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Communication Style Adaptation in Human-Computer Interaction: An Empirical Study on the Effects of a Voice Assistant's Politeness and Machine-Likeness on People's Communication Behavior During and After the Interacting

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Abstract

Humans adapt their communication style when interacting with one another. With interactive technologies such as voice assistants taking over the role of an interaction partner, the question arises whether and to what extent humans also adapt to their communication style. The adaptation could have a grounding function, ensuring efficient communication with the current interaction partner, or be based on priming which could endure and influence subsequent interactions. In a pre-registered experimental lab study, 133 participants interacted with a voice assistant whose communication style varied regarding politeness (polite vs. non-polite) and machine-likeness (machine-like vs. natural). Participants' verbal behavior during and in a subsequent communication situation was analyzed. Politeness as well as machine-likeness adaptation was observed during the interaction but not afterward, supporting the grounding hypothesis. Furthermore, the adaptation process appears to be unconscious as the voice assistant's different communication styles did not affect conscious evaluations.

Keywords: voice assistant, communication styles, adaptation, politeness, machine-likeness

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Introduction

With the progressing prevalence of interactive technologies, various questions regarding their effects on human interaction behaviors arise. Particularly, voice-activated intelligent personal assistants (in the following referred to as voice assistants), which are integrated in smartphones or smart speakers such as Amazon's Alexa and Apple's Siri, are well-known and widespread (López et al., 2018). Voice assistants are used for diverse services such as playing music, setting an agenda or to do-lists, retrieving news, weather information, or directions. They are operated via voice commands, which is considered intuitive and related to natural human behavior (López et al., 2018). In human-human interaction, people tend to adapt their verbal and nonverbal behavior to match the person they are interacting with (Burgoon et al., 1995; Giles et al., 1991). Since voice assistants are operated in an interactive way which resembles a human-human interaction, the question arises to what extent these adaptation processes also take place here. As previous research has shown, people tend to react socially to interactive technologies, for instance by applying politeness or responding to flattering (Nass & Moon, 2000; Reeves & Nass, 1996). In line with that, there is first evidence that people adapt their communication behavior when talking to machines (L. Bell et al., 2003; Branigan & Pearson, 2006; Branigan et al., 2003; Branigan et al., 2010; Oviatt et al., 1998; Suzuki & Katagiri, 2007). This could be due to a grounding function, where mutual understanding is established via adaptation to ensure efficient communication (Clark & Brennan, 1991), or be based on priming, where a certain communication style may activate contextual interaction scripts leading to an adaptation of that communication style (Hoey, 2007). While a mere grounding function would not influence subsequent interactions, a priming effect could entail that voice assistant users carry over negative communication patterns (e.g., a more non-polite or machine-like communication style) into human-human conversations. This would have crucial implications for the dialogue design of these devices. To shed further light on the question of whether and to what extent the communication style of a voice assistant has the potential to affect the communication style of the human interacting with it, we investigate potential adaptation processes *during* and *after* the interaction. The voice assistant's perceived competence and sociability are considered as influencing factors to receive further evidence why people adapt their communication behavior to machines (Branigan & Pearson, 2006; Riordan et al., 2014).

At the beginning of this paper, we review related work on alignment processes in human-human as well as human-machine interaction, concluding with our hypotheses and research questions. Next, we describe the methods of our experimental lab study and the results we obtained from our analyses. We conclude by discussing the findings, elaborating their importance for the field, and giving an outlook for future research.

Related Work

People adapt to each other verbally and nonverbally (e.g., proximity, gaze, smiling, silences, response latency, utterance length) as well as behaviorally (e.g., helping, global intimacy, affect, resources; Burgoon et al., 1993). These adaptation processes were given many names such as accommodation, alignment, convergence, congruence, synchrony, or reciprocity (Giles et al., 1991). According to the Communication Accommodation Theory (CAT), the aim is to "index and achieve solidarity" via "realignments of patterns of code or language selection" (Giles et al., 1991, p. 2). The Interaction Adaptation Theory (IAT) by Burgoon et al. (1995) describes the process as matching or synchronizing the timing of behavior. In the current work, we focus on communication accommodation in terms of the alignment of verbal aspects which we refer to as communication style adaptation.

