old"). The manipulations took place for text description (A), topics of interest (B), most viewed contents (C), quotes (D), and audience size (E). See Table 1 for text.

Table 1: Information content in persona profiles. The example is shown for "Yvette". Color coding highlights the changes made in the treatments. The third column refers to the corresponding segment in Figure 2.

Persona information	Description of the information	Fig. 2	Treatment effects (TT: Text Treatment, NT: Numbers Treatment)
Age, Gender, Location	An element showing this information	A	TT: Yvette Female | Twentysomething | United States NT: Yvette Female | 29 | United States
Text description	Text description of the persona	A	TT: Yvette is a twentysomething female living in the United States and works in the Sales field. She likes to read about Social Media, Research, and Police on her Mobile. She usually watches quite a bit of video. NT: Yvette is a 29-year-old female living in the United States and works in the Sales field. She likes to read about Social Media, Research, and Police on her Mobile. She usually watches about 7.4 minutes of video.
Industry	The most likely work industries of the audience corresponding to the persona attributes	A	TT: Possibly in Sales NT: 13% in Sales*
Education	The most likely education levels of the audience corresponding to the persona attributes	A	TT: Likely a College graduate NT: 46% a College graduate
Marital status	The most likely marital statuses within the audience corresponding to the persona attributes	A	TT: Most likely not married NT: 62% not married
Topics of interest	Most and least preferred topics of the persona based on the organization's own topical taxonomy	B	TT: Social Media - Popular with a few personas; Research - Popular with many personas; Police - Popular with a few personas NT: Social Media - Popular with 3 personas; Research - Popular with 4 personas; Police - Popular with 2 personas
Quotes	Descriptive quotes from people similar to the persona, from social media comments	C	TT: "saying is one thing but if nothing is done what's the point of commenting help them" (a few people liked this) NT: "saying is one thing but if nothing is done what's the point of commenting help them" (5 people liked this)
Most viewed content	Top social media content pieces the persona is interested in	D	TT: China's Rich Girls - 101 East, Fairly Recent Video, Extremely Popular NT: China's Rich Girls - 101 East, 09 June 2016, 4,227,061 views
Audience size	The number of similar people corresponding to the persona (by age, gender, location, interests)	E	TT: Represents a very large segment NT: 16,100,000 people in this segment
*NOTE: Percentage implies the largest value among categories retrieved from Facebook Marketing API.			

3.5 Think-Aloud Data Collection

In addition to eye-tracking data, we collect (a) think-aloud voice recordings, and (b) survey data. More specifically, we used the concurrent think-aloud method [2], where the participants gaze the screen and explain simultaneously what they are looking at and why. In case the participant was silent, we encouraged them to explain what they are looking at and why. To mitigate interfering with the task completion [23, 64], we only talked to the participant when he or she stopped voicing his or her cognitive process. We did not, for example, ask about particular screen areas to avoid directing participants' attention.

Here, we could not opt for complete non-obstruction since we specifically wanted to learn about the cognitive processes of the participants as a form of triangulating eye tracking with think-aloud [8]. As can be seen from the qualitative analysis (Section 4.3), the participants were able to provide useful information on their use of the personas. Therefore, even though the think-aloud protocol may affect eye tracking results [22], we consider this trade-off acceptable given the purpose of our study.

3.6 Survey Data Collection

To quantitatively analyze the participants' perceptions of numerical and non-numerical persona profiles, we created a survey. For the survey creation, we utilize the perceptions and items from the Persona Perception Scale [67]. This instrument, validated in previous research, deals with various dimensions related to users' perceptions toward personas, including credibility, clarity, consistency, and so on. From this instrument, we chose six perceptions (see Table 2). We chose these perceptions because they are central to the adoption and usage of personas and are conceptually related to our hypotheses. We created a survey using the items of Table 2 as statements shown to respondents. For each statement, we used a seven-point Likert scale from (1) Strongly disagree to (7) Strongly agree [67].

3.7 Analysis Variables

We define two types of experimental measures: perception and engagement. Both perception [24] and engagement [62] are variables with various nuanced meanings depending on the context. We define perception as the mental impression of the end user regarding the persona, and visual engagement as the end user visually interacting and being occupied with the persona.

