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RESEARCH ARTICLE

Intelligent Attributes of Voice Assistants and User's Love for AI: A SEM-Based Study

DEBAJYOTI PAL[1], MOHAMMAD DAWOOD BABAKERKHELL[2], BORWORN PAPASRATORN[3], (Senior Member, IEEE), AND SUREE FUNILKUL[3]

[1]Innovative Cognitive Computing Research Center, King Mongkut's University of Technology, Bangkok 10140, Thailand
[2]Department of Information Technology, Shaikh Zayed University (Khost), Khost 2501, Afghanistan
[3]School of Information Technology, King Mongkut's University of Technology Thonburi, Bangkok 10140, Thailand

Corresponding authors: Mohammad Dawood Babakerkhell (dawood.csf@gmail.com) and Debajyoti Pal (debajyoti.pal@mail.kmutt.ac.th)

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ABSTRACT Adoption of Voice Assistants (VA) has been a hot topic of research currently. However, the existing studies are based on traditional models like the Technology Acceptance Model that is less suitable for investigating adoption of AI-based technologies like VAs. This is because the conventional models do not consider the anthropomorphic nature of AI-based technologies that has the potential to form emotional bonds between man and machines. Therefore, in this work we propose artificial autonomy as an intelligent AI—based attribute founded on three task primitives of sensing, thinking, and action autonomy. Further, we use the concept of interpersonal love and apply it in the context of human-AI relationship based on Sternberg's Triangular Theory of love. Data is collected from 607 participants across two Asian countries. Partial Least Squares (PLS) based Structural Equation Modelling (SEM) has been used for the purpose of model building and testing. The results highlight the importance of artificial autonomy on all the three aspects of love, indicating the presence of consummate love. ''*Love for AI*'' is different from ''*brand love*'' since in the later case some of the love aspects of passion, intimacy, and commitment are missing. Theoretically, this study improves our understanding of artificial autonomy as an intelligent AI-attribute and the perceptions of love in Information Systems research. The findings can help technology companies develop novel strategies for improving the human-likeliness of these VAs.

INDEX TERMS AI, artificial autonomy, love theory, personalization, voice assistant.

I. INTRODUCTION

In the past few years, the growth in artificial intelligence (AI) powered services has been on the rise, and conversational agents are a typical representation of it. Conversational agents or voice assistants (VA) refer to AI-based software programs that emulate text and voice-based conversations through Natural Language Processing (NLP). These are able to strike human-like conversation with the users, offer various types of information, and perform a variety of actions. VAs work on computers, mobile phones, and are even available as standalone devices, e.g., smart speakers. *Siri* from Apple, *Alexa* from Amazon, *Google Assistant* from Google, *Cortana* from Microsoft, and *Bixby* from Samsung are some well-known commercially available VAs currently available in the market. In order to promote the application and diffusion of AI technologies in the society, it is important to understand people's usage of these agents.

Being powered by AI, VAs possess intelligent attributes that help providing several unique benefits for the consumers. In terms of intelligence, being autonomous is an important aspect through which the VAs can understand the needs of

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its consumers, and then perform the daily activities for the consumers based on their preferences [1]. The autonomy features are made possible due to the capability of the VAs to sense, think, and monitor in an autonomous fashion when executing tasks such as collecting different types of data from IoT devices, using self-learning to support decisions based on user's preference and habit, or even activating various functions on other devices and applications. Thus, autonomy helps in making the VAs intelligent that allows them to interact naturally and in a more human-like manner with the users based on their preferences [2]. Such intelligent attributes may lead to better user experiences, which in turn may help develop relations of love between man and machines.

Previous research has investigated AI-based technologies from a Computers are Social Actors (CASA) paradigm to look into the various social aspects of technologies that includes voice, embodiment, information, and personality [3], [4]. However, little academic research has been done in the aspect of artificial autonomy as the intelligent attribute of VAs, and what consequences it has on the human-machine relationship. One possible reason for having such a few number of studies might be because the previous IT artifacts were not as smart and intelligent like the current AI-based artifacts (e.g., VAs), due to which the previous IT systems were examples of partial autonomy, whereas the AI-based systems are fully autonomous [5]. Since the purpose of the VAs is to provide assistance in various day-to-day activities of the users, it is important to understand that how an intelligent attribute like artificial autonomy fosters the perception of these agents being perceived as humanlike and helps in the formation of a loving man-machine relationship. However, the problem is although intelligent attribute like artificial autonomy has its own advantages, yet a high level of this feature may create negative perceptions and experiences with its users [6], [7]. Likewise, VAs with high autonomy have been found to be giving active advertisement notifications to the users, which is not good for long term commitment as users perceive this to be intrusive [2]. Given the advantages and concerns with the intelligent attributes, research in this field should broaden our understanding of how these affect the anthropomorphic nature of this technology.

Since AI-based technologies like VAs try to simulate the human conversational patterns, therefore they are anthropomorphized having human-like features that has been extensively reported in previous literatures [8], [9]. However, to better understand that how the intelligent features of VAs affect the adoption scenario. like artificial autonomy, it is necessary to explore it in greater depth from this angle. There are some theories like the Sternberg's Triangular Theory of Love (STT) that has been used to explain inter-personal relationships [10]. According to this theory love formation can happen due to the presence of passion, intimacy, and commitment. Information Systems (IS) researchers have investigated the commitment aspect, and it has been found that when users are committed to use a technology, it leads to its sustained usage [11]. Likewise, marketing studies have revealed that consumers may develop intimacy and passion for specific brands, as they would with another person, and this perception is different from commitment [12]. For VAs, which are highly anthropomorphized due to the presence of intelligence features, it is likely that the users will generate emotional connections and feelings for them. However, it is not clear that whether and how intimacy and passion can be formed between the users and these agents. In this work, based on the theory of love, we explore how love can be formed between man and these intelligent agents, focusing specifically on the aspects of passion and intimacy, and their relationship with commitment and effects on usage.

Through this work we make a number of contributions in AI research through the love perspective. First, we directly respond to repeated calls made by current IS researchers in [13], [14], with regards to the investigation of AI-based technologies and applications from new theoretical perspectives. Instead of focusing on traditional IT adoption factors like ease of use, usefulness, enjoyment, and trust, in this work we demonstrate the role and effect that the intelligent feature of VAs like artificial autonomy has in developing feelings of love for the VAs. Particularly, we inspect the love components of passion, intimacy, and commitment to explore the adoption scenario. Second, we investigate the novel AI-based artifact of artificial autonomy as an intelligence feature of the VA, and how it affects the love formation between humans and VAs. We identify three distinct types of artificial autonomy: sensing, thought, and action in terms of three task primitives. Such artificial autonomy enhances the love feelings, and to further promote the usage of AI-based applications, both cognitive and affective computing technologies must be applied during the designing and development of the applications, since these may directly enhance the users experience by invoking feelings of love. Our results contribute in a meaningful manner to bridge the knowledge gap in the field of "*love for AI*" by considering its intelligent attributes.

