Computers in Human Behavior 29 (2013) 1608–1616

Contents lists available at SciVerse ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Virtual research assistants: Replacing human interviewers by automated avatars in virtual worlds ☆

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ARTICLE INFO

Article history:

Keywords:
Social virtual worlds
Automated data collection
Survey interviewing
Bots
Avatars
Media equation

ABSTRACT

We conducted an experiment to evaluate the use of embodied survey bots (i.e., software-controlled avatars) as a novel method for automated data collection in 3D virtual worlds. A bot and a human-controlled avatar carried out a survey interview within the virtual world, *Second Life*, asking participants about their religion. In addition to interviewer agency (bot vs. human), we tested participants' virtual age, that is, the time passed since the person behind the avatar joined *Second Life*, as a predictor for response rate and quality. The human interviewer achieved a higher response rate than the bot. Participants with younger avatars were more willing to disclose information about their real life than those with older avatars. Surprisingly, the human interviewer received more negative responses than the bot. Affective reactions of older avatars were also more negative than those of younger avatars. The findings provide support for the utility of bots as virtual research assistants but raise ethical questions that need to be considered carefully.

1. Introduction

Virtual worlds provide a rich platform for embodied human interaction in a manner comparable to the physical world. A prominent example is *Second Life* (SL),[3] where thousands of people can interact through avatars (i.e., graphical representations of themselves) in a shared three-dimensional virtual space. SL users engage in various social activities that are similar to the ways people work, play, and learn together in real life (RL). This offers attractive opportunities for social science researchers to study a wide range of psychological and social phenomena (Bainbridge, 2007). SL's large population and widespread use facilitate the large-scale recruitment of diverse samples of subjects for participation in surveys and interviews (Bell, Castronova, & Wagner, 2009; Novak, 2010). Moreover, its scope and nature allow for observation of social interactions in naturalistic settings and experimentation with human behavior in a relatively controlled environment. Similar potentials have been described for massively multiplayer online role-playing games (MMORPGs), such as *World of Warcraft*, used as research laboratories (Castronova, 2006; Ducheneaut, 2010). However, MMORPG are more restricted in terms of predefined plots and narratives compared to social virtual worlds like SL that are characterized by user-generated content.

Many studies conducted within SL have used a participant observation approach where the researcher logs into SL with his avatar, visits participants in their virtual locations, observes their behavior and talks with them about their ongoing activities (see Au, 2008; Boellstorff, 2008, for ethnographic reports, and Williams, 2007, for a methodological discussion). While such manually conducted research is labor intensive and time consuming, novel research tools have been developed for *automated* in-world data collection; that is, software that actively collects data within the virtual world of interest while no human monitoring is required.

We start with a review of the state-of-the-art in automated surveying in SL, and present a novel approach using embodied survey bots (i.e., software-controlled avatars) as virtual research assistants. The goal of this paper is to evaluate the consequences of replacing human interviewers by survey bots, which will lead into a discussion of ethical implications.

1.1. Automated surveying in Second Life

The most common techniques for automated in-world data collection are self-administered surveys integrated into the SL user interface (Bell et al., 2009; Dean, Cook, Murphy, & Keating, 2012; Derval & Menti, 2008; Moschini, 2010). These so-called "survey kiosks" are scripted objects that can be designed in any shape (e.g., as a vending machine or sofa) and placed anywhere within SL (given that the researcher has permission by the virtual land

☆ Part of this research has been presented at the 10th International Conference on Intelligent Virtual Agents, Reykjavik, Iceland, September 15–17, 2011 (Friedman, Hasler, Brovman, & Tuchman, 2011).

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[3] http://secondlife.com.

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http://dx.doi.org/10.1016/j.chb.2013.01.004

owner to do so). After clicking a survey kiosk predefined questions are presented using in-world communication tools (e.g., note cards or instant messaging) or customized survey interfaces. Survey kiosks can further be used for automated handling of obtaining informed consent and assigning rewards for the completion of the survey; for example, offering a gift or payment in Linden Dollars (SL's virtual currency).

The idea of automated survey interviews is not new. Computer-assisted self-interviewing (CASI) has been widely used as a means of standardizing interview procedures (see Couper & Nicholls, 1998, for a review). There have also been attempts to implement automated interview programs into Internet-based instant messengers, such as ICQ (Stieger & Reips, 2008). While interviewer appearance and (nonverbal) behavior are likely to influence respondents' answers in face-to-face interviews, CASI is an efficient strategy for avoiding such unwanted interviewer effects (see Rosenthal, 1976). Comparisons between CASI and face-to-face questioning further showed that computerized interviews create a sense of privacy, which tends to result in more honest replies (i.e., less social desirability); especially for sensitive topics (Couper & Rowe, 1996; Newman et al., 2002).

1.2. The paradox in automated surveying

There has been a long debate surrounding the social nature of survey interviewing (see Beatty, 1995, for a review). Some claimed that high levels of standardization (as given in CASI methods) are necessary to collect valid self-report data in survey interviews. Conversely, critics of standardized survey interviewing stressed the essential role of rapport in the interviewer–respondent interaction; thus, requesting more personal interviewing styles (Dijkstra, 1987).