The perception variables are based on question items from a previously developed survey instrument [67] (see Table 2). The visual engagement metrics are derived from the raw gaze fixation data exported from the eye-tracking software for statistical analysis. The fixations in the dataset were pre-computed by the eye-tracking software using a black-box algorithm, which is a common practice for commercial eye trackers.

Table 2: Measurement constructs and survey items.

Perception	Definition	Items
Credibility	The persona is not 'made up' but matches what is perceived as a real person.	The picture looks authentic. The persona seems natural. This persona seems like a real person. The persona seems to have a personality.
Clarity	The persona information is presented clearly.	The basic information (age, gender, etc.) about the persona is well presented. The text is clear enough to understand. The persona information is easy to understand. The persona is easily memorable.
Completeness	The persona is not missing crucial information.	The persona profile is detailed enough to make decisions about users (e.g., relating to marketing or product development). The persona profile seems complete. The persona profile has enough information to understand the people it describes. There is plenty of information about the persona in the persona profile.
Usefulness	The persona will not end up in "desk drawer" but will be used by decision makers.	The persona would improve my ability to make decisions about users. This persona seems useful for user analysis. I find this persona helpful for understanding the online audience. Information about this persona seems useful for my task. I would like to know more about this persona. The persona provides actionable information. I would like to use this persona's information in my work.
Consistency	The persona is a coherent composition of logically interlinked information.	The quotes of the persona match other information. The picture of the persona matches other information. The persona information seems consistent. The persona's demographic information is well matched with other information.
Likability	The persona is liked by the respondent.	I can relate to this persona. I feel strong ties to this persona. I feel like I understand this persona. I feel as if I am on the same wave length as this persona. I can imagine a day in the life of this persona

In our analysis, the dependent variables included the (a) total number of fixations, (b) their total and average duration, and (c) the average distance between each fixation. The average distance was calculated using the average of the Euclidean distance between each set of coordinates. This was done to capture the dispersion of the participants' gaze movement [20]—if the participants repeatedly look far apart, that would indicate that they are more "sporadic" (possibly due to confusion or lack of clarity of the persona profile) than people who visually engage by making smaller gaze point shifts.

The participants were randomly assigned to persona (Anar or Yvette) and experimental variable (Text or Numbers). This allowed two within-subjects comparisons: persona and use of numbers. For both analyses, two between-subjects variables were included: the participant's role and previous experience with personas.

4 RESULTS

4.1 Perception Results by Professional Role

The sample was split by marketers and analysts to obtain two nested models and determine if any of the global effects differed between groups. The effect of treatment type (numbers vs. text) on *completeness* was significant for both marketers ($F(1, 11) = 9.963$, $p = 0.009$, $p < 0.05$) and analysts ($F(1 , 25) = 6.678$, $p = 0.016$, $p < 0.05$). In both cases, *completeness* ratings were higher in the Text condition. The effect of treatment type on *usefulness* was significant only in the analyst group ($F(1, 25) = 5.383$, $p = 0.029$, $p < 0.05$), where usefulness ratings were higher in the numbers condition. The effect of treatment type on *usefulness* was not significant in marketer group ($F(1, 11) = 0.294$, $p = 0.114$).

The statistical analysis was done through repeated measures mixed MANOVAs [29]. The results for H1–H6 are shown in Table 3. As shown, H4 was partially supported: *the use of numbers increased the perceived usefulness for analysts.* H3 was significant, but it was not significant in the predicted direction. Moreover, H01 (*credibility* of the persona profile) was not supported. The use of numbers in the persona profile did not significantly increase the perception of *credibility.* The use of numbers rather than text did not increase the perceived *clarity* of personas (H02). *Consistency* (H5) and *Likability* (H6) were not reduced using numbers compared to text, unlike we predicted.

4.2 Visual Engagement Results

The omnibus tests for both between-subjects and within-subjects effects show that there were no significant differences between treatments for any of the measurements (Pillai's Trace = 0.025. $F(4, 31) = 0.195$, $p = 0.781$). However, a single significant between-subjects effect was identified regarding the role variable, suggesting differences in at least one measurement between roles (Pillai's Trace = 0.344, $F(4, 31) = 4.058$, $p < 0.01$).