II. LITERATURE REVIEW

A. ARTIFICIAL AUTONOMY AS AN AI ATTRIBUTE

Artificial autonomy can be defined "*as the extent to which a product can operate by itself, in a goal-oriented manner without any interference from the users*" [15]. It is distinct from human autonomy, since it is incorporated into the machines by engineers through technology and is supposed to mimic human intelligence and decision-making capabilities. Moreover, artificial autonomy is a typical attribute that distinguishes intelligent products from non-intelligent products [16], [17]. Typically, non-AI based products are non-intelligent and they rely on prefixed logical rules and algorithms to perform pre-defined tasks and obtain the output. Therefore, non-intelligent products or services are examples of non-autonomous or semi-autonomous systems [18]. On the contrary, intelligent products are fully autonomous systems and they have cognitive capabilities like self-learning by which they can learn continuously and change their behavior

over a period of time based on the input and preferences of the users [19]. Typically, these devices have the capability to perceive and analyze the user's intentions and emotions, and accordingly perform the daily tasks based on the user's preferences. For e.g., in case of a smart-home system, the VAs can collect and recognize various forms of IoT data that are aggregated from the sensors, and then learn autonomously from such patterns for supporting decision making based on the user's preferences. In this respect it is important to note that artificial autonomy is not dichotomous, rather it varies along a continuum from no autonomy to full autonomy [20]. Consequently, artificial autonomy may create perceptions of human likeliness, making these AI-based devices to have anthropomorphic capabilities.

Previous research in the IS and Human Computer Interaction (HCI) domain have investigated a wide range of AI-based features that may lead to anthropomorphism, e.g., voice [21], personality [22], embodiment [23], interactivity [24], and socialization [25]. However, the important and extremely relevant aspect of artificial autonomy has been neglected in terms of its anthropomorphic capabilities. At the same time several researchers have raised concerns against this concept of artificial autonomy, particularly related to ethical issues [26], [27], its role in technology [5], and human-autonomy teaming [28]. Certain studies even suggest that artificial autonomy helps in fostering man-machine relationship only to a certain extent, and beyond a threshold it can invoke feelings of eeriness and discomfort [6], [29].

From the above discussion it becomes clear that artificial autonomy is an important and core aspect of the AI-based conversational agents. Still, its usage as an IT artifact by the current adoption models is rare. Moreover, artificial autonomy may create both positive and negative perceptions in the user's mind, which depends to the extent it has been implemented in a particular application scenario. In this work we fill in these research gaps by exploring whether perceptions of artificial autonomy help to create a bonding of love between the users and the VAs, together with the continuance usage. Since the perception of artificial autonomy offered by the current generation VAs may vary across different users, we define artificial autonomy from the user's perspective as "*the degree to which the user's feel that the VAs can independently complete the tasks that are assigned to them without the need of any human intervention*".

B. THE CONCEPT OF LOVE

The theory of love originated from Sternberg [30], and has been accepted by several researchers due to its generalizability and good psychometric properties [31]. Researchers have validated the STT theory to measure the different components of love (passion, intimacy, and commitment) for different types of loving relationships, e.g., love for parents, siblings, friends, or lover/spouse. Figure 1 presents the triangular concept of love as proposed by Sternberg, which shows the presence of four distinct types of love: romantic

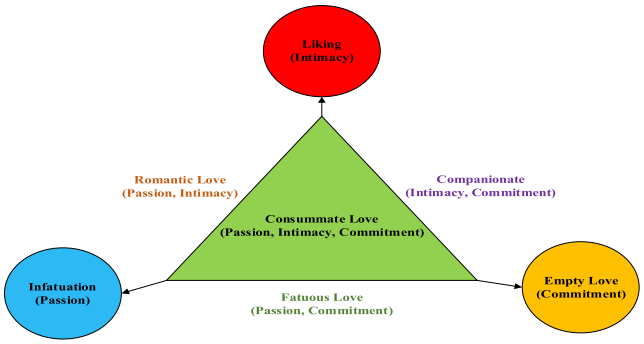

FIGURE 1. The different aspects of love [30].

(passion + intimacy), companionate (intimacy + commitment), fatuous (passion + commitment), and consummate (passion + intimacy + commitment). Passion is developed from the emotional and motivational attachment between individuals. Intimacy refers to the feelings of closeness and connectedness.Commitment reflects the willingness to sustain the loving relationship for long term in the future.

In addition to the inter-personal contexts as mentioned above STT theory has also been implemented while explaining relationships between humans and objects. For e.g., the concept of love has been used in the field of marketing for addressing the consumer's love for products and brands [12], [32]. Some studies as in [33] and [34] consider that the love for non-human entities like brands can be analogously represented by the inherent inter-personal relationships of passion, intimacy, and commitment, which happens when individuals find a product to be attractive that leads to an intense desire to consume it and develop a long-term relationship. However, there is a second line of research as in [12], [34], and [35] that argues that human-object relationships cannot be modelled on the basis of inter-personal relationships since the former are usually less frequent, and often only limited to an unique transaction, which are not personalized and interactive due to which the essence of human love and attachment is missing. With regards to the antecedents of brand love as outlined above, previous studies have concluded brand experience, utilitarian values, hedonic values, and brand image to affect the relationship [12], [33], [35].

Apart from the concept of brand love, research that deals with love for technology (IT in specific) is rather scarce. Some of the works approach the concept of love in terms of attachment theories that deal with the affectionate bonds people may develop with technology. For e.g., authors in [36] proposed a framework based on attachment theory to explore how people perceive the intimacy of different media and their preferred methods of communication with romantic partners. Similarly, the concept of attachment has been used by authors in [37] to examine the association between texting and romantic relationship satisfaction. Another line of research that considers love for technology employs the traditional HCI techniques, for e.g., they test the different forms of love (affect, liking, attachment, etc.), and try to determine their main antecedents and consequences. For e.g., based

on affect theory authors in [38] examine how emotional attachment leads to patient's satisfaction with mobile health-monitoring services. Likewise, loyalty of elderly people to social networking sites is affected by interpersonal and group attachment [39].

C. LOVE FOR AI: THE RESEARCH GAP

From the literature review presented above, three research gaps are evident. First, the importance of artificial autonomy as an intelligent attribute of the VAs has been neglected by current research. The primary goal of any AI-based product is to achieve artificial autonomy that tries to mimic the different aspects of human autonomy. In doing so the technology becomes intelligent, which is one crucial difference between AI-based technology and traditional IT technology. One possible reason for the under-representation of AI-based artifacts maybe because the IT artifacts considered by current research are not as smart as the AI artifacts, due to which they could be treated as "*relative automation*", and not as autonomous actors [5]. However, with technological advancements made possible due to AI, ML and NLP-based approaches, VAs can be regarded as intelligent products that are autonomous. Hence, this issue cannot be neglected as it forms an important factor in explaining the adoption of AI-based systems.

Second, VAs being smart and intelligent have anthropomorphic capabilities that current research has acknowledged. However, what is not known is the consumer's love formation with these smart devices as a consequence of interactions with them that stems from their intelligent attribute like artificial autonomy. While the concept of "*brand love*" do exists, however, it considers technology as a mere tool, and ignores the feelings consumers might develop with technology. Likewise, although current works have researched on the attachment aspect with traditional IT technologies, however, such findings will be incorrect to be extended to smart technologies because the later provide a more sophisticated AI-based platform that make them unique. In fact, there have been calls from HCI and IS researchers alike to explore adoption of AI-based technologies from newer theoretical perspectives [13], [14].