Human–computer interaction (HCI) researchers have provided a possible answer to this paradox in their attempts of humanizing computer interfaces (Sproull, Subramani, Kiesler, Walker, & Waters, 1996). According to the Media Equation Theory (Reeves & Nass, 1996), people have a natural tendency to anthropomorphize computers and treat them as social actors; especially or even more so if human cues, such as a talking face, are added to the interface (Hoffmann, Krämer, Lam-chi, & Kopp, 2009; Nass & Moon, 2000). Humanizing survey interfaces has been claimed to be an effective way of re-introducing the social nature into computer-based survey interviews while maintaining a high level of standardization and perception of privacy (Cassell & Miller, 2007; Tourangeau, Couper, & Steiger, 2003).

1.3. Automated avatars as survey agents

Virtual worlds like SL are ideally suited to implement human-like characteristics into automated survey interviews. SL makes it possible to program automated avatars, also called "bots," that look like any SL avatar but are controlled by software rather than by a human operator. Unlike MMORPG where non-player characters are common, bots are still the exception in social virtual worlds like SL (Burden, 2009). Varvello and Voelker (2010) estimated that 4–7% of SL avatars are suspected to be bots. SL bots are often employed as receptionists, mannequins, sales representatives or to simulate staff presence.

The technical and social properties of SL bots make them interesting candidates for automated large-scale data collection; though their potential as virtual research assistants is still widely unexploited (Friedman, Steed, & Slater, 2007a; Yee & Bailenson, 2008). Bots have the same capabilities as survey kiosks to automatically conduct survey interviews. In contrast to stationary survey kiosks that wait for SL users to pass by, bots can be programmed to proactively approach avatars within SL. This may not only increase participation rates but also reduce self-selection bias. Besides recording the verbal responses to survey questions, bots can collect meta-data (e.g., time and place of the encounter), as well as logs of user activities and their virtual surroundings (e.g., whether avatars are alone or in groups). Bots can also be programmed to interact with objects and perform (simple) social tasks. This enables them not only to observe and collect data but also to participate in social activities; thus, essentially carrying out social experiments within SL.

Friedman et al. (2007a) were among the first to use a fully-automated research bot in SL. Their bot visited different regions within SL, and extracted the date the SL account was created from the profile pages of all avatars that it encountered. This data was later used to explore the distribution of SL users' virtual age. In another study, they programmed a bot to invade other avatars' personal space and recorded their (verbal and spatial) reactions (Friedman, Steed, & Slater, 2007b).

Van Vliet, Neviarouskaya, and Prendinger (2009) conducted an automated experiment within SL to test whether the situated context of an interview had an impact on opinion formation. A bot conducted survey interviews on genetically modified food in either an interactive environment that exemplified the topic or a static environment using only images. The bot would first express its "own" opinion, which was based on opinions that it automatically retrieved from the Web, and then ask participants to present theirs. Participants expressed more elaborated opinions when they were immersed in the realistic experience of an interactive (albeit virtual) environment.

Derval and Menti (2008) describe a hybrid (half-human half-bot) approach that requires a human-controlled avatar for the recruitment of survey participants. If they are willing to participate, the researcher switches to an automated data collection mode, which presents predefined questions in the chat interface and records participants' responses. Once the survey is completed, the researcher can switch back to human-controlled mode within the same avatar. This semi-automated technique helps to circumvent the problem of natural language processing in survey bots. It is technically possible to implement advanced dialog capabilities using generic chatbot software, which enables a bot to participate in a more natural chat conversation with its human interlocutors. However, chatbots are merely designed to *simulate* an intelligent human conversation, but are not able to understand it (Burden, 2009; Deryugina, 2010). In addition, there is a tradeoff between having very limited chatbots and having chatbots that are more sophisticated but unpredictable.

1.4. Adding bots and human-controlled avatars to the media equation

Due to the novelty of this methodological approach and the lack of empirical studies on the general acceptance of bots within SL, it is still unclear whether bots will be equally accepted in their role as research assistants as their human counterparts. According to the Media Equation Theory (Reeves & Nass, 1996), we would expect participants to treat bots as social actors, which would engender similar responses as if the avatar was controlled by a human operator.

Testing the media equation hypothesis is a crucial first step in the evaluation of the utility of this new approach. Previous media equation studies often confounded agency and modality effects (Gong, 2008); for example, when comparing survey interface agents with paper-based, telephone or face-to-face questioning. In virtual worlds, however, both the human and the computer operate at the same level of abstraction (Burden, 2009). They are equal regarding their modality of representation (i.e., avatar embodiment) and communication mode (at least if text channels are used). This provides optimal conditions for a "fair" test of the media equation hypothesis.

In the present study, a bot and a human interviewer conducted an avatar-based survey interview within SL. The survey interview aimed at collecting information about SL users' RL backgrounds; specifically their religion. While SL users typically hide their RL identity, researchers often wish to know who the real people are behind the avatars. This information can only be gathered by asking them directly. Thus, collecting RL information is a typical use case of in-world survey interviewing.

If bots and human interviewers were equal in SL, we expected them to achieve similar response rates, and participants would be equally willing to disclose information about their RL in their responses. We further expected to find similar affective reactions towards the bot and the human interviewer. It is well known that behavior in SL changes as participants become more experienced and versed in the environment (Boellstorff, 2008; Harris, Bailenson, Nielsen, & Yee, 2009). Therefore, we also explored whether participants' virtual age (as a measure of their SL experience) was related to their attitude towards bots and would affect their responses.