The results of univariate tests for between-subject effects (see Table 4) show that the role significantly influenced both the average duration of the fixations ($F(1, 34) = 17.345$, $p < 0.001$) and the average distance between fixations ($F(1, 34) = 5.057$, $p < 0.05$).

As the omnibus test indicated no differences between treatment conditions, using numbers in the persona profile did not affect visual engagement. However, observing the marginal estimated means revealed that marketers exhibited both lower average fixation duration ($M = 348.290$ versus $M = 394.770$ for analysts) and the higher average distance between fixations ($M = 220.220$ versus $M = 199.862$ for analysts). In other words, the marketers' eyes stayed less time in the same place and moved further between fixations than analysts.

4.3 Qualitative Think-Aloud Results

To further understand how the participants interacted with the AI-driven personas, we performed a qualitative analysis of the transcribed think-aloud voice recordings. The qualitative analysis of the transcripts was performed separately by two of the researchers. The first researcher, who was also one of the observants in the eye-tracking sessions, analyzed the interviews and created a codebook [16] to guide the qualitative coding process (see Table 5). The second researcher used this codebook to analyze the interview transcripts and isolate segments related to each code category. The identified segments were also marked as negative or positive for sentiment.

Table 3: Result for perceptions between treatments and job roles (tasks).

	Marketer			**Analyst**		
Perception variable	Text M(SD)	Number M(SD)	ANOVA	Text M(SD)	Number M(SD)	ANOVA
Credibility (H1)	17.00 (5.427)	16.17 (6.658)	$F(1, 11) = 0.146$, $p = 0.71$	18.27 (5.876)	20.31 (5.198)	$F(1, 25) = 2.870$, $p = 0.103$
Clarity (H2)	20.67 (4.271)	18.25 (6.917)	$F(1,11) = 0.930$, $p = 0.356$	20.12 (4.616)	20.42 (5.315)	$F(1,25) = 0.071$, $p = 0.792$
Completeness (H3)	14.42 (4.602)	10.33 (4.638)	**$F(1, 11) = 9.963$, $p = 0.009$**	17.42 (5.457)	14.08 (3.187)	**$F(1, 25) = 6.678$, $p = 0.016$**
Usefulness (H4)	26.58 (8.723)	30.42 (8.785)	$F(1, 11) = 0.294$, $p = 0.114$	28.81 (7.955)	33.58 (7.991)	**$F(1, 25) = 5.383$, $p = 0.029$**
Consistency (H5)	17.50 (4.210)	13.58 (6.775)	$F(1, 11) = 3.027$, $p = 0.110$	18.58 (4.925)	19.46 (3.839)	$F(1, 25) = 0.523$, $p = 0.476$
Likability (H6)	21.08 (4.481)	17.42 (7.925)	$F(1, 11) = 3.647$, $p = 0.083$	20.15 (7.058)	22.77 (4.208)	$F(1, 25) = 2.964$ $p = 0.098$

Table 4: Univariate tests for between-subjects effects of experience with personas, and the role of participants for visual engagement.

Indep. Variable	Dep. Variable	Sum of Squares	df (error)	Mean Square	F	Sig.
Experience	Total Fixations	121238.2	1 (34)	121238.2	1.07	0.31
	Total Duration	1.31E+10	1 (34)	1310.0	0.83	0.37
	Average Duration	1206.498	1 (34)	1206.5	0.65	0.43
	Average Distance	744.762	1 (34)	744.8	0.61	0.44
Role	Total Fixations	24.424	1 (34)	24.4	0.00	0.99
	Total Duration	7.61E+09	1 (34)	7610.0	0.48	0.49
	Average Duration	32224.29	1 (34)	32224.3	17.35	**<0.001**
	Average Distance	6181.651	1 (34)	6181.7	5.06	**0.03**

Interestingly, we found two new perceptions that we had not included as study variables. The first one we labeled 'Similarity', and it was mobilized when the participants relate to the personas on a personal level either positively: "[…] In fact we can be born in the same place and have different lives." (P21, TT); or negatively: "I don't agree with his opinions, and I don't freely belong to his group." (P12, NT).