Third, the love aspect that is formed between the users and VAs has not been examined holistically by the current works. Currently, researchers have taken it for granted that love is distinctly explored via singular proxies such as liking [40], attachment [38], satisfaction [41], or passion [42]. Therefore, there is no uniform consensus as to what is "*love for AI*", and what can be its antecedents and consequences. Therefore, in this respect dedicated theories explaining loving relationships like the STT theory becomes important and might serve as the basis for exploring the adoption of AI-based smart products through a newer theoretical lens.

III. HYPOTHESES DEVELOPMENT

In this study we have classified artificial autonomy into three types: sensing, thought, and action based upon our understanding of current literatures. Further, drawing on the STT theory of love, we examine how the perceptions of autonomy affect the three components of love (passion, intimacy, and commitment), which in turn may affect the users' continuance usage intention of the VAs. Figure 2 summarizes the theoretical model that we propose in this study.

A. THE THREE TYPES OF ARTIFICIAL AUTONOMY

The definition of artificial autonomy that we presented before in the literature review section clearly indicates that this intelligent attribute depends on the nature of the task performed. For e.g., the extent of artificial autonomy provided by a VA while entertaining the users might be different from a scenario that involves some productive tasks. In fact, the user experience provided by the VAs is known to vary depending on the task type. Such variations have been captured by current works [43], [44]. However, no matter how simple or complex a task might be, it can always be decomposed into three basic primitives as per the Sense-Think-Act (STA) paradigm [45]. Each of these task primitives can act as an independent AI-based artifact that do not need any human intervention, which has been demonstrated in the context of human-robot interaction [20].

The STA paradigm further proposes three levels of autonomy (low, medium, and high) for each of the three task primitives. However, since our objective in this work is to explore how artificial autonomy by itself is capable of providing the needed intelligence features to a VA at a macro level that is responsible for evoking loving relationships, hence we ignore the different autonomy levels. For the present research scope, sensing autonomy results from the VAs capability to see, listen, and feel the different things happening around it. This is possible due to the presence of various sensors, cameras, and microphones on these devices that the VAs can control by themselves depending on the needs while interacting with the users. Thinking autonomy emerges from the VAs capability to formulate a plan when responding appropriately to the users' requests, either without or with very minimal human intervention. For e.g., the VAs can sense the user's mood, and intelligently create a plan to turn on/off their favourite playlists, or even change the lighting of the environment to suite the mood – all these highlighting the thoughtful nature of the VA. Action autonomy stems from the VAs ability to carry out the actual actions/tasks that it has planned previously, and independently being capable of controlling the entire process while performing the specific task or a series of tasks. Although these different autonomy types are more or less similar across VAs from multiple brands, however, the perception and experience obtained by the users may vary based on the demographics, the usage scenario, and the environment. Therefore, while referring to artificial autonomy we focus on the users' perspective.

B. ARTIFICIAL AUTONOMY AND LOVE

Drawing from the Sternberg theory of love [30], we already summarized the three aspects of passion, intimacy, and com-

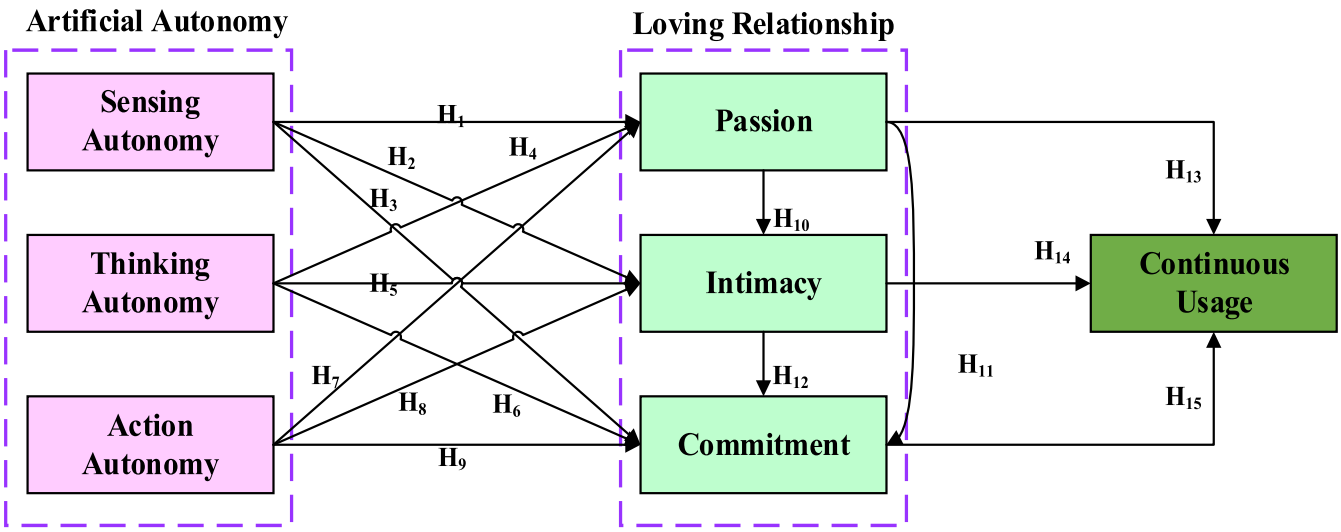

FIGURE 2. Artificial autonomy, love, and the proposed research model.

mitment in the previous section. Such aspects of love may arise from the intelligent features of the VA – artificial autonomy being one such primary factor. However, to the best of our knowledge there are no studies that test the direct relationship between VA autonomy and the developed love perceptions, which we propose next.

First, we theorize that artificial autonomy might contribute to the perception of love stemming from the users' interactions with the VAs and perceiving them to be intelligent, capable, and skillful [46]. The artificial autonomy possessed by the VAs is symbiotic by nature, meaning that VAs are interactive products that communicate not only with the users, but also other smart devices, such as lamps, IoT devices, domestic appliances, and many more to complete the proposed activities. At the same time, they are capable of adapting their responses by reacting to the environment and learning from new situations [47]. Since products having artificial autonomy are capable of independent operation, it saves a lot of time and effort of the users [18], [25], [48]. Furthermore, the VAs also conduct hedonic tasks (such as playing songs, cracking jokes, or reading story books) that can lead to emotional reactions [8], [49]. Therefore, it is safe to assume that such autonomy aspect of the VAs will give rise to smart experiences among the users. IS research indicates that smart experiences may result in generating greater anthropomorphic cues and attachment, thereby invoking feelings of love [50], [51].