2. Method

2.1. Participants and sampling

We used an online list of all active SL regions as destinations for the bot to visit.[4] The bot visited 257 randomly selected regions from the this list. Out of those 99 regions did not have any avatars online at the time of sampling, and 99 other regions had between one to four avatars. The bot approached 2546 avatars during 112 h of actual run time. The main reasons for down time were procedural rather than technical. Eight months later, human interviewers visited the same locations in random order, but limited to the 59 regions in which the bot found more than four participants. The human-controlled avatar approached 135 participants within 35 h.

The responses from 35 participants (1.31%) that came from other bots were removed from the original sample. This includes auto-reply messages by temporarily unavailable users. Another 36 participants were removed that were not able to communicate in English. Two avatars that had already been contacted by the bot were removed from the sample that the human interviewer collected. The remaining sample consisted of 2480 avatars contacted by the bot, and 125 by the human-controlled avatar. Participants did not receive payment or any other compensation for participating in the study.

2.2. Materials

Our main bot platform is implemented on top of the LibOpenMetaverse[5] software library. This library makes it possible to log into SL with any SL account, just like a regular participant. Then, instead of manually controlling the avatar its behavior is controlled by the software. The bot thus appears to SL participants like any other human-controlled avatar would. Both the bot and the human interviewer were represented using the same female SL avatar in order to keep potential appearance-related interviewer effects constant across the two agency conditions.

The survey interview was standardized using a single predefined question about participants' religion.[6] The short nature of the survey interviews created comparable agency conditions, and allowed for testing of first impression effects. According to Groves and Couper's (1996, 1998) Theory of Survey Participation, such initial moments of the survey encounter play an important role in participants' decision about whether or not to participate in a survey interview.

We chose to use private instant messaging (IM) instead of public chat because the public chat channel is visible to everyone within a 20 (virtual) m range, and we preferred that participants would know that their privacy is respected. Although we implemented a chatbot engine in our research bots, this feature was not used in the present study. Instead, the text uttered by the bot was hard-coded in the script, and the bot was not capable of responding to participants' messages. The bot disclosed itself as an unintelligent software-controlled avatar when it approached participants. This part of the IM text was removed in the (otherwise identical) message sent by the human interviewer. The text of that message (with the respective adjustments for interviewer agency) is presented in Appendixes A and B.

2.3. Procedure

The bot teleported[7] between random regions during its operation. Upon arrival in a new region, the bot attempted to talk to each participant in that region in a random order. The bot would try to walk up towards an avatar to an acceptable social distance, aiming at five virtual meters, facing that avatar.[8] Following the approach the bot sent an IM to that avatar, containing a personalized greeting (using the avatar's name) and the question about his or her religion (see Appendixes A and B). The bot waited at the same position for 2 min, and then continued to the next participant. The same routine was followed by the human interviewer. Three human research assistants conducted the survey interviews independently but operating the same avatar at different times. Although they were instructed to keep their interactions with the participants as short as possible, they replied to questions and comments if required. The contact situation between the interviewer and the participant is illustrated in Fig. 1.

When the bot finished contacting all avatars within a region, it teleported to the next region. The bot maintained a list of all participants that it contacted throughout the study in order not to attempt to contact the same participant again. The SL participant's name was used as a key. It is possible that the bot would have contacted the same person more than once if that person had more than one avatar in SL. This tendency is not uncommon (Bell et al., 2009; Boellstorff, 2008). In addition to recording participants' IM responses and extracting their virtual date of birth from their profile pages, the bot recorded the public chat channel and the positions of other avatars in its vicinity. The human interviewer copy-pasted the IM chat conversation manually into a database, noted participants' avatar name and looked up the date the avatar has been created in its profile page.

2.4. Measures

2.4.1. Outcome variables

2.4.1.1. Response rate. Response rate was calculated separately for the bot and the human-controlled avatar by dividing the number of avatars that replied by the total number of avatars that have been contacted.

[4] http://gridsurvey.com.

[5] http://openmetaverse.org/projects/libopenmetaverse.

[6] The current study was conducted in collaboration with a scholar of online religion (ANON). The bot was used as an additional, exploratory research method, as part of ANON's large-scale research on religion (specifically Buddhism) in SL. In this paper we do not discuss the issue of online religion at all. We merely focus on the methodology of using bots for automated in-world data collection.

[7] Teleportation is the means by which avatars can travel instantaneously between remote locations within the virtual space.

[8] Note that SL is a complex environment. Thus, in practice there might have been obstacles or lag. This means that the precise nature of the approach (in terms of distance and gaze direction) cannot be guaranteed.