The second one was labeled 'Appreciation', and it was used to mark the segments that had positive remarks about the presentation of personas, in general. For example, "Their names are very interesting." (P9, TT); "[The personas] had background, education, where they come from, the demographics and stuff. I think it gives [the persona's] interested and not interested things, I think they cover a lot of the important things." (P29, NT).

A closer analysis of the coded segments reveals several interesting phenomena. There is a difference of style between the criticism of analysts and marketers. While the analysts commented dominantly on the provided data and how it is presented [e.g., "Usually in the description you provide the exact age, not 40-something." (P12, TT); "Because the labels for me, they seem not correlative with the title of the video." (P5, NT)], marketing professionals were more focused on making generalized inferences from the information provided [e.g., "I think what I wanted was basic information, which was there, like age, the gender, and stuff like that." (P27, TT); "Yeah, he gives enough information about his most interested." (P28, NT)].

Another difference comes from the unpacking of keywords that were present in persona information. For example, one persona contains this information: "works in production […] interested in research." Numerous analysts tried to unpack this information: "So he works in a production field. I actually don't know what production is." (P16, NT); "I don't know what it means production." (P13, NT); "Works in the production field. Not sure what that means." (P22, TT); "I don't know what production field means." (P15, TT); "I don't know what research means here, but I guess it's documentary." (P10, NT); "So, research is a strange, very generic topic. Because in my mind research is something very particular, like scientific research, but it could be other research." (P16, TT). In contrast, no participant from the marketing profession voiced any concerns on these pieces of information, implying they had previous knowledge of this concept.

Table 5: Think-aloud codebook with category frequencies.

Category	Code	Count		% of Total Codes	
Negative Response	Clarity	66		14.2%	
Positive Response	Appreciation	30		6.4%	
		Positive	Negative	Positive	Negative
Persona Perception	Likability	25	7	5.4%	1.5%
	Credibility	22	48	4.7%	10.3%
	Similarity	4	6	0.9%	1.3%
Elements of Persona Profile	Audience Size	3	13	0.6%	2.8%
	Basic Information	18	38	3.9%	8.2%
	Images	23	8	4.9%	1.7%
	Quotes	9	32	1.9%	6.9%
	Topics of Interest	8	32	1.7%	6.9%
	Viewed Videos	10	15	2.1%	3.2%

Finally, participants from the marketing profession were more likely to understand the personas through *narratives* they pieced together from selective information on the screen. Some examples are: "[…] it showed me Yvette is in the US, she reads these publications, and she's interested in these topics […]" (P30, TT); "He's a layman, an everyday man, a common man." (P33, NT); "[…] she works in the medical field, but she's looking at videos on Arab language, literacy around the world, so I don't know, I didn't see the connection." (P38, TT). For analysts, forming such narratives was not as common.

5 DISCUSSION AND IMPLICATIONS

5.1 Research Contributions

Our research goal was to investigate the use of numerical information in data-driven persona interfaces and to address if the use of numbers affects (a) user perceptions and (b) visual engagement with the persona interface by job roles. The quantitative analysis shows that the use of numbers has a significant positive effect on perceived *usefulness* by analysts, and a significantly negative effect on user perceptions of *completeness* for both marketers and analysts. For other perceptions measured, there was no difference in perceptions with the use of either text or numbers. We did find a significant effect on the visual engagement of *average duration* and *average distance* by job roles, with marketers having lower average fixation durations and longer fixation distances.

Even though the differences were not statistically significant, other perceptions (*credibility*, *completeness*, *usefulness*, and *likability*) were all weighed toward the use of numbers (with higher averages and lower standard deviations). Regarding the lack of support for H1, it is possible that using numbers is not as

crucial for a persona's credibility. Some previous research supports this interpretation, with findings that the expectation of numerical precision varies by context [19]. The credibility of personas may primarily rely on factors other than numbers, such as profile images [68] or consistency of the information [9].