Communication Style Adaptation in Humans

The adaptation of communication styles is argued to build the basis for successful social communication situations (Pickering & Garrod, 2006). It is assumed to take place automatically and unconsciously with the goal of establishing a joint semantic concept for the persons involved in the interaction, which reduces the need to exchange explicit information (Garrod & Anderson, 1987). For instance, in a study by Garrod and Anderson (1987), participants were tasked to navigate a labyrinth together. Here, if one speaker described where they were located by saying "third row two along," the other would typically use a subsequent description such as "second row three along." In several studies, communication partners were observed to converge in sentence structure and choice of words which facilitates appropriate reference to something or someone without precise knowledge of the partner or their experiences (Bock, 1986; Branigan et al., 2000; Brennan & Clark, 1996).

There are two prominent theories offering explanations for these processes: grounding and priming (Riordan et al., 2014). Grounding stands for the establishment of mutual knowledge and reciprocal understanding to facilitate an efficient conversation (Clark & Brennan, 1991). Consequently, interactions are seen as collaborations between speaker and listener: the listener indicates understanding and the speaker considers the listener's knowledge, beliefs, and abilities and monitors their understanding (A. Bell, 1984; Riordan et al., 2014). For instance, when speaking to children, people tend to use simpler vocabulary and shorter sentences (Riordan et al., 2014). Other researchers argue that priming may offer a better explanation for the observed alignment processes (for a review, see Ferreira & Bock, 2006). Following this argumentation, verbal and nonverbal alignment result from the interlocutors priming each other (Riordan et al., 2014). A speaker activates, for instance, an expression for a listener who then uses the same or a closely related expression when becoming the speaker. Following priming theory, the usage of certain words, sentence structures, and language style will activate certain contextual interaction scripts (Hoey, 2007) which may remain activated in a subsequent interaction with a different interlocutor. While these adaptation processes are well-investigated in the human-human context, the growing prevalence of social and communicative technologies, such as voice assistants, unveils new types of interaction partners which may also elicit communication style adaptation.

Communication Style Adaptation in Human-Machine Interaction

As we know from media equation theory (Nass & Moon, 2000; Reeves & Nass, 1996), minimal social cues such as interactivity, natural speech, and the fulfillment of a social role are sufficient to elicit unconscious social reactions toward machines that are typical for human-human interactions. In this vein, research has shown that people also adapt their behavior to nonhuman interaction partners such as computers (cf. Fogg & Nass, 1997), robots (cf. Lorenz et al., 2016; Sandoval et al., 2016), and virtual agents (cf. Krämer et al., 2013). This is for instance examined in the context of reciprocal self-disclosure (von der Pütten et al., 2010), establishment of rapport (feeling of being "in sync"; Huang et al., 2011), mimicry of facial expressions (Krämer et al., 2013), and game and negotiation strategies (Asher et al., 2012; Mell et al., 2018). Besides these behavioral and social adaptations, the convergence of communication behaviors is of particular interest when studying interactions between humans and machines. Previous research has shown that humans adapt to computers in terms of their speech rate (L. Bell et al., 2003), their loudness of speech and response latency (Suzuki & Katagiri, 2007), their syntax (Branigan et al., 2003), as well as their linguistic alternation, articulation, speech segments, pauses, use of final falling contours, and linguistic variability (Oviatt et al., 1998). Lexical alignment was observed when the computer deliberately used different terms than the human interaction partner (Brennan, 1996). Branigan et al. (2010) conclude in their review that communication style adaptation occurs in interactions with machines, often to an even greater extent than in interactions with other humans.

The communication style of a machine mostly differs regarding two aspects: its politeness and machine-likeness. Politeness is a universal social norm and a powerful mechanism that was developed to facilitate efficient interactions between individuals (Ribino, 2023). Most interactive devices employ politeness strategies as they help to facilitate the perception of trustworthiness and reliability as well as the social acceptance of the device (see review by Ribino, 2023). Machine-likeness can relate to several aspects such as appearance, behavior, and communication style, which varies extensively in different types of interactive devices. A machine-like communication style was found to lead to less perceived social presence, competence, and warmth (Dautzenberg et al., 2021; Kim et al., 2021) and further to inhibit or even suppress social responses (Lee, 2010). Therefore, a more natural communication style is often strived for.