Specifically with respect to sensing autonomy it supports the VAs ability to actively sense the various aspects of the environment by seeing, listening, or monitoring the status of the objects. Therefore, the VAs are constantly ready for the users' commands, and they actively monitor the different needs of the users whenever needed, together with detecting abnormal or any changes in conditions of the ambient environment. Sensing autonomy results in data collection about the environment by the VA that may include data from the users too, e.g., text recognition, voice recognition, recognizing objects, etc. For VAs, whenever users are involved, the interaction is mostly handsfree, i.e., through voice, which upon successful processing will lead to smart experiences by the users, perceiving them to be intelligent, skillful, and as human companions. Such intelligence, and companionship have been found to evoke emotional attachment and bonding, as well as feelings of closeness and connectedness between man and machines [17], [25], [50]. Sensing autonomy, therefore conveys a signal about the apparent concerns of the VAs for its users that will lead to the VAs being perceived as loving, caring, passionate, intimate, and committed. Therefore, we posit:

H_1: The users' perceptions of sensing autonomy will positively influence her/his passion for the VAs

H_2: The users' perceptions of sensing autonomy will positively influence her/his intimacy with the VAs

H_3: The users' perceptions of sensing autonomy will positively influence her/his commitment with the VAs

Thinking autonomy helps the VAs to evaluate important things and take decisions, for e.g., giving shopping, travel, or restaurant recommendations to the users based on their preferences. The suggestion provided the VAs is based on continuous self-learning as per the previous interactions. Hence, this type of autonomy provides clarity and wisdom to the VAs for future analysis and provide the users with even more optimal and personalized plans to meet their requirements. Thinking autonomy make the VAs to be perceived as more friendly, and that they care about the users' well-being. Hence, from the user's perspective since it helps in reducing their information redundancy or overload and create personalized offerings for them, thereby it makes the VAs suitable as life companions on which the users can trust and depend upon [52], [53], [54]. It becomes evident that thinking

autonomy helps in creating smart experiences for the users by generating positive feelings, likings, loyalty, and intentions to repeat interactions [55]. Hence, we hypothesize:

H_4: The users' perceptions of thinking autonomy will positively influence her/his passion for the VAs

H_5: The users' perceptions of thinking autonomy will positively influence her/his intimacy with the VAs

H_6: The users' perceptions of thinking autonomy will positively influence her/his commitment with the VAs

Action autonomy is concerned with the execution and implementation of the actions that affect the environment, and results in fewer manual user interventions. The goal of this type of autonomy is to enable the VAs to act as a proxy for its users by directly fulfilling the users' goals and purposes. Hence, it helps the VAs to take instructions in a hands-free manner and perform the desired tasks with little to no manual intervention [56]. Moreover, when the expectations with regards to the various task completions are met by the users, it will naturally help in generating positive smart experiences, and perceptions of friendliness and love from the users. When expectations are fulfilled, or even surpassed, it helps in creating deeper bonds that is representative of passion, intimacy, and commitment. Hence, we propose:

H_7: The users' perceptions of action autonomy will positively influence her/his passion for the VAs

H_8: The users' perceptions of action autonomy will positively influence her/his intimacy with the VAs

H_9: The users' perceptions of action autonomy will positively influence her/his commitment with the VAs

C. THE CENTRAL ASPECT OF LOVE

As outlined previously according to the STT theory of love; passion, intimacy, and commitment are the three core aspects. According to Sternberg, passion emerges from the motivational involvement of the partners involved [30]. It results in invoking sentimental associations in the individual that promote affectionate feelings [3], [35], [42]. Therefore, whenever an individual feels passion, the closeness and bondage with the other party increases, and it results in a strong attachment between the two [57], [58]. Hence, passion results in intimacy that is also confirmed by authors in [59].

Passion is also responsible for generating commitment. Commitment is an important aspect, especially in the highly competitive scenario of smart products where a lot of options are available, and the switching tendencies are high [60]. Research in love theory establishes that whenever an individual feels good about a product, or is excited about a brand, then she/he will try to have repeated transactions with the same and try to be committed by establishing a long-lasting relationship [33], [34], [50]. A perception of moral obligation is developed that leads to repeated purchase, and association with the particular brand. Therefore, in this study we assume that consumers passion for the VAs will drive their commitment towards these.

Intimacy is also an important aspect of love that is representative of a stable feeling in case of inter-personal relationships, and that may increase the commitment level [30], [59]. Intimacy starts with feelings of affection, care, attachment and trust, and with the passage of time it results in the creation of an indispensable relationship [50]. Therefore, if an individual has sense of intimacy, then there will be perceptions of commitment [61]. Current research on love has mainly focused on this intimacy aspect, using similar concepts of attachment. Thus, it becomes evident that all the three aspects of love are important in this scenario.

The artificial autonomy that we discussed previously as an intelligent attribute of the VAs make them different from traditional IT technologies, by imparting them with anthropomorphic capabilities. Anthropomorphism of any product can generate feelings of love [62]. Since these are AI-based autonomous devices, hence they are capable of communicating verbally (like humans) with the users, offer personalized services, and have advanced cognitive and emotional capabilities that inspires fascination, and lovable feelings for them in the user's mind. Consequently, in this work we take the three aspects of love as the central theme. However, unlike the other works on love theory that stresses on the intimacy aspect, in this work we consider passion to be the main activator of both intimacy and commitment. We feel that this is justified, since passion provides the primary motivation for the other sentiments that last for a prolonged time period [42], [50]. Thus, a passionate user of a VA will also show greater intimacy with it, and become committed towards it [59]. Based on the above discussion we propose:

H_{10}: The passion that users' feel for her/his VA positively influences her/his feelings of intimacy with it

H_{11}: The passion that users' feel for her/his VA positively influences her/his feelings of commitment to it

H_{12}: The intimacy that users' develop with her/his VA positively influences her/his feelings of commitment to it

We take continuous usage as the final dependent variable of this study. Continuous usage is closely related to actual usage and is evident from the high correlation between these two factors [63]. According to researchers in [64], investigating continuous usage is more important than actual usage because the latter refers to the past, whereas the former refers to the future and has long term implications. Likewise, more the users' use a particular technology, greater becomes their familiarity with it, and their intentions become more stable and comprehensible. Therefore, investigating continuous usage becomes very important as it helps to predict the future performance and the long-term sustainability of a technology. Consequently, in this work we explore what effect the three love components of passion, intimacy, and commitment have on the continuous usage of VAs. We hypothesize:

H_{13}: The passion that the users' have for her/his VA positively influences her/his continued usage of the VA

H_{14}: The intimacy users' feel for her/his VA positively influences her/his continued usage of the VA

TABLE 1. Sample demographics (N = 607).

Characteristic	Category	Frequency	Percentage (%)
Age (in years)	18 – 30	242	39.87
	31 - 40	207	34.10
	41 - 50	119	19.60
	Above 50	39	6.43
Gender	Male	341	56.18
	Female	266	43.82
Education level	High school or below	45	7.41
	Undergraduate degree	291	47.93
	Post graduate degree	255	42.01
	Others	16	2.65
Experience with VAs	Less than 6 months	110	18.12
	6 month – 1 year	162	26.69
	1 year – 2 years	247	40.69
	More than 2 years	88	14.50
Usage frequency of VAs	At least once a week	467	76.94
	At least once every 2 weeks	77	12.68
	At least once a month	51	8.40
	Less than once a month	12	1.98
Type of VA	Google Home	145	23.89
	Amazon Alexa	186	30.64
	Apple Siri	139	22.90
	Samsung Bixby	76	12.52
	Microsoft Cortana	58	9.55
	Others	3	0.50

H_{15}: The commitment users' have for her/his VA positively influences her/his continued usage of the VA

