Adoption of Virtual Assistants for Human-Computer Interaction among Smartphone Users in Lagos, Nigeria

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Abstract
Steady advancements in digital technologies are facilitating human-machine interaction to rival human conversations in many societies. Human-machine exchanges have received further boosts through Artificial Intelligence (AI) powered virtual assistants (VA) in intelligent devices such as Siri, Cortana, Alexa and Assistant. As mobile devices spread within African communities, beyond urban areas to rural communities, an increasing demand exists to integrate African communications systems into the global digital ecosystem. Given that most African languages are expressed orally, AI and virtual assistants could be the key to facilitating inclusive communication. This study utilised a pragmatic mixed research method to evaluate how Nigerian smartphone users in Lagos currently use and accept AI-powered voice-enabled virtual assistants. Using SPSS and Nvivo to analyse surveys of 357 persons and nine interviews and deducing from the media richness and the uses and gratifications theories, results show that virtual assistant awareness in Lagos is low. However, those who use using the tools find richness and satisfaction in interacting with VAs to carry out communications tasks. Current challenges exist that pertain to accents, internet access and localised languages. To ensure that voice-enabled VAs can truly solve financial and educational inclusion challenges across Nigeria, further extensive studies are needed using a wider population.

Keywords: Virtual Assistants, Human-machine interaction, Artificial Intelligence, Indigenous languages, technology adoption.

Background

Technology is becoming increasingly dominant in human communication. The spread of Information and Communication Technologies (ICTs) has led Hao (2019) to argue that these technologies create a new global economy in which information is a critical resource. These technologies for information have evolved from linear to interactive and transactional models (Drew, 2020). Digital communication has traditionally been conducted in outlying devices like the computer keyboard, mouse and, most recently, touch-sensitive screens. However, artificial intelligence (AI) powered voice technology has led to virtual assistant (VA) development.

VAs are AI-based systems that offer help with multiple day-to-day digital tasks. According to Juniper (2021), by 2024, technology users will network with virtual assistants on more than 8.4 billion devices. Therefore, increased reliance on VAs is predicted in Nigeria, where mobile phone penetration is expected to be at 56.4 percent of the overall population (Ceci, 2021). VA penetration across Africa offers excellent opportunities in education, healthcare, agriculture and other domains. These critical opportunities are limited because African languages are mostly communicated orally (Osoba and Alebiosu, 2016). Despite advancements in these VAs to recognise speech patterns of all users worldwide, it does not support most indigenous African languages, and there are frequent instances where the users need to repeat themselves or execute their command by touch (Beneteau et al. 2019; Bolaños et al. 2020).

Existing literature from Pal, Arpnikanondt, Funilkul, and Varadarajan (2019); (2019), Brill, Munoz, and Miller (2019), and many other scholars show the numerous benefits of VA and AI and how widely they are used worldwide. In Nigeria, most of these scholarly works have focused on text-enabled VA.

Therefore, to contribute more insight into this domain, this study evaluates how Nigerian smartphone users use AI-powered voice-enabled VA and how much they accept this tool in their everyday lives.

Research Questions

i. What is the current level of usage for AI-enabled virtual assistants by smartphone users in Lagos?
ii. What are the experiences of smartphone users in Lagos when using AI-enabled virtual assistants?
iii. What are the perceived benefits and limitations of using AI-enabled virtual assistants among smartphone users in Lagos?

Literature Review

Artificial Intelligence and Voice-Assisted Virtual Assistants

Voice-activated devices are becoming commonplace across the world. People can use their voices to control smartphones and interact with their smart homes through virtual assistant devices (Ballati et al., 2018). The spread of such voice-controlled devices is possible thanks to the increasing capabilities of natural language processing, positively impacting device accessibility. Forty-four percent of smartphone users are said to employ virtual assistants on their mobile devices. At the same time, VAs are continually integrated into the everyday lives of their users (Verto Analytics 2017, cited in Rawassizadeh et al., 2019). Users can open their music applications, and interact with others through a voice command.

Natale (2020) explains that each VA is represented as an individual character that can be networked with like a friend, notwithstanding that it is non-human. So, in using VAs, individuals can communicate with a computer and, in the same way, share with their human network. These voice-activated VAs are designed to heighten the user's experience using recognisable features such as gender, accents etc. Thus, AI-enabled VAs are designed to give users the illusion or experience of interacting or communicating with a human.

However, Doumbouya et al. (2021) showed that most in need of voice-enabled VA technology are often the most underserved by it. Furthermore, cultural distinctions in English expression and system engagement are significant to the usability of VAs (Pyae and Scifleet, 2018). The VAs are mainly designed for native English speakers with particular accents and exempt others.