Referring back to the two theories that offer explanations for communication style adaptation observed in human-human interaction (grounding and priming theory, Riordan et al., 2014), we aim to investigate which theory may be adequate to explain communication style adaptation that occurs in human-machine interaction. Some researchers argue that the observed adaptation in human-machine interaction could be a case of audience design (Riordan et al., 2014), which goes in line with the grounding theory. According to this assumption, participants adapt by using words and phrases the computer uses to facilitate an efficient conversation (Riordan et al., 2014). In case the adaptation has a grounding function to ensure efficient communication with the current interaction partner (Branigan & Pearson, 2006), it will occur *during* the current communication situation. However, considering the priming theory, it could also be that the machine's communication style activates contextual interaction scripts (Hoey, 2007). By using a certain communication style, such as politeness or machine-likeness, this style is also triggered for the human interaction partner who then applies it in the following. The activated communication style may remain activated in a subsequent interaction with a different interlocutor. Consequently, the adapted communication style may also be observable *after* interacting with a machine (Ferreira & Bock, 2006; Hoey, 2007; Pickering & Garrod, 2004; Riordan et al., 2014).

In sum, previous research offers substantial evidence for the occurrence of communication style adaptation when interacting with machines such as voice assistants. According to the grounding theory, this will take place *during* the interaction to ensure an efficient communication (Riordan et al., 2014). Considering the priming theory, the machine's communication style activates a certain communication style of the listening human, which then stays activated and can be observed *after* the interaction. Since politeness and machine-likeness are relevant aspects of the communication style of machines, we postulate the following:

> **H1**: Individuals adapt to a voice assistant's communication style *during* the interaction: Individuals interacting with a voice assistant that displays (a) a *polite* (vs. non-polite) communication style will use a more polite communication style and (b) a *machine-like* (vs. natural) communication style will use a more machine-like communication style.

> **H2**: Individuals adapt to a voice assistant's communication style *after* the interaction: Individuals who interacted with a voice assistant that displays (a) a *polite* (vs. non-polite) communication style will subsequently use a more polite communication style and (b) a *machine-like* (vs. natural) communication style will subsequently use a more machine-like communication style.

The results by Branigan et al. (2010) suggest that in many cases communication style adaptation occurs to a greater extent in human-machine than in human-human interaction. This is explained with people's goal of establishing mutual knowledge and reciprocal understanding to facilitate an efficient conversation (Clark & Brennan, 1991). When the machine-likeness is more salient, this could trigger concerns regarding the extent to which the machine has the knowledge and ability that is needed for an easy-flowing and successful communication. This could likely lead to a stronger effort to adapt the own communication style to that of the machine. Consequently, we hypothesize that individuals more strongly adapt to the voice assistant's communication style, in this case its politeness, the more machine-like it communicates:

> **H3**: There is an *interaction effect* of the voice assistant's polite and machine-like communication style: Individuals interacting with a voice assistant displaying a *polite* (vs. non-polite) communication style will use a more polite communication style when the voice assistant displays a *machine-like* (vs. natural) communication style.

Perception of the Voice Assistant Influencing the Communication Style Adaptation

Another indication that communication style adaptation behavior is caused by grounding might be delivered when investigating the voice assistant's perceived competence and sociability. Adaptation was found to occur to a greater extent when interacting with computers compared to humans, likely with the goal to enhance communicative success as a response to the perceived limited capabilities of computers (Branigan et al., 2010). Supporting this theory, participants were shown to adapt their communication style more strongly to a computer that is evaluated less competent (Pearson et al., 2006). Since interaction behaviors such as machine-likeness and politeness influence the evaluation and liking of artificial entities as interaction partners (Horstmann & Krämer, 2020, 2022), the voice assistant's communication style is assumed to influence how sociable and competent it is perceived. While the perception of low competence appears to be clearly linked to stronger communication style adaptation behavior (Pearson et al., 2006), the effect which the voice assistant's perceived sociability may have is less clear. Against this background, the following hypothesis concerning the voice assistant's perceived competence and the following research question concerning its perceived sociability are formulated:

> **H4**: A voice assistant's communication style influences individuals' communication style adaptation during the interaction via the voice assistant's perceived *competence*: (a) a polite vs. non-polite communication style is perceived more competent leading to less adaptation; (b) a machine-like vs. natural communication style is perceived less competent leading to more adaptation.

> **RQ1**: Do individuals interacting with a voice assistant displaying a polite vs. non-polite and a machine-like vs. natural communication style show differences in their communication style adaptation depending on how they perceive the voice assistant's *sociability*?

Method

An experimental lab study with a 2 (machine-like vs. natural communication style) × 2 (polite vs. non-polite communication style) between-subject design was conducted. We preregistered the study at the OSF platform (https://osf.io/m8rha) and the local ethics committee approved the study's procedure. Supplementary study material (experimenter instructions, interaction script, questionnaire, codebook) can be found online: https://osf.io/grqn4/.