IV. METHODOLOGY

For testing the research model, we followed a quantitative approach by collecting data from regular VA users. An online survey was conducted via Google Forms targeting VA users of two Asian countries: India and Thailand. We used a mixture of convenience and snowball sampling strategies distributing the survey to all the known contacts of the authors, which was further shared in the relevant social media channels of Facebook, Twitter, and LinkedIn groups. Since VAs have been found to be useful for people belonging to wide demographics, including students, middle aged people, as well as the elderly, therefore while distributing the survey we did not have any specific target group in mind, rather the objective was to gather data from a wide demographic of VA users. In order to ensure that the respondents were experienced VA users, we used the following screening question: "*Do you have experience using VAs*"? Those who responded "*no*" to the screening question were eliminated from the survey. For the remaining respondent's further questions were asked related to their VA usage: "*Which VA do you use the most?, How long have you been using a VA?, In what scenario do you often use VA?*". This was followed by general demographic questions and items related to the different factors of the proposed research model. The overall sample demographics is presented in Table 1. The survey was conducted for a period of 2 months spanning January and February of 2023. A total of 651 responses were obtained, out of which 44 were eliminated because of missing values, or answering in a specific pattern. This gave us a total of 607 valid final responses.

In order to ensure measurement validity; all the items used in this study were adapted from previous research and modified wherever necessary to align to the present research context. All the three aspects of artificial autonomy were assessed based on previously used items in [18] and [24]. The love components of passion, intimacy, and commitment were adapted from [50] and [65]. All the items were measured on a 7-point Likert scale rating ranging from 1 (strongly disagree) to 7 (strongly agree). Although we re-used items from previous research, yet to ensure quality we followed a three-step procedure. In the first step, a 5-member team was consulted (2 professors having more than 10 years teaching experience in HCI, 2 professors having more than 10 years teaching experience in Information Systems, and 1 PhD student working in the area of technology adoption) to check if all the questionnaire items were concise and comprehensible. In the second step, after modifying some of the items based on the suggestions, we conducted a pre-test with a small sample size of (n = 20), and further refined the wordings of some of the items based on the participants' feedback. Table 2 presents the final items used in this study.

Since any type of self-reported data can be associated with Common Method Bias (CMB), it becomes important to check for the presence of CMB. We used several statistical analyses to check for this issue. First, a Harman's Single Factor test was conducted in SPSS that examines whether the correlation among the variables is significantly influenced by their common measurement source [66]. The results revealed that there were more than one factor with eigenvalues greater than 1.0, but the first factor accounted for only 24.61% of the

TABLE 2. Measurement items used in the study.

Factor	Item	Mean	Std Dev
Sensing autonomy (SA)	My VA can autonomously be aware of the state of its surrounding environment My VA can autonomously recognize information about the state of its surrounding environment My VA can independently recognize the different objects in the surrounding environment without my help My VA can independently monitor the status of the objects present in the surrounding environment	5.51	1.22
Thinking autonomy (TA)	My VA can autonomously provide me with the choice of what to do My VA can independently recommend the implementation plan to me of the assigned matters My VA can independently provide me with recommendations for action plans for assigned matters My VA can autonomously suggest what can be done in relation to specific queries	5.36	1.29
Action autonomy (AA)	My VA can take decision by itself and independently complete the tasks assigned to it My VA can determine itself how its conducts tasks My VA can autonomously perform the operation of the skill My VA can carry out the operation of skills autonomously	5.61	1.14
Passion (PA)	I am very passionate about my VA I cannot imagine my life without my VA My relationship with my VA is very important I find my VA very attractive, and it really fascinates me I feel great happiness when I use my VA	5.30	1.26
Intimacy (IN)	I feel emotionally close to my VA I have the help of my VA in moments of need I have an intimate relationship with my VA Most of the time I feel very close to my VA	4.27	1.04
Commitment (CM)	I am committed to maintaining my relationship with my VA I would rather be with my VA than with anyone else I have confidence in the stability of my relationship with my VA I consider the relationship with my VA as a thought-out decision	5.76	1.09
Continuous usage (CU)	I will continue using this VA I will use this VA for a long time I will continue using this VA to solve my problems	5.82	1.14

TABLE 3. Measurement model.

Factor	Cronbach's Alpha (α)	Composite Reliability	Average Variance Extracted
Sensing autonomy	0.92	0.92	0.75
Thinking autonomy	0.93	0.93	0.74
Action autonomy	0.89	0.93	0.78
Passion	0.93	0.90	0.76
Intimacy	0.90	0.88	0.72
Commitment	0.87	0.84	0.64
Continuous usage	0.88	0.89	0.68

total variance. This indicates that CMB is not of significant concern in this study. Second, we further tested for CMB by following a marker variable approach, as suggested by authors in [67]. We selected a variable having the lowest degree of correlation with the variables in the study – gender as a label variable and added it to the structural equation model for assessment. The results show that the significance of the predicted paths remains the same, indicating that CMB is not a problem for the present case.

V. RESULTS

We analyzed the results using Partial Least Squares (PLS) method of Structural Equation Modelling (SEM). We chose to use PLS over other similar methods like Linear Structural Relations (LISREL) because in this study we investigate the exploratory relationships of love with AI, such exploratory research being best analyzed by PLS-based methods [68]. Additionally, since PLS uses a component-based approach for the different estimation purposes, it places minimal restrictions on sample size, requirements for data normality, and residual distributions. Also, when compared to covariance-based approaches like CB-SEM, PLS is free from model identification issues [69]. We followed the standard two-step approach in which the measurement model is evaluated first, followed by the structural model [70].

A. MEASUREMENT MODEL

First, we tested the measurement model in terms of the different reliability and validity measures. Reliability is assessed by investigating the Cronbach's α values (internal consistency), and the Composite Reliability (CR). With regards to validity, we evaluate two types: convergent validity, and discriminant validity.

Table 3 presents the results of the measurement model. The Cronbach's α and CR values for all the factors are above the threshold value of 0.70 [71], indicating sufficient reliability of the measurement model. With respect to the

TABLE 4. Correlation matrix and discriminant validity.

Factors	SA	TA	AA	PA	IN	CM	CU
Sensing autonomy	**0.866**						
Thinking autonomy	0.198	**0.860**					
Action autonomy	0.161	0.276	**0.883**				
Passion	0.264	0.287	0.256	**0.872**			
Intimacy	0.245	0.196	0.229	0.537	**0.848**		
Commitment	0.302	0.241	0.250	0.602	0.516	**0.800**	
Continuous usage	0.209	0.198	0.214	0.554	0.492	0.436	**0.825**

TABLE 5. Htmt ratio of correlations.