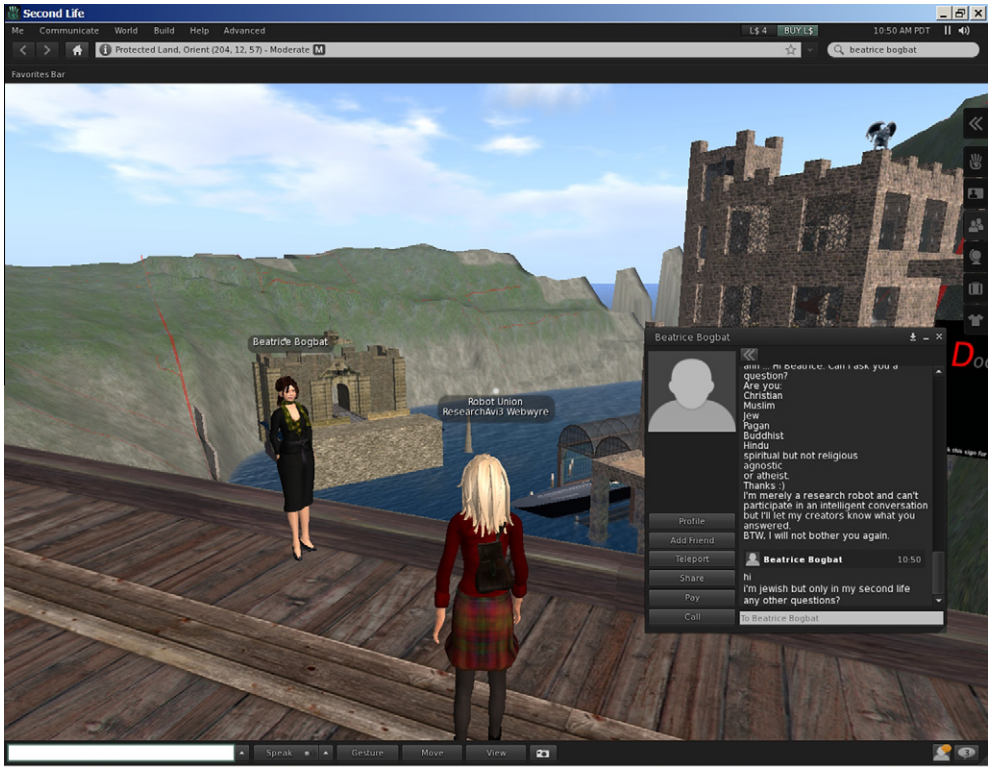

Fig. 1. The research bot (right) facing a participant (left) and asking the survey question in IM; this image was posed for illustration.

2.4.1.2. RL disclosure. Two independent raters divided the respondents into two groups: (1) those who answered the question about their religion, and (2) those who did not answer the question. An answer was also considered as valid if participants came up with a religion or belief system that was not on the list. The two raters achieved absolute agreement in this dichotomous categorization.

2.4.1.3. Affective reactions. Two independent raters coded the participants' messages using the categories "positive," "neutral," and "negative". If the reply was short and informative it was regarded as neutral. Examples for the three categories of affective reactions are provided in Appendixes A and B. During this process the raters also marked whether the response was from another bot or from a human-controlled avatar. Disagreements in the affective coding were resolved by consensus. Then we calculated the proportion of positive, negative, and neutral messages for each participant.

2.4.2. Predictors

2.4.2.1. Virtual age. The age of participants' avatars was calculated based on the date when the SL account was created. The creation date was subtracted from the date of the encounter with the bot or the human interviewer. Avatar age varied between 0 days and 7.22 years (M = 1.21 years, SD = 1.28 years), and was not normally distributed. Fig. 2 shows the distribution of participants' virtual age, indicating a large number of newly created avatars as observed in previous SL studies (Friedman et al., 2007a).

3. Results

3.1. Response rate

The bot received 975 messages from 767 (out of 2480 contacted) avatars, while the human interviewer received 257 replies from 82 (out of 125 contacted) avatars. A Likelihood Ratio Chi-Square Test showed that the response rate achieved by the human interviewer (65.6% responses vs. 34.4% non-responses) was significantly higher than the response rate of the bot (30.9% responses vs. 69.1% non-responses), $\chi^2(1) = 60.02$, $p < .001$.

A logistic regression analysis was performed for interviewer agency (coded with human = 1, bot = 0) and participants' virtual age (using z-transformed age values) as predictors for response rate (coded with 1 = response, 0 = non-response). The results of the logistic regression analysis are presented in Table 1. Only interviewer agency significantly predicted the likelihood of responding to a survey interview. Thus, participants were more likely to respond to a human interviewer than to a bot. Virtual age and the interaction of agency and age were not statistically significant.

3.2. Disclosure of RL information

Among those who responded, an equal proportion answered the RL question when asked by the bot (76.3%) and by the human interviewer (75.6%), $\chi^2(1) = .02$, $p = .89$. A logistic regression analysis was performed for interviewer agency (coded with human = 1, bot = 0) and participants' virtual age (using z-transformed age values) as predictors for disclosing RL information (coded with 1 = question answered, 0 = not answered). The results of the logistic regression analysis are presented in Table 2. Only participants' virtual age significantly predicted the likelihood of answering a RL question, while interviewer agency and the interaction of agency and age were not statistically significant.