Digital Exclusion in African Communities

Digital exclusion research has revealed how the initiation of ICT into human societies is propagating new methods of societal stratification. As digital platforms grow in influence, new practices of reliance on ICT are emerging, and the digital divide in communities is the new method of socio-economic segregation (Antonio and Tuffley, 2014). "The influx of the information society is an ambivalent process" (Castells, 2011). It encourages novel methods of human freedom; however, it stimulates newer ways of rulership and community exclusion (Mariën & Prodnik, 2014).

Gonzales (2016) postulated the technological maintenance theory on the socio-economic effect of broadband prices and device updates. Other scholars have examined the concerns of multiple device usage, such as smartphones, tablets, personal computers and wearables (Pearce & Rice, 2013). However, according to Osborn (2010), as the global ICT ecosystem develops and permeates into rural Africa, a significant divide occurs for millions of citizens whose only languages are not supported online. Considering that education and information diffusion are more effortless in a person's mother tongue than in acquired languages (Rabiah, 2018), the absence of voice-activated VAs in indigenous languages is a form of exclusion.

Several scholars across the world have approached the digital divide phenomena from various perspectives. Conversely, Brill et al. (2019) studied a consumer satisfaction perspective of virtual assistants. The research utilised random sampling of adults with data collected from the United States digital platforms. In Nigeria, Nwosu (2018) studied the extent of using AI by Nigerian banks. Top Nigerian banks like Access Bank, and FCMB, have implemented AI-powered chatbots to enable customers to carry out simplified banking activities.

In comparison, Brill et al. (2019) expressed that the larger sample size consisted of Apple Siri users amounting to 72% of respondents. The findings showed that when the anticipations of the VA user are met, it induces a symbiotic relationship leading to user satisfaction and gratification with the VA. Similarly, Pal et al. (2019) explored a narrower perspective on the features of virtual assistants by focusing on the impact that accents have on VA speech recognition. The survey conducted in Thailand included 275 users. The research results showed low variance in usability and satisfaction between the highlighted user groups.

Theoretical Framework

The Media Richness Theory and the Uses and Gratification theories provide the theoretical backing for this study. As proposed by Daft and Lengel in 1986, the Media Richness Theory posits that different media have varying levels of information richness, which affects communication effectiveness. Many scholars have utilised this theory to understand how individuals choose communication channels in their interactions, including new media such as phone calls, emails, and video conferencing. Fleischmann et al. (2020) found that members of a group with lower language proficiency feel less included in all collaboration channels, while those with higher language proficiency feel less satisfied with the lean collaboration. With the increasing adoption of AI-powered technology and low-cost IoT devices, there is potential for capturing and integrating media-rich information for more effective communication and augmenting reality. In this study, the concept of media richness is important for understanding Nigerian smartphone users' satisfaction with voice-enabled VAs in their daily lives (Sheth et al., 2019).

The Uses and Gratification Theory propounded by Blumer and Katz (1974) suggests that media users are actively involved in their use and choice of media. It postulates that the users of media channels keenly participate in the communication practice and are outcome-oriented when using the media. According to Momoh et al. (2015), consumers of media search for messages and mediators that gratify their fantasies. The theory postulates that the audience is goal-oriented and, as such, will use the media to achieve their goals (Agha et al., 2021). The essence of this theory in this paper is to investigate the satisfaction derived from virtual assistants as a channel of interactive communication. The reasons why individuals make media choices are essential for behavioural research. Persuasive arguments by Daft and Lengel (1986) have connected media choice with individual and group effectiveness.

Methodology

This study uses a mixed-method approach to investigate how smartphone users in Lagos, Nigeria, use AI-powered voice-enabled virtual assistants (VA) in their everyday lives. According to Statista (2021), there are 15.5 million smartphone users in Nigeria; using the Taro Yamane probability sampling method, 400 respondents were chosen for the online questionnaire, while a purposive sampling technique was used to recruit nine participants for in-depth interviews. The data collected were analysed using SPSS for the quantitative study and thematic analysis for the qualitative study. The findings were presented using a descriptive narrative, illustrative quotes, and charts.

Data Presentation and Analysis

While creating the questionnaire, none of the questions was made compulsory. Therefore, the responses obtained contained 10.75% missing data; approximately 43 were omitted from the dataset. Thus, the total number of completed responses for the entire survey was 357, about 89.25% of the full sample size. Although the whole valid datasets are under the desired 400, the decision to go ahead with the available data was guided by the work of Diddi and LaRose (2006), which utilised a sample size between 300 to 600 to study media's practical uses and gratifications. Thus, the researcher decided to proceed with the data analysis.