Factors	SA	TA	AA	PA	IN	CM	CU
Sensing autonomy							
Thinking autonomy	0.198						
Action autonomy	0.161	0.376					
Passion	0.264	0.287	0.356				
Intimacy	0.245	0.196	0.339	0.538			
Commitment	0.302	0.341	0.250	0.612	0.517		
Continuous usage	0.209	0.298	0.214	0.554	0.494	0.436	

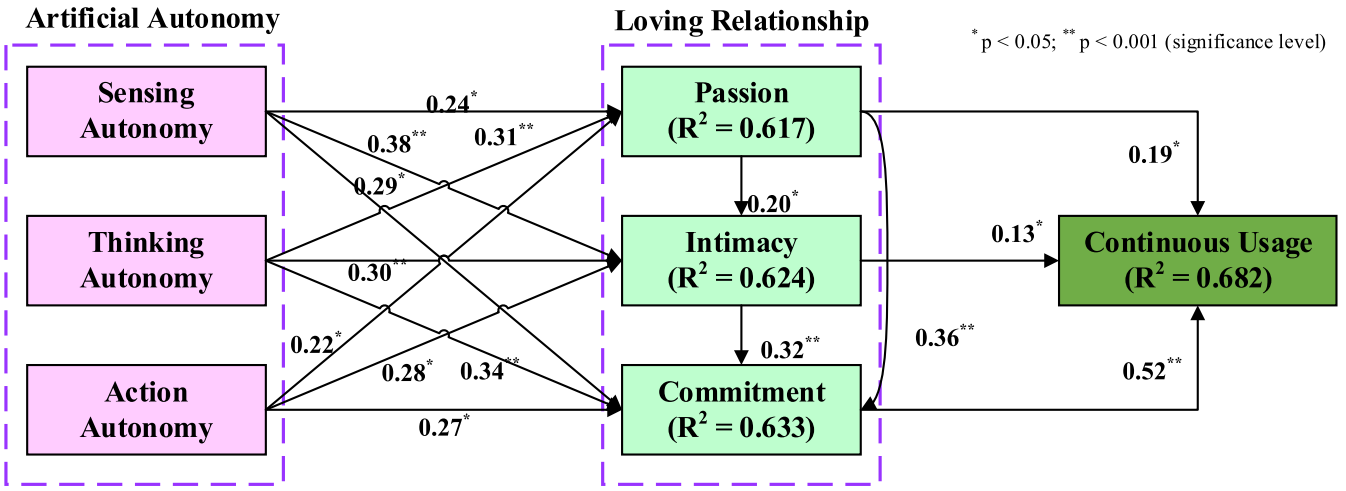

FIGURE 3. Results of the structural model.

convergent validity two conditions must be satisfied: the CR values must be greater than 0.70, and the AVE values must be greater than 0.50 [71]. Both the requirements are satisfied (Table 3), hence convergent validity is passed. For evaluating the discriminant validity, the square-root of AVE of each factor is compared with its correlation coefficients with the other factors. The discriminant validity is satisfied if the square-root of AVE of each latent factor is greater than its highest correlation with any other factors (Fornell Larcker criterion). Table 4 presents the inter-factor correlation matrix, and the square-root of AVE values (diagonal elements), which shows sufficient discriminant validity for all the factors. Due to the recent criticisms to Fornell Larcker criterion [68], as a second check we assessed the values of the Heterotrait-Monotrait (HTMT) ratio of correlations (Table 5). The values of the HTMT do not exceed the recommended threshold of 0.90 [72], thereby indicating good discriminant validity.

B. STRUCTURAL MODEL

The structural model was evaluated in SmartPLS 3.0. We evaluated the structural model by doing a bootstrap analysis considering 5,000 resamples [72]. The Goodness of Fit (GoF) was assessed through the score of the Standardized Root Mean Square Residual (SRMR) value. We obtained a SRMR value of 0.64 that is below the threshold value of 0.80 [72], hence suggesting a good model fit. Table 6 presents the results of hypothesis testing. The proposed research model is able to explain 68.2% of the variance in continuous usage, 61.7% of the variance in passion, 62.4% of the variance in intimacy, and 63.3% of the variance in commitment. Figure 3 presents the structural model.

With respect to the proposed hypothesis, all the three types of artificial autonomy are found to have a significant positive effect on the three love components. Sensing autonomy is found to positively influence passion ($\beta = 0.24, p < 0.05$),

TABLE 6. Results of hypotheses testing.

Hypothesis#	β value	T statistic	*p* value	Status
H_1 (Sensing autonomy -> Passion)	0.24	14.84	< 0.05	Supported
H_2 (Sensing autonomy -> Intimacy)	0.38	21.32	< 0.001	Supported
H_3 (Sensing autonomy -> Commitment)	0.29	17.62	< 0.05	Supported
H_4 (Thinking autonomy -> Passion)	0.31	18.55	< 0.001	Supported
H_5 (Thinking autonomy -> Intimacy)	0.30	17.96	< 0.001	Supported
H_6 (Thinking autonomy -> Commitment)	0.34	19.87	< 0.001	Supported
H_7 (Action autonomy -> Passion)	0.22	13.69	< 0.05	Supported
H_8 (Action autonomy -> Intimacy)	0.28	17.01	< 0.05	Supported
H_9 (Action autonomy -> Commitment)	0.27	15.95	< 0.05	Supported
H_{10} (Passion -> Intimacy)	0.20	12.27	< 0.05	Supported
H_{11} (Passion -> Commitment)	0.36	20.43	< 0.001	Supported
H_{12} (Intimacy -> Commitment)	0.32	19.21	< 0.001	Supported
H_{13} (Passion -> Continuous usage)	0.19	9.82	< 0.05	Supported
H_{14} (Intimacy -> Continuous usage)	0.13	4.20	< 0.05	Supported
H_{15} (Commitment -> Continuous usage)	0.52	24.67	< 0.001	Supported
	Control variables			
Age -> Passion	0.22	13.15	0.06	Not supported
Gender -> Passion	-0.19	10.06	< 0.05	Supported
Education -> Passion	0.07	2.08	0.08	Not supported
Usage frequency -> Passion	0.25	14.92	0.07	Not supported
Age -> Intimacy	0.26	15.33	0.08	Not supported
Gender -> Intimacy	0.09	2.21	0.07	Not supported
Education -> Intimacy	0.04	1.17	0.09	Not supported
Usage frequency -> Intimacy	0.31	18.68	< 0.05	Supported
Age -> Commitment	0.16	5.54	0.08	Not supported
Gender -> Commitment	0.12	3.91	0.09	Not supported
Education -> Commitment	0.03	1.24	0.08	Not supported
Usage frequency -> Commitment	0.74	28.92	< 0.001	Supported

intimacy ($\beta = 0.38, p < 0.001$), and commitment ($\beta = 0.29, p < 0.05$), thereby supporting hypothesis H_1, H_2, and H_3 respectively. Thinking autonomy also positively and significantly influences all the three love components of passion ($\beta = 0.31, p < 0.001$), intimacy ($\beta = 0.30, p < 0.001$), and commitment ($\beta = 0.34, p < 0.001$), thereby supporting hypothesis H_4, H_5, and H_6 respectively. Finally, action autonomy is also found to significantly influence the aspects of passion ($\beta = 0.22, p < 0.05$), intimacy ($\beta = 0.28, p < 0.05$), and commitment ($\beta = 0.27, p < 0.05$), therefore supporting hypothesis H_7, H_8, and H_9 respectively. Hence, all the intelligent aspects of artificial autonomy of the VAs are capable of invoking loving relationships. In relation to the central concept of love, the respective effects of passion ($\beta = 0.20, p < 0.05$), intimacy ($\beta = 0.36, p < 0.001$), and commitment ($\beta = 0.32, p < 0.001$) are found to be true, hence supporting hypothesis H_{10}, H_{11}, and H_{12}. Finally, the continuous usage of VAs is also positively influenced by the presence of all the three aspects of love: passion ($\beta = 0.19, p < 0.05$), intimacy ($\beta = 0.13, p < 0.05$), and commitment ($\beta = 0.52, p < 0.001$); supporting hypotheses H_{13}, H_{14}, and H_{15} respectively.