Regarding perceptions other than completeness, it appears that numbers do not have a negative impact except on completeness, and, although not statistically significant, all the 'desirable' perception measures were weighted toward numbers. The results have particular implications for data-driven personas [5] that can portray both textual and numerical information. We show that, in principle, the effects of such attempts, are more likely to produce desirable (or at least not negative) effects on end user perceptions with the persona profiles.

The use of numerical information in persona user interfaces has not been widely studied in the HCI literature. Ours is one of a few studies focused on user perceptions and engagement of real users with persona system interface [30]. Apart from a couple of studies [30, 68], eye-tracking has not been deployed to investigate persona interfaces, and even those studies did not directly focus on design implications of data-driven persona interfaces.

Our findings on design of persona profiles and the job roles by data analysts and marketers make connections between professionals' information use in support of goal-oriented tasks in the workplace [25, 40]. In sum, the findings described in this research have implications for the design of persona profiles, including quantitative data-driven personas [34] serving as system interfaces, traditional persona descriptions [32], ad-hoc personas [59], and proto-personas [28].

5.2 Design Implications

As guidance for persona creators, we suggest considering the users' job roles when including numbers in the persona profile. First, textual information was found more complete than numerical information by users from both professions. This implies text is important for satisfying the information needs of persona users. Second, analysts found numbers more useful than marketers, highlighting distinct information processing styles and information needs of those professions. Analysts, perhaps having a more "numbers mindset", are more likely to value numbers in persona interfaces, whereas for marketers, such effect was not observed. In contrary, marketers were more apt to form user narratives from the information, which implies an empathetic information processing style.

In sum, these differences suggest that there is a need for two design considerations for AI-driven persona interfaces:

a) *adaptability*, presenting persona information in a different way, according to information behavior differences between professionals whose daily work tasks vary; and
b) *user choice*, meaning that the user has a say concerning the degree of numerical information shown to him or her in the persona interface.

In the following subsection, we illustrate the latter principle with an example of including additional layers that ensure the interface is not cluttered with numerical information, while numbers remain accessible for the users.

5.3 Practical Illustration of Persona Interface

To illustrate the practicality of the findings, the core insights of this study were incorporated into the design and development of persona profiles in the APG system [34] that combines both qualitative and numerical information about the personas. Specifically, the presentation of numbers takes place through the notion of 'layered persona profiles', with each information layer providing additional information (Figure 3 and Figure 4).

The visible interface layer (*Information Layer 1*) shows persona profiles with some numbers, such as Age, which is typical for many persona profiles, and Audience Size, as shown in Figure 3. The "hidden" (accessible via clicking) interface layer (*Information Layer 2*) exposes more granular numerical information, including,

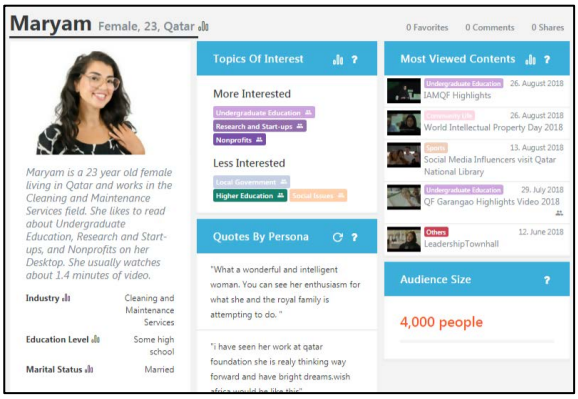

Figure 3: Visible layer (Information Layer 1) of the APG Persona Profile with some numbers such as the age of the persona and audience size the persona represents.

Figure 4: Information Layer 2 of the APG Persona Profile presenting a graphical display of all the topical interest of the persona, showing topics the persona is most and least interested in.

for example, the variation of persona's topical interests (Figure 4). The layered design is made possible because the APG system has access to the underlying data of the persona. Thus, for most of the persona attributes, it is possible to provide callout boxes (denoted by the graph icons) where end users of the persona profiles can expose more numerical information, as shown in Figure 4.