In order to further examine the effect of virtual age, we divided the sample of respondents (N = 849) into two age groups using a median split (Md = 248 days). The mean age of young avatars (N = 425) was 55.5 days (SD = 70.28 days). The older avatars (N = 424) were created in average 2.28 years (SD = 1.18 years) prior to their participation in the study. A Likelihood Ratio Chi-Square Test showed that younger avatars (among which 81.0% answered the RL question and 19.0% did not answer) were more likely to

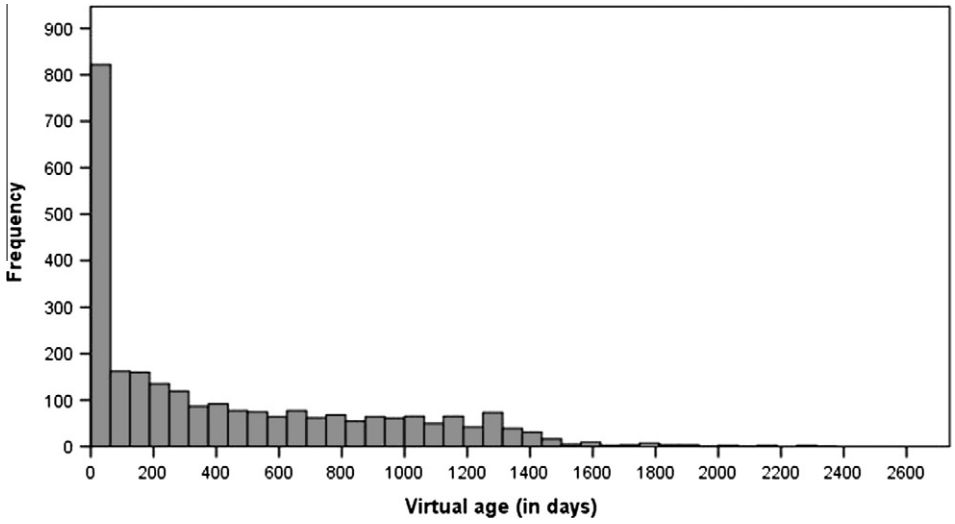

Fig. 2. Distribution of participants' virtual age (days since joining SL).

Table 1
Logistic regression predicting response from interviewer agency and participants' virtual age.

Predictor	*B*	SE	Wald's χ^2	Df	*p*	Odds ratio
Agency (human)	1.44	.19	55.15	1	<.001	4.23
Virtual age	−.01	.04	.05	1	.82	.99
Agency × Age	.24	.20	1.42	1	.23	1.27
Constant	−.80	.04	342.07	1	<.001	.45

Table 2
Logistic regression predicting answer to RL question from interviewer agency and participants' virtual age.

Predictor	*B*	SE	Wald's χ^2	df	*p*	Odds ratio
Agency (human)	−.05	.28	.03	1	.87	.95
Virtual age	−.28	.08	13.69	1	<.001	.75
Agency × Age	.10	.25	.15	1	.70	1.10
Constant	1.19	.09	188.89	1	<.001	3.28

disclose RL information than older avatars (71.5% answered vs. 28.5% did not answer), $\chi^2(1) = 10.57$, $p = .001$.

3.3. Affective reactions

Table 3 shows the proportions of positive, neutral, and negative responses to the bot and the human interviewer. In addition, we report the proportions of affective reactions for the two virtual age groups of respondents.

A repeated measures analysis of covariance (ANCOVA) was calculated with affect (positive, neutral, negative) as the within-subject variable, interviewer agency (bot vs. human) as a between-subject variable, and respondents' virtual age as a (continuous) covariate. The ANCOVA revealed a significant main effect for affect, $F(2,1692) = 16.85$, $p < .001$, $\eta_p^2 = .02$, indicating a generally higher proportion of neutral responses than positive and negative responses. The interaction of affect and virtual age, $F(2,1692) = 4.29$, $p = .01$, $\eta_p^2 = .05$, as well as the interaction of affect and interviewer agency, $F(2,1692) = 126.62$, $p < .001$, $\eta_p^2 = .13$, were statistically significant.

Univariate analysis showed that the bot received significantly more *neutral* responses than the human interviewer, $t(847) = 12.07$, $p < .001$, while the human interviewer received significantly more *negative* responses than the bot, $t(847) = 15.56$, $p < .001$. The bot and the human interviewer did not significantly differ regarding the proportion of *positive* responses, $t(847) = .20$, $p = .84$. Respondents' virtual age was positively correlated with the proportion of *negative* responses, $r = .11$, $p = .001$, and negatively correlated with the proportion of *neutral* responses, $r = -.08$, $p = .02$. Accordingly, a comparison of the two virtual age groups showed that the older avatars responded more negatively, $t(847) = 4.06$, $p < .001$, and less neutrally, $t(847) = 2.40$, $p = .02$, than the younger avatars. Respondents' virtual age was not correlated with the proportion of *positive* responses, $r = -.01$, $p = .71$.

4. Discussion

The main goal of this research was to test the media equation hypothesis (Reeves & Nass, 1996), according to which a bot and a human-controlled avatar were equally accepted in their role as survey interviewers within SL, and would consequently engender similar responses from participants. The evaluation included response rate as a quantitative measure, and a qualitative analysis of participants' affective reactions and willingness to disclose information about their real life. In addition to interviewer agency (bot vs. human), we tested participants' virtual age as a predictor for response rate and quality. We first discuss the methodological and social implications of our findings. Then we discuss the ethical

Table 3
Means and standard deviations of proportions of positive, neutral and negative responses (in %) for interviewer agency and respondents' virtual age.