C. POSTHOC ANALYSIS

As an additional analysis, we tested the impact of four control variables – age, gender, education, and usage frequency on all the love aspects of passion, intimacy, and commitment. We observed that gender has a significant negative effect on the passion for the VAs (Table 6), which implies that males may have greater passionate feelings for VAs when compared to females. Currently, out of the box most of the commercially available VAs have a female voice. As per flirtation theory female voices may be more attractive for male users, and vice versa, hence the results. We also observed that the usage frequency had a significant positive effect on intimacy, and commitment for the VAs, which means that if people use the VAs frequently then they are likely to become committed users of these devices. The control variables of age and education did not have any effect on any of the love components.

Since all the three aspects of artificial autonomy are supported for each of the love components, therefore we further examined the comparative impacts of each of the autonomy dimensions on passion, intimacy, and commitment. Thinking autonomy has the highest impact on the aspects of passion and commitment, whereas intimacy is mostly determined by sensing autonomy.

VI. DISCUSSION

In this work we identified artificial autonomy to be an intelligent attribute of the VAs that help love formation between the users and the VAs, which in turn impacts the continuous usage scenario. Due to the anthropomorphic nature of AI-based applications, users may develop human-like relationships with the VAs. In this work we deeply examined this love aspect from the autonomy perspective.

First, our results show that artificial autonomy enhances all the love perceptions of passion, intimacy, and commitment. Although this is a new finding and has not been formally

tested in previous studies to the best of our knowledge, however, the findings are consistent with our understanding of artificial autonomy. If the VAs have got a high level of autonomy, they will be able to interact in a natural manner with the users and the environment, as well as effortlessly implement the tasks that have been requested by the users. Such effortless interactions, and capabilities of serving the users' requests correctly have been found to give rise to perceptions of warmth and affection [18], [24], and the same is highlighted by our results too.

Second, our results show that humans experience all the love aspects of passion, intimacy, and commitment while interacting with the VAs, and it helps in promoting continuous usage. Therefore, our results indicate towards the presence of consummate love that is characterized by the present of all the three aspects [30]. This is different from the previous results obtained in [73], where love was conceptualized to be romantic, i.e., devoid of any form of commitment. One possible reason for this may be because the researchers in [73] focused more on the performance expectancy aspects of the VAs, which is related only to the utilitarian aspects of an IS, however, our research considers artificial autonomy as an intelligent AI attribute that covers the entire working spectrum of the VAs including both the utilitarian and hedonic aspects of an IS. Our results affirm the fact that the VAs capability to empathize with the users have a strong effect on the feelings of love, thus going beyond the utilitarian aspect.

Third, previous research on love between humans and objects has restricted itself to the concept of "*brand love*" [34], [50]. Under such circumstances passion and intimacy has been found to co-exist when users have high experience and value from a brand [12], [34], [55]. However, the third aspect of commitment has never been investigated, therefore the concept of love being confined to romantic by nature. However, for AI applications that are more humanlike, e.g., the VAs, users have a higher expectation of humanlike features. High emotional capability becomes a critical factor in such a case to make the VAs more humanlike, and when such a thing happens the users tend to develop perceptions of commitment towards these devices. Consequently, in contrast to "*brand love*", "*love for AI*" seems to exhibit a consummate nature that is characterized by the presence of all three components of passion, intimacy, and commitment.

Fourth, in line with previous post-adoption research on VAs, we found that the individual differences of age, and educational level do not have any effect in enhancing the continuous usage intention [25]. Therefore, these individual control variables have no distinction with the usage of VAs. We also observed that a higher frequency of usage of the VAs results in enhanced levels of intimacy and commitment, however the aspect of passion is missing. This finding is very interesting as it indicates the presence of companionate love as per STT theory [30], and has never been reported before even in the context of "*brand love*". Companionate love indicates that a longer usage frequency with the VAs is able to create a very specific type of relationship between the users and these devices that is based on care, affection, and commitment with each other. We would like to emphasize that typically companionate love is developed only after prolonged period of relationship, as against passionate love that happens at the onset of a relationship [30]. The overall positive influence of artificial autonomy as an intelligent AI attribute of the VAs together with a greater usage frequency determining a growing strength of intimacy and commitment over time is able to explain this presence of companionate love.

Finally, although we did not formally hypothesize, our results reveal that sensing, thinking, and action autonomy have different impacts on passion, intimacy, and commitment. Since thinking autonomy is related to the relevance of the actual tasks being performed by the VAs, or the recommendations being given by them, hence it forms a major basis of how the users perceive the VAs, which explains as to why this type of autonomy has the highest impact on passion, and commitment. Likewise, the actual actions performed by the VAs are possible because of its sensory capabilities, and since such actions happen in the close proximity of the users, therefore it creates perceptions of intimacy.

A. THEORETICAL CONTRIBUTIONS

There are several theoretical contributions that this research makes. First, we contribute to the previous research on artificial autonomy by providing a different perspective of the three types of artificial autonomy. For e.g., previous research as in [24] had considered artificial autonomy to be a single factor, and did not distinguish it into three different types. Moreover, how artificial autonomy as an intelligent AI-based attribute affects the user experience is also a lesser-known aspect. The current study advances our knowledge of artificial autonomy research by making a conceptual distinction with regards to the three task primitives of sensing, thought, and action based on the STA framework. We find all the three aspects of artificial autonomy to affect the loving relationship that users develop with the VAs and given the fact that artificial autonomy is one of the most important AI-based artifacts (e.g., for the autonomous cars, and smart grids) [46], this research is timely as it helps to extend the scope of the emerging field of artificial autonomy research.

Second, this research extends our current knowledge about the psychological processes involved with artificial autonomy, and how it results in the establishment of man-machine love. Previous research into artificial autonomy has investigated it from a macro level [5], [24], [46], however, in this work we investigate the individual interactions of the users with VAs, thereby focusing on a micro level. In the context of conceptualizing the artificial autonomy of VAs, the current study extends the Sternberg's triangular theory of love by identifying the effects of VA autonomy on the users' behavior in terms of passion, intimacy, and commitment. Although anthropomorphic capabilities of the VAs have been projected to be one of the unique aspects of these devices, however, how this anthropomorphism develops from a loving perspective

has been unknown. The current results related to the intelligent AI-based attribute of artificial autonomy and the love concept is able to shed some light on this aspect.

Third, in relation to adoption of AI our study offers a new understanding by demonstrating that users may form love relationships that is characterized by passion, intimacy, and commitment with the VAs as they would do with a human partner. This implies that the interactions that take place between the users and the VAs can be examined from the perspective of interpersonal relationships. Therefore, in addition to the theory of love, other theories focusing on social relationships can also be applied in the context of human-AI interaction research to have a strong understanding of how users get engaged with these types of applications.