As explained in [34], the APG system uses topic modeling to classify topics of interest of social media posts or content that the persona would be most or least interested in. *While Information Layer 1* of the persona profile presents the top three most interested and least interested in textual form (see Figure 3), *Information Layer 2* shows all topics in graphical form with the associated level of interest (see Figure 4).

Moreover, providing a layered interface can be viewed as a form of *persona transparency* [69]. Consider the case of showing users the demographic distribution of the persona. APG creates personas by inferring behavioral content consumption patterns across demographic groups, and then chooses the dominant demographic group as a representative group (e.g., Male 25-34, USA) to be shown in the visible layer. Yet, each behavioral pattern takes place to some effect in other demographic groups, as well. Visualizing the weight values of the algorithm in the hidden layer (see Figure 5) provides a way for the users to probe the persona composition in greater detail, without causing confusion in the visible layer by showing multiple demographic groups. This enables analysts and marketers both to use the system in their respective ways – analysts can probe into the detailed numerical information, while marketers can view the big picture. For both, the information is accurate; just the granularity of it varies.

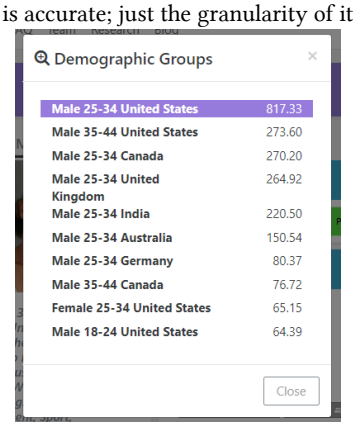

Figure 5: Distribution of demographic groups of the persona. The top demographic group with the highest weight value determined by the algorithm is chosen as the representative demographic group shown in the visible layer, while this second layer shows the weights of other high-ranking demographic groups.

5.4 Future Research Avenues

Future research could investigate the effects of using mixed forms of information, *both* text and numbers, on the end user experience. Since text and number are not mutually exclusive, it is possible to introduce a third condition of text AND number, which is potentially more informative than text or number only.

Second, even though there are various potential ways of displaying numerical information about personas, this research was limited to testing one way of implementing numbers in personas. Therefore, future research could investigate other ways to implement numbers in persona interfaces, as slight interface changes can cause perceptual differences for end users. Third, it is crucial to investigate how interface choices of AI-driven personas support data exploration activities for business decisions [4, 38].

Employing a deeper layer of information in AI-driven personas is an interesting research topic, one potentially bridging persona research with Web analytics platforms. As illustrated, these numbers can be included as a 'hidden layer' in the persona profiles that show more granular information. This diversity of information may possibly mitigate users' stereotypical thinking about the persona [30, 68] and enhance the transparency of the persona system [21, 82]. How users respond to this layered approach is a possible area of future HCI studies.

Finally, significant differences between marketers and analysts in the average distance between fixations suggest the role of user characteristics in visual engagement deserves further research. Studies of user search behavior have shown that the user characteristics of cognitive styles are correlated with patterns of visual engagement for complex search tasks [48, 76, 83].

In terms of limitations, the number interface shows both numbers and colored bars (see Figure 2A) while the text interface only shows text. The additional visual encoding may increase visual appeal and influence the results. This potentially confounding factor was not considered. Additionally, information about numeracy (i.e., the ability to understand and work with numbers) could have been collected, as numeracy may provide a more precise measure of the phenomenon [37].

6 CONCLUSION

With personas moving to electronic formats and becoming data- and AI-driven, numerical information is becoming more available for persona interfaces. The textual interface was found more complete than numerical interface by both marketers and analysts. Analysts found numbers more useful than marketers, highlighting differences in information processing and needs. Regardless of their perceptual impact, incorporating numbers can be beneficial, given that end users are asking for more numerical information in persona profiles. What is interesting is that these numbers already exist within online analytics platforms that many organizations are using. However, these analytics platforms are missing the context that personas provide. The benefit of using numbers in persona profiles, along with text, may be that the numbers can be associated with goal-oriented tasks, indicating a possible synergy between personas and Web analytics platforms for professional information use.

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