		N	Positive		Neutral		Negative	
			M	*SD*	*M*	*SD*	*M*	*SD*
Interviewer agency	Human	82	18.08	26.51	7.14	22.43	74.77	32.98
	Bot	767	18.89	36.07	66.99	44.28	14.12	33.61
Virtual age	Young	425	20.28	36.63	64.99	44.88	14.73	33.33
	Old	424	17.35	33.79	57.41	47.18	25.24	41.58

issues that need to be considered when using such automated entities for research purposes, and outline possible future scenarios.

4.1. Methodological and social implications

4.1.1. Response rates

The bot achieved a response rate of 30.9%, which was lower compared to the response rate of 65.6% achieved by the human interviewer. The different response rates could be interpreted in terms of a lower acceptance of bots in their role as research assistants compared to their human counterpart. However, this finding does not necessarily reflect a general disapproval of bots by the SL community. If the SL community generally rejected bots, then we would have expected participants' virtual age (as a measure of their familiarity with the SL norms and customs) to influence their response rates. However, the results of the present study do not provide support for this assumption.

From a methodical point of view, the bot can be considered as more efficient since it was capable of successfully contacting a much larger number of avatars in a given time than its human competitor. Most importantly, the bot ran automatically without requiring permanent monitoring or maintenance by a human researcher. This makes bots a cost-effective technique for large-scale survey interviewing within SL.

We note that the bot's response rate is still much higher than the typical response rates obtained with other recruitment techniques in survey kiosk studies in SL (Bell et al., 2009; Dean et al., 2012). Bell et al. (2009) recruited participants via external channels (i.e., mailing lists) and in-world recruitment methods (i.e., classified ads[9] and random placement of survey kiosks within SL). They reported a response rate of only 2.73% for the mailing list recruitment method. The estimated response rates for the in-world recruitment techniques were even lower. While their survey kiosk was open for 30 days (24 h a day) and collected a sample of $N = 2094$ valid responses, our bot successfully recruited 767 participants within only 112 h. The bot's efficiency (considering its response rate and "working hours") may be attributed to its capability of approaching participants while they are online. Bots bring the survey to the participants instead of trying to bring participants to the survey, which is the common recruitment procedure of the survey kiosk method.

Dean et al. (2012) compared various recruitment methods, and found that they attracted different kinds of respondents. For instance, more experienced SL users (i.e., older avatars) responded to an ad placed in the SL Herald (SL's official virtual newspaper), while a proportionally larger number of young SL avatars responded to classified ads. In contrast, participants in our study that responded to the bot and the human interviewer did not differ significantly regarding their virtual age. Bots seem to be successful in recruiting both experienced and inexperienced SL users. In addition, they have the advantage of approaching SL users in a highly-random fashion, which may lead to more representative samples of survey participants.

4.1.2. Disclosure of RL information

Interviewer agency had no influence on participants' willingness to disclose RL information. In contrast, younger avatars answered the survey question about their religion more often than older avatars; irrespective of whether the question was asked by a bot or a human-controlled avatar. On the one hand, these findings provide support for the media equation hypothesis: Bots and human interviewers were equally successful in collecting information about SL users' RL background. This finding is consistent with earlier studies that demonstrated participants' willingness to disclose private information towards virtual agents (Bailenson, Yee, Merget, & Schroeder, 2006; De Angeli, Johnson, & Coventry, 2001). The fact that no differences were found regarding the content of responses indicates the validity of replacing human interviewers by research bots.

On the other hand, the relation between virtual age and RL disclosure shows the important role of users' experience with the respective medium that needs to be considered when conducting survey interviews in online environments. The more time users spend within a virtual community, the more likely they are to adopt the social norms and customs of that community. The SL community has established the custom to keep "first life" out of *Second Life*. Thus, survey interviews on RL topics might be a sensitive issue; especially for experienced SL users that may be more aware of and adhere to the social norms of their community than inexperienced users. The ongoing discussion on the SL community forum[10] about whether or not RL identity should be kept private shows the importance of the RL–SL issue. The forum contains numerous statements by SL users according to which asking for RL information is considered to be rude and impolite, especially if RL questions are asked by strangers. This attitude is also reflected in some of the (negative) responses that both the bot and the human interviewer received in the present study: "*that is invasion of my privacy*", "*Thats private info, i'm offended by it*", "*one thing never ask these quiestions they are agaisnt the tos [sic]*", "*This is too personal. I don't know you*", to only mention a few.

4.1.3. Affective reactions

Older avatars showed more negative and less neutral responses irrespective of whether the interviewer was a bot or a human. This finding is consistent with the decreased willingness to disclose RL information with increasing virtual age. It further demonstrates the importance of considering users' experience when evaluating the social acceptance of bots as virtual research assistants.

Surprisingly, the majority of the responses to the bot were categorized as neutral (66.99%), while the human interviewer received mainly negative responses (74.77%). This finding contradicts the media equation hypothesis, according to which we would have expected participants to show similar affective reactions towards the bot and the human interviewer. It also contradicts earlier studies that observed unfriendly and aggressive responses in conversations with (disembodied) chatbots (De Angeli & Brahnam, 2008; De Angeli et al., 2001).