Fourth, this study has implications with respect to IT adoption and usage. IS researchers have used several theories and models like TAM, and UTAUT for explaining the users' adoption and usage of various types of technologies. However, majority of such adoption works have treated IT usage as an object, and the evaluation has been done based on traditional factors like usefulness, ease of use, enjoyment, trust, or social influence [2], [25], [58]. Unlike IT usage, AI applications exhibit humanlike features due to which users may form humanlike relationships with them. This necessitates exploring the relationship that users develop together with the adoption aspects of AI-based applications from the perspective of new factors and theories [13], [14]. By focusing on the concept of artificial autonomy and loving relationships we have attempted to present a new and fresh angle of exploring human-AI interactions. We find the presence of consummate love between users and the VAs that is characterized by the presence of passion, intimacy, and commitment.

Finally, through this study we contribute to the theory of love by applying it in a context that is different from interpersonal relationships by exploring the nature of relationship between consumers and AI-based smart technologies. Therefore, it shows the suitability of this theory beyond interpersonal relationships and provides a comprehensive view of consumers love for AI-based technologies. It is also noteworthy that the type of love that is developed between the users and VAs depends on the nature of interaction happening between the two, together with the usage frequency. Particular, previous works related to love for AI applications as in [50] and [73] found the aspect of intimacy or commitment missing, mainly because they considered the productive aspect of the VAs. However, our consideration of VAs as an autonomous intelligent device involving real-life interactions with the users confirms the aspect of consummate love, and their capability to establish real-life like human relationships.

B. PRACTICAL IMPLICATIONS

The current findings provide new insights that might be of interest to both the users and developers of the VAs. First, our results suggest that the companies manufacturing the VAs must importance to the role human-likeliness plays in the users' continuous intention. These human-likeliness perceptions when projected on the VAs refer to the love perceptions of passion, intimacy, and commitment. We found that all these different components of love affect the continuous usage intention of the VAs. Therefore, the manufacturers and service providers who want to increase their customer base of the VAs should keep in mind about all these three aspects of human perceptions about love.

The manufacturers should also acknowledge the importance of artificial autonomy that promotes the continuous usage too through the feelings of love. For the current generation of VAs, they can autonomously perform three task primitives – sensing of the environment and surrounding objects, formulating a plan, and taking actions based on the plan. All these three aspects of autonomy are strongly prominent in the current generation of VAs, and therefore these should be the primary focus of the manufacturers who want to further develop these capabilities. If the manufacturers want to promote continuous usage intention of the VAs, then they have to focus more on giving exclusive features to the VAs that enhances each of the autonomy types. For e.g., sensing autonomy might be promoted by providing features such a visual recognition and location. Likewise, thinking autonomy may be improved by offering relevant recommendations (that might be based on the time of the day, or location of the user), and even suggesting personal schedules. Action autonomy can be enhanced by improving the speaking capability (in terms of clarity, tone, politeness, multiple language support, etc), searching, and reminder capabilities of the VAs.

The designers and developers should focus on a "*love-centric*" approach that complements the previous strategies which focused on the usefulness aspect of the VAs to promote their continuous usage. Special focus must be given towards empowering the VAs with empathetic emotions that are important for the success of AI applications. Emotional capability is one of the distinguishing features between AI-based vs. non-AI-based technologies, due to which the focus should be on developing more advanced cognitive, data analytic, and affective features for the VAs. For e.g., enhancing the sensing autonomy to include visual recognition will in-turn enable the AI algorithms to recognize emotions based on face monitoring, and accordingly adjust their behavior (speaking style, pitch of voice, mannerism, etc) during their interaction with the users. Therefore, the VAs can interact more emotionally and compassionately with the users that will enhance the loving relationship.

VII. CONCLUSION AND LIMITATIONS

In this work we investigated the adoption aspect of the VAs by considering these to be one of the frontliner representatives of AI-based technologies available in the market today. Instead of following the conventional technology adoption aspect that is based on traditional models like TAM, UTAUT, or its derivatives, in this work we explored the continuous usage scenario of the VAs from the perspective of the theory of love. Further, we conceptualized three types of artificial autonomy in the VA context that represent the intelligent AI-attribute

of these devices, along with the three task primitives. Our findings reveal that artificial autonomy is present and highly relevant for the present generation VAs. This autonomy contributes to all the three aspects of love – passion, intimacy, and commitment, thereby giving rise to consummate love. Moreover, we also find the existence of companionate love that is determined by the usage frequency of the users and the VAs. Typically, a greater usage frequency is marked by greater strength between intimacy and commitment that evolves over time.

There are certain limitations of this study that in turn pave the pay for future work. First, although our data is collected from two different Asian countries, however they are culturally similar. Thus, future research can extend our research model to other countries in order to account for the cultural variations. Second, the scope of this research is confined only to the conversational AI scenario, which can be extended to other specific AI-based contexts, for e.g., chatbot interactions, smart-homes, and human-autonomy teaming. Third, we collected the data from a single questionnaire survey that might limit the robustness of our proposed model. Future research must compare the current results with data collected via other methodologies, such as experiments. Conducting experiments may allow researchers to manipulate some of the variables and test their effect on the strength or significance of the loving relationships. Finally, in this work we did not differentiate between brands or types of VAs. Future research may try to compare user experiences with smartphone-based VAs, i.e., conversational agents with vs. without screen, and even VAs from different manufacturers. In each case the perceptions might vary, which might cause the users to have different experiences with this technology.

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DEBAJYOTI PAL received the B.E. degree in electrical engineering from Nagpur University, Maharashtra, India, in 2005, the M.Tech. degree in information technology from the Indian Institute of Engineering Science and Technology, Shibpur, Kolkata, India, in 2007, and the Ph.D. degree in information technology from the School of IT, KMUTT, Bangkok, Thailand. He is currently a Lecturer with KMUTT. His research interests include multimedia systems, the IoT, and human–computer interaction.

MOHAMMAD DAWOOD BABAKERKHELL was born in khost, Afghanistan. He received the B.C.S. degree in computer science from Shaikh Zayed University (Khost), Afghanistan, in 2009, and the M.Sc. degree in network technology and management from the Amity Institute of Information Technology, Amity University, UP, in 2019. He has been working as a Lecturer with the Information Technology Department, Computer Science Faculty, Shaikh Zayed University (Khost), since 2011. His research interests include information technology management, computer network and security, cloud computing, and the Internet of Things.

BORWORN PAPASRATORN (Senior Member, IEEE) received the D.Eng. degree in telecommunications from Chulalongkorn University, Thailand, in 1988. He is currently an Associate Professor with the School of Information Technology (SIT), King Mongkut's University of Technology Thonburi, Thailand, where he was also the Founding Dean, from 2003 to 2010. He has published four books and 36 research papers and 100's of management articles. His current research interests include IP communications, humanity, and technology adoption. He was an Executive Board Member of the Thailand Telecommunication Research and Industrial Development Institute (TRIDI), from 2008 to 2009.

SUREE FUNILKUL received the B.Sc. degree in mathematics from Mahidol University, Thailand, and the M.Sc. and Ph.D. degrees in information technology from the King Mongkut's University of Technology Thonburi, in 2008. Her research interests include information systems and database programming.