It was expedient to determine whether each respondent owned a smartphone since this is the prerequisite to accessing virtual assistants. Results show that 100% of respondents use a smartphone, and as shown in Chart 1, 61% use devices that rely on the Google play store, while 38% use the Apple Store.

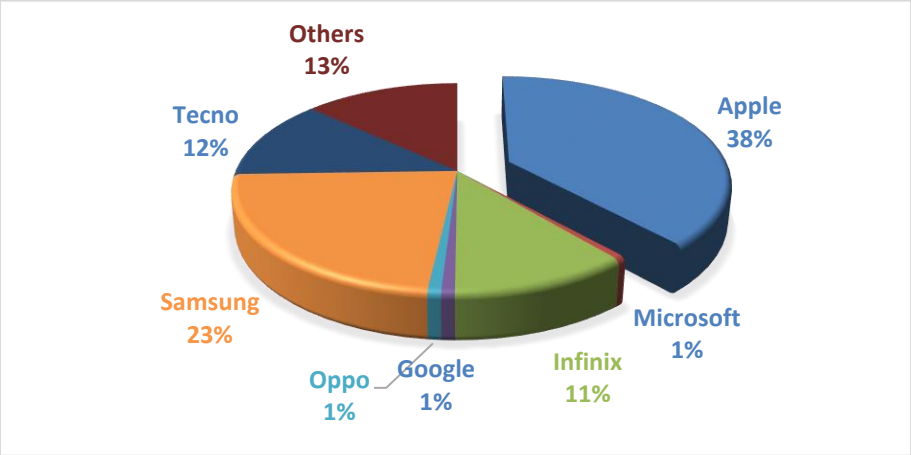

Chart 1: Brand of Smartphone.

Based on age categorisation, 20 – 29 years olds were in the majority (50.4%), followed by respondents whose ages were between 30 – 39 years (38.4%). Further results from the survey showed that 51.5% of the respondents are employed, 24.4% are self-employed, and 21% are Nigerian students. The results revealed that representing 52% of respondents claim they do not know what VAs are, while 33.6% use VA on their smartphones. Results revealed a low level of awareness about VAs among the respondents. The study also revealed that 52.9% of the respondents are familiar with Google Assistant, while 33.3% are familiar with Apple Siri. Therefore, this data clarifies that the respondents may be unaware of the term virtual assistant, but most have heard of the branded VAs.

Table 1: Use Cases for Virtual Assistants by Nigerian Smartphone Users.

Functions	Percentage Distribution
Phone Calls	37.4
Exercising	7.8
Messaging	25.1
Social Networking	23.7
Shopping	10
Navigating with maps	40.2
Banking	9.6
Entertainment	34.2

Emailing	15.1
Others	23

A majority (52%) of the respondents claim they rarely use virtual assistants; 32.5% use VAs a few times weekly, while 11.5% of the respondents use VAs many times daily. Furthermore, map navigation has the highest variable, with 40.2%. Other responses are shown as VA usage for phone calls and entertainment, dominating with 37.4% and 34.2%, respectively. However, it is important to note that although virtual-assisted maps are speech-enabled, the VA is mostly the speaker while the user listens. To understand whether the VA understands when each respondent speaks, they responded to the said question, "My virtual assistant understands me when I speak," on a 5-point Likert scale. Also, 51.3% strongly agree, while 21.6% belong to the category of smartphone users that have never used VAs (strongly disagree).

Cross-tabulating the relationship between gender and VA understanding, 126 males strongly agreed that VAs understand them when they speak. This adds up to 58% and 42%, respectively. The association between gender and human-machine interaction is explained and analysed using chi-square distribution. Results showed that the null hypothesis is rejected at p-value (0.000) < 0.05 (5% significance level), as well as the effect of the likelihood ratio showing the p-value = 0.000, which is less than 0.05 (5% significance level). This indicates an association between gender and VA's understanding of human speech. Based on this premise, gender could be said to determine the efficacy of human-machine interaction in this study.

Results from In-Depth Interviews

The in-depth interviews were conducted via telephone conversations with smartphone users in Lagos, Nigeria. This was important to get a deeper insight into VA function and experience, particularly to respond to the second and third research questions. Audio recordings of all the discussions were transcribed by the researcher using Microsoft Word and subsequently uploaded to Nvivo for further coding and analysis. The coding process resulted in several themes (nodes) and sub-themes, with the respondents, referred to with numbered pseudonyms.