It is possible that the reactions towards the bot were less negative than towards the human interviewer because participants were aware that it would not understand their negative responses. However, participants were explicitly informed in the bot's IM that their responses will be forwarded to its human "creator". Consequently, some participants treated the bot merely as a medium to communicate with the human programmer or researcher behind it, as indicated in the following responses: "*could one of the creators of this avatar please message me back with the anticipated research outcomes of this question?*", "*/me blinks and wonders why your creators want to know.", "Hi to your creators then, and the answer is spiritual but not religous:) [sic]*", and "*tell your creators that it is none of their business and that their research is flawed*". However, the number of responses that directly addressed the bot's creator was relatively low, and this communication strategy was equally applied to express positive, neutral, and negative reactions. Most responses were directed towards the bot as an independent social actor, which is in line with previous research on source orientation

[9] http://secondlife.com/community/classifieds.

[10] http://community.secondlife.com; for example, see discussion threads entitled "Real-life identity and personal info – a never-ending battle to keep it out of SL" or "No RL in my SL, PLEASE!!!!!!!".

in HCI. These studies showed that participants assign responsibility for messages to the most proximate source available (i.e., the computer rather than some projected human behind it), even when it is made explicit that it is merely a messenger (Nass, Moon, & Carney, 1999; Sundar & Nass, 2000).

The different response rates provide an alternative explanation for the lower proportion of negative responses to the bot compared to the human interviewer. It is possible that those who did not reply to the bot had negative preconceptions, and that "not responding" was an expression of their disapproval. However, this explanation is also unsatisfying since not responding can still be considered as more polite than attacking an interviewer verbally.

Another plausible explanation for the different affective reactions towards the bot and the human interviewer lies in their different verbal interaction capabilities. While the human interviewer was able to exchange messages with the participants (although the dialogs were kept short), the bot did not respond to participants' messages. For instance, a typical first reaction to the human interviewer was the question of why she wants to know about SL users' religion. Although some participants asked the bot the same question (knowing that it is not capable of answering it), it was more frequently observed in encounters with the human interviewer. However, this particular message was categorized as neutral. Since the human received significantly less neutral responses than the bot, we can also rule out this methodical artifact as an explanation for the different affective reactions.

In summary, there were differences in response rates and affective reactions towards the bot and the human interviewer, but no differences between the two agency conditions were found regarding the information collected in the survey interview. Thus, the results of the present study provide support for the validity of replacing human research assistants by bots to carry out survey interviews within SL. Although it can be regarded as a positive evaluation result that the bot received less negative responses than the human interviewer, further research is needed to explore the reasons behind the different affective reactions in the two agency conditions. A better understanding of user reactions and attitudes towards automated avatars as social actors within a virtual community will eventually help us to determine their adequate deployment for research purposes.

4.2. Ethical issues

This research had ethics approval from two institutional review boards; both at the involved universities. Despite formal permission from Linden Lab (the company behind SL) to operate the bot in SL for the purpose of the present study, it was temporarily banned from SL several times. While the number of explicit negative responses to the bot was small, some participants were distressed and complained to Linden Lab. We received email messages from Linden Lab indicating that the bot violated the Terms of Service (TOS).[11] The bot was found "guilty" of: "Violation: Disturbing the peace: Repetitive Content, Spamming". The last two IMs received before the bot was removed from SL were: "*I know you wont bother me again. I filed an AR and just muted you*," and "*reported to LL. . .. Muted. . . an drop dead!" [sic]*.

Since we have carefully made sure that the bot does not communicate with the same avatar more than once, the bot's activity cannot be considered as "spam and repeated content," and is not in violation of the TOS. It is important to note that human interviewers may run into the same type of response. One of the research assistants was also banned from SL while carrying out the survey interview in the present study. Although the bans were quickly turned around by Linden Lab, these incidents illustrate the importance of a careful consideration of research ethics within virtual worlds.

The ambiguity of responses from different participants reflects the nascent nature of virtual worlds, and the fact that social conventions and norms are still emerging. There has been a discussion of research ethics in the context of virtual worlds (Fairfield, 2010; Grimes, Fleischman, & Jaeger, 2009; McKee & Porter, 2009; Rosenberg, 2010; Stanton, 2010). However, an extensive review of virtual world research ethics is beyond the scope of the present study. Instead, our suggestion is to put this discussion in the wider context of a digital society where automated processes and even automated entities are becoming abundant. We agree with the call for involvement of the audience in the ethical decision making process even when it comes to research ethics; in the spirit of Athens practices of rhetoric in the 4th century BC (McKee & Porter, 2009). In a sense, our study reported here is a step in this direction.

One of the main issues in the ethics discussion refers to the private/public distinction of virtual spaces (Rosenberg, 2010). In the physical world we would expect to be approached by research assistants in a campus or even a public street, but not in a private home or establishment. A key question is whether the places visited by our bot constitute a public or a private space; see McKee and Porter (2009) on why it is far from easy to label places in a virtual world as public or private. We expect SL users to resolve these issues in the near future, and the results may be backed up by technical protocols; for example, land owners may be able to define the types of bot activities allowed on their land. The research community needs to follow these developments and adjust the research methods to the social norms expected by the participants.