Experimental Manipulations and Procedure

First, a cover story was presented explaining that the participants were supposed to test the made-up interaction program SAM running on an Amazon Echo Dot smart speaker. After the procedure and alleged purpose were explained and participants gave their written consent, they filled out some pre-questionnaires on a laptop (sociodemographic background, previous experiences with voice assistants). This was followed by an introduction of the interaction program SAM that was allegedly running on the smart speaker. In reality, pre-recorded audio files were played simulating an interaction with SAM. One Echo Dot was placed in the middle of a table on a black box in front of the participants (see Figure 1). A second Echo Dot was placed underneath the box for the audio output (since it was not possible to turn on the well-known blue light of the device and use it as a speaker for audio output simultaneously). Next, the experimenter pretended to start the interaction program SAM and asked the participants to wait a few seconds. The experimenter left the room, allegedly so that the participants would not feel observed during the interaction. From the adjacent room, the experimenter controlled the voice assistant's output by using a webcam that was installed in the lab (see Figure 1, top right corner) to see and hear the participant and let the voice assistant react accordingly (Wizard of Oz design; see Dahlbäck et al., 1993). The webcam was justified by explaining that in case of errors the developers of SAM could track what went wrong.

FIGURE 1 Experimental Setup With an Amazon Echo Dot Placed on and One Placed Under a Black Box, a Webcam, and the Cooking Requisites Which Are Needed for the First Interaction Task

Photos taken and owned by authors.

In the first part of the interaction, SAM walked the participants through a salad recipe which they followed by using cooking requisites (see Figure 1). In the following interaction part, the voice assistant asked about dietary restrictions and preferences, allergies, intolerances, as well as the preferred food preparation difficulty and time with the alleged aim to recommend suitable recipes in the future. The cooking task and personalization of recipe suggestions was chosen to represent a plausible everyday application scenario for a voice assistant in the private sphere. In both parts, the voice assistant's communication style was manipulated regarding politeness and machine-likeness (see next subchapter). Then, participants were sent back to the laptop where they were asked to imagine a person to whom they are explaining the recipe from part one and to record how they would go through the recipe step by step. The aim was to measure whether the communication style adaptation lasts beyond the interaction situation with the voice assistant. This was followed by questionnaires including participants' evaluation of the voice assistant's competence and sociability and manipulation checks (and personality variables, which were not used for the current analyses). Upon completion, the experimenter returned to the lab, debriefed the participants, and compensated them for their time with money or course credits.

Politeness and Machine-Likeness Manipulation

In the polite conditions, the voice assistant used *verbal markers* of politeness (e.g., "please" and "thank you") and *structural elements* of politeness (e.g., requests formulated as interrogatives versus imperatives; mitigating verbs, e.g., "would" and "could" versus forceful verbs, e.g., "must" and "have to"). For the machine-like conditions, the voice assistant used short and functional sentences with a repetitive structure and a limited range of vocabulary (e.g., saying "okay!" after each executed recipe step or "your answers have been processed" after each reply to the recipe recommendation questions), while lengthy and colloquial sentences in a varying structure and a larger vocabulary range were characteristic for the natural conditions (e.g., alternating between expressions like "thanks for your answer" or "I will remember that" when reacting to replies to the recipe recommendation questions; *structural elements*). Furthermore, there were no hints to having own feelings or intentions in the machine-like conditions, which was different for the natural conditions (e.g., for intentions: " . . . will be taken into account" vs. "I will take into account . . . ," or by saying "I am glad to meet you" vs. "Now we get to know each other"; *verbal markers*). The entire script can be viewed in the online supplementary material (https://osf.io/8mn6g).

Sample

The software G*Power was used to conduct a power analysis (.80 power, medium effect size of $f^2(V) = 0.0625$, standard .05 alpha error probability). The results recommend a minimum of 113 respondents. In total, 137 participated in the experimental lab study of which four were excluded (failure of both attention checks, suspicious answering behavior, heavily restricted language skills), analyses were conducted with 133 participants; 85 of those stated to be female, 47 to be male, and one to be diverse. On average, participants were 23.15 years old, ranging from 18 to 35 ($SD = 3.64$) years. Most of the participants reported to be students (93.2%) and to hold a university entrance level (79.7%) or university degree (18.8%). Most of the participants had interacted with a voice assistant before (84.2%), on average with a medium frequency ($M = 2.59$, $SD = 1.32$; 1 = "very rarely" to 5 = "very often") and a rather low intensity of use ($M = 1.97$, $SD = 1.04$; 1 = "little intensively" to 5 = "very intensively").