While interacting with the respondents on their knowledge of virtual assistants, they were unaware of the term. However, on giving examples, the analysed responses showed that most were mindful of Siri and Google Assistant, as shown in Figure 1. A respondent stated:

> "I did not know it is called Virtual Assistant. I only know it as Siri…" (Respondent 1, personal conversation).

Figure 1: Types of virtual assistants known by respondents

Regarding the personal experience with VA usage and the resultant effect on communication. The themes highlighted were the most frequent, as the respondents explained by giving examples.

> "Basically, with a virtual assistant, especially Siri, it's good. It's been quite helpful, quite easy, it's been fun. You just click your phone and say Siri play me particular music, and it does that instantly." (Respondent 2, personal conversation).

Figure 2. Experience using Virtual Assistants

The thematic analysis also mapped some negative nodes that highlighted the challenges faced by the respondents. Many mentioned accents and internet access as limitations to receiving optimal satisfaction from VAs, as seen in Figure 2 and the excerpt below.

> "I'll say language barrier. Sometimes Siri doesn't understand my accent. So, I have to repeat myself or speak slowly." (Respondent 4, personal conversation).

Discussion of Findings
What is the current level of usage for AI-enabled virtual assistants by smartphone users in Lagos?

To assess the extent of VA usage, the question sought to examine the familiarity with VAs, the level of use, the exposure of respondents to the VA types, and the purposes for which VAs can simplify daily human lives. The findings show that the Nigerian respondents use voice-enabled VAs for maps, entertainment, and phone communication. However, the level of VA usage has yet to be widespread. Also, most of these Nigerian respondents are not quite aware that Siri, Google Assistant and Alexa are called virtual assistants.

The responses given by the respondents showed that although 100% of respondents were smartphone users, just 33.6% of these respondents were aware of and utilised VA on their smartphones. About 51% initially claimed they do not use VAs; however, the same respondents showed familiarity with specific VA brands by name. The most known VA was Google Cortana, at 52.9%, while 33.3% had heard of Apple's Siri. Further questions to test the usage and repeat usage of VAs by Nigerian smartphone users showed that 52.4% of the respondents rarely use VAs. Only 32.5% said that they use VAs a few times a week, while 11.5% claimed to use VAs many times daily. This means that most of the respondents do not use VA; even when they do, VAs have not wholly taken over as the main mediator of their daily communication efforts.

However, 45% of the respondents use VAs to satisfy various conditions, including map navigation, phone calls at 37.4%, and entertainment at 34.2%. The responses align with the uses and gratifications theory by Katz and Blumler (1974), which depicts media audiences as dynamic consumers who use specific media to gratify particular needs. These results show that these Nigerian smartphone users utilise this digital media tool to gratify their navigation, communication, networking, entertainment, banking and shopping needs.

Besides, digital literacy could also be responsible for the low frequency of VA usage. This is corroborated by Doumbouya et al. (2021), who state that those most in need of voice-enabled VA technology are often the most underserved. Findings from the in-depth interviews also fingered poor internet services as a challenge to frequent VA usage.

What are the experiences of smartphone users in Lagos when using AI-enabled virtual assistants?

This research question sought to measure the experience and effectiveness of VAs for smartphone users in Lagos by determining the level of media richness of VA as an effectual communications mechanism. This analysis is rooted in the media richness theory proposed by Daft and Lengel (1983), which posits that media has diverse richness intensities determined by the medium's capacity to accept equivocality and uncertainty. The criteria for judging richness include "the multiplicity of cues, the immediacy of feedback, personal focus, natural language, equivocality and uncertainty". The survey and interview results show data based on the VA's understanding of the user's speech, the user's understanding of the VAs speech and the satisfaction derived from VA usage.

The results show that 51.3% strongly agree that VAs comprehend human commands, while 51% agree that they understand their VAs when it speaks to them. Also, as regards the satisfaction derived from VA usage by the respondents, 52.9% indicated that they are satisfied. A cross-tabulation between gender and human-machine interaction shows that gender can be considered a determinant of richness for human-machine interaction, and results show that a larger percentage of men experience satisfactory VA usage than women.