At present, bots are still relatively rare in SL. Out of the total number of SL avatars encountered in the present study only 1.31% has been (manually) identified as bots. This number is even lower than automatically calculated estimations in previous studies that suspected 4–7% of avatars in SL to be bots (Varvello & Voelker, 2010). Specifically, bots that freely navigate within SL, proactively approach and initiate interactions with other avatars are still the exception. In the typical use cases for bots, they are mainly stationary and interact with SL users upon their request (e.g., sales representatives or mannequins in a shop). When encounters between bots and human-controlled avatars become more frequent in SL, the increasing amount of personal experiences of SL users will also shape the community's attitude and expectations towards bots. This will require an extension of the current discussion on virtual world research ethics, including regulations for an adequate administration of bots for research purposes that respect the community's social norms.

Bots may not only become more common within social virtual worlds in the near future, but also more realistic (i.e., human-like) in their verbal and nonverbal behavior. Currently, chatbots still have limitations as survey interviewers within virtual worlds. They are not able to run off script to gather more information on a particular response of interest, detect potential misunderstandings in participants' responses and provide clarifications, or simply answer questions from the respondents. Several researchers have addressed the issue of how to optimize survey response quality with verbal features of an agent's conversational capabilities (Conrad, Schober, & Coiner, 2007; Peiris, Gregor, & Alm, 2000; von der Pütten, Hoffmann, Klatt, & Krämer, 2011). Others work on improved nonverbal behaviors for automated avatars in virtual worlds, including the design of more emotionally expressive bots (Breitfuss, Prendinger, & Ishizuka, 2009; Slater & Burden, 2009).

Such technical advancements that allow for increased anthropomorphic realism in research bots may also raise new ethical

[11] SL Terms of Service (TOS): http://secondlife.com/corporate/tos.php; see also Linden Labs' Community Standards of Practice: http://secondlife.com/corporate/cs.php and http://secondlife.com/policy.

questions. The higher a bot's behavioral realism is, the more social influence it is likely to have in interactions with human-controlled avatars. According to the Threshold Model of Social Influence (Blascovich, 2002), the social influence of humans represented by avatars will always be high, while the social responses elicited by computer-controlled avatars depend on the degree of their behavioral realism. Virtual agents that show highly realistic behavior have been found to be more persuasive (Guadagno, Blascovich, Bailenson, & McCall, 2007), lead to more self-disclosure in their human interlocutors (Bailenson et al., 2006), and higher levels of perceived social presence and awareness (von der Pütten, Krämer, Gratch, & Kang, 2010).

If bots become more human-like in their behavior, it may be difficult for participants to detect that there is no human operator behind the avatar. This can be a considered as a new form of deception if the human user behind an avatar does not notice that he is interacting with a machine rather than another human-controlled avatar. Unlike in MMOPRG where players are used to interacting with automated entities, the working assumption in social virtual worlds is that avatars are being controlled by a human (Burden, 2009). The ultimate goal of "artificially intelligent" computer programs that mimic human-like behavior is to pass the Turing Test (Turing, 1950). While in a conventional Turing Test a computer is required to prove that it is human, bots within virtual worlds must not give-away the fact that they are not human. Due to this presumption, it is already possible with the current generation of SL bots that people mistakenly assume in an initial period of an encounter with another SL avatar that it is controlled by a human. In any case it is important that bots clearly declare themselves as bots (Friedman et al., 2007a).

Finally, this research has implications beyond those of research ethics. By replacing humans by automated entities in virtual worlds, we create a new digital society with its own rules and dynamics. Such inter-species relations need to be fully understood in a virtual world where we might co-exist with automated entities.

Acknowledgments

This research was partially funded by the EU ICT FP7 project BEAMING (Grant No. 248620). The first author's work was supported by a Marie Curie Intra European Fellowship within the EU FP7 Programme (Grant No. *254277*). We would like to thank Gregory Grieve from the Department of Religious Studies at the University of North Carolina for his collaboration on this research, and Ady Nae O'Malley, Aidai Seidakmatova, and Sharon Gitelman for their assistance in the data collection.

Appendix A. IM text

The following IM was sent by the bot and the human interviewer; [avatar name] was replaced by the name of the avatar that was being approached:

```
ahh ... Hi [avatar name]. Can I ask you a question?
Are you:
Christian
Muslim
Jew
Pagan
Buddhist
Hindu
spiritual but not religious
agnostic
or atheist.
Thanks:)
```

Additional part of the message sent by the bot:

```
I'm merely a research robot and can't participate in
  an intelligent conversation but I'll let my
  creators know what you answered.
BTW, I will not bother you again.
```

Appendix B. Examples of positive, neutral, and negative responses to the bot and the human interviewer

Interviewer	Positive	Neutral	Negative
Bot	*Cool project. Hope I get to read the results one day.*	*ummm Im not interested in participating thank you*	*I'm anti-spambot! Is that a religion? I sure hope so!*
	u didnt bother me dear..it was lowely.. we had fun and add good times to each other.	*im just a part of the univerzum others details from me pleaze request God*	*voodoo. and if you ever IM me again, i will have to get medieval on you >:-o*
Human	*good luck on your study*	*does it really matter?*	*i have been abused when i was a kid by severall prieststs so plaese save me that religon shit*
	whoa u got all the answers writen allready.. thats kewl..	*dont believe in omi present imaginary beings..*	*look you get banned you bish*

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