Furthermore, thematic findings from the in-depth interviews augment the quantitative data on the richness of VA for message mediation based on the criteria of the multiplicity of cues, immediacy of feedback, and natural language. Participant Eight said,

"I use just my Google Assistant on my Android, and it's quite easy to use. All I need to do is just call it up, Hi Google, for example, and it responds by saying Hey Ada, or Hi, What's up? It's quick to respond. I'd say language intonation is a challenge. You need to choose your words carefully while talking to your Google Assistant; you need to talk slowly so that your Google Assistant will understand you." (Respondent 3, personal conversation). This respondent's quote represents personal satisfaction and richness based on the immediacy of feedback. Conversely, it also represents challenging experiences in the domain of natural language based on the user's accent. The VAs are mainly designed for native English speakers with particular accents; as such, they do not adequately capture commands given by persons speaking English with different accents. Based on the results, the experiences of Lagos VA users will be enhanced when African and Nigerian accents and dialects are integrated into future VA software updates.

What are the perceived benefits and limitations of using AI-enabled virtual assistants among smartphone users in Lagos?

The role of human actors has become more dynamic as communication agents in the digital ecosystem (Naik and Kim, 2010). It is reasonable to assume that the characteristics and capabilities of technologies will also alternate with human actions, influencing new processes in communities.

The results reveal that an average Nigerian smartphone user benefits from VAs in multiple ways. Quantitative findings show that the most common functionalities that respondents use VAs for are maps (40.2%) and phone calls (37.4%). Other pervasive functions include entertainment (34.2%), messaging (25.1%), social networking (23.7%), shopping (10%) and banking (9.6%). From the qualitative studies, a respondent stated, "I'll like for Google Assistant to be able to do more things like book an Uber, but I use

it to book appointments…Asides from music and Google map, it doesn't respond to commands within an app like Instagram". (Respondent 5, personal statement).

There are several uses and gratifications that emanate from the data. For example, the clear majority use VA to locate houses, offices, restaurants, churches/mosques and other public locations in communities across Nigeria. The data gathered on respondents' experience using VA show that most Nigerian smartphone users find suitable, dynamic and satisfactory gratification from using voice-enabled virtual assistants. This is in line with Verto Analytics (2017), cited in Rawassizadeh et al. (2019), which stated that VAs are fast becoming integrated into users' everyday lives in Asia. Similarly, the respondents can open their music applications, interact with others by sending text messages, call others and even open certain documents through a voice command. However, the findings also clearly show the gaps that exist and limit the optimal usage of VA. For Nigerian smartphone users to achieve optimal and functional gratification, upgraded features and localisation need to be entrenched considering the cultural contexts in the society.

Conclusion

This study examined the usage, experiences, perceived benefits and limitations of AI-enabled virtual assistants among smartphone users in Lagos. The findings revealed that while smartphone usage is widespread, the level of VA usage is not yet widespread. The most popular VAs among the respondents were Google Cortana and Apple Siri, mainly used for navigation, communication, networking, entertainment, banking and shopping needs.

The study also found that the level of satisfaction derived from VA usage was relatively high, although there were challenges with language intonation and natural language processing. The experiences of Lagos VA users will be enhanced when African and Nigerian accents and dialects are integrated into future VA software updates. Overall, the benefits of VAs for Nigerian smartphone users were identified as convenience, time-saving, and accessibility. The limitations included language barriers, poor internet services, and accuracy and natural language processing issues. To fully realise the potential of VAs in Nigeria, it is important to address these limitations and improve digital literacy, internet infrastructure, and the development of VA software tailored to local accents and dialects.

Recommendations

The study has provided insights into the voice-enabled virtual assistants used by Nigerians. Based on the data, the following recommendations are suggested.

Virtual assistants should be designed to accommodate a range of users with different abilities and disabilities. It's important to ensure that virtual assistants are accessible to everyone, regardless of their individual needs. Also, one of the main challenges of virtual assistants is accurately understanding natural language. Companies and academia should continue to invest in natural language processing technologies to improve the accuracy of virtual assistants' responses to user queries.

Furthermore, virtual assistants should be designed to learn and improve over time. Companies should leverage machine learning algorithms to continually improve the performance of virtual assistants. On improvement, service providers in Lagos will be enabled to incorporate voice-activated virtual assistants into customer service: As virtual assistants become more advanced and intelligent, they can serve as valuable addition to customer service teams. Software companies should also explore integrating virtual assistants into their customer service processes to provide more efficient and personalised customer support in multiple languages. Notably, virtual assistants collect a significant amount of personal data.

The creators of these digital tools should be transparent about their data collection practices and ensure that user privacy is protected at all times.

Finally, this study only employed a small sample size in Lagos that does not reflect the complete Nigerian identity. Future studies should consider using a larger sample size and even a comprehensive set of variables to better understand the usage, benefits and experience of VAs across Nigeria as the world continues to move into the fourth industrial revolution.

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