Measurements

Communication Style Adaptation

To analyze whether and to what extent the participants adapt their communication style to that of the voice assistant, we analyzed how often participants used *structural elements* and *verbal markers* of politeness or machine-likeness, respectively, during and after the interaction. This follows the theoretical basis by Bunz and Campbell (2004) that was also used to design the voice assistant's different communication styles. The analyses were conducted using the coding software MAXQDA 2022 (the final codebook is available in the online supplementary files; https://osf.io/yf2j7). *Structural elements* of politeness include *opening and closing acts* (greeting and saying goodbye) and whether requests are formulated as *imperatives* or *interrogatives* (e.g., "Continue with the next step!" vs. "Can you continue with the next step?"; Bunz & Campbell, 2004; De Jong et al., 2008). *Verbal markers* of politeness comprise *thanking acts*, *saying please*, expressions of *appreciation* (e.g., "I would appreciate if you could repeat the last step"), *flattering* (e.g., "You explained that very well"), *redressing hedges* (words or phrases that diminish the face-threatening force of a speech act, e.g., "I just want to ask if we could continue"), and the use of *mitigating verbs* such as could, would (like to), and can instead of *forceful verbs* such as must, have to, need to, and want to (e.g., "I want easy recipes" vs. "I would like easy recipes"; Bunz & Campbell, 2004; De Jong et al., 2008). Additionally, we analyzed whether participants indicated to consider their interlocutor as *social entity* with social needs, for instance, by suggesting group membership (De Jong et al., 2008) or attempts to reduce the other's uncertainty (e.g., replying to "Let me know when you're done" with "Will do").

Structural elements of machine-likeness include participants' *word count* (number of words they used; Hoffmann et al., 2020), *direct address* of their dialogue partner (e.g., "You can start"; Hoffmann et al., 2020), and lexical diversity measured via *Type-Token-Ratio*, the ratio of different words (types) to total words (tokens); Templin, 1957). For *verbal markers* of machine-likeness we checked the communication style for *functionality* (short, functional expressions, e.g., "No meat") in contrast to *verbosity* (long, copious sentences conveying more information than needed, e.g., "I do not really like meat, so I think I would like recipes that are vegetarian") and for *list structures* (e.g., "One: no meat, two: no mushrooms, three: spicy"; Hoffmann et al., 2020; Horstmann et al., 2018). Furthermore, expressions suggesting *intentionality* (intentions, thoughts, and opinions, e.g., "no meat because it's bad for the environment") and *personal preferences* (e.g., "I'd prefer no meat") were considered (Horstmann et al., 2018).

Voice Assistant Evaluation and Manipulation Checks

The voice assistant's perceived *competence* was assessed via adapted items of the Task Attraction subscale (5 items; e.g., "The voice assistant would be a poor problem solver with regard to speech-based interaction"; $\alpha = 0.68$) of the Interpersonal Attraction Scale (IAS;

McCroskey & McCain, 1974; 1 = "strongly disagree" to 5 = "strongly agree") and a collection of adjectives from Horstmann and Krämer (2022) rated on a five-point semantical differential (10 items; e.g., "incapable–capable"; $\alpha = 0.83$). The voice assistant's perceived *sociability* was measured with the Social Attraction subscale of the IAS (5 items, e.g., "I think the voice assistant could be a friend of mine"; $\alpha = 0.74$) and another collection of adjectives from Horstmann and Krämer (2022; 15 items, e.g., "cold–warm"; $\alpha = 0.87$).

To check the *success of the manipulations*, participants were asked to rate the voice assistant's expressions as either 1 = "rather non-polite," 2 = "completely neutral," or 3 = "rather polite" and as either 1 = "rather machine-like," 2 = "completely neutral," or 3 = "rather natural." An ANOVA revealed that the voice assistant displaying a machine-like compared to a natural communication style was perceived as more machine-like ($F(1, 131) = 4.12$, $p = .044$, $\eta_p^2 = 0.03$; machine-like: $M = 1.61$, $SD = 0.74$; natural: $M = 1.38$, $SD = 0.58$). The voice assistant displaying a polite compared to a non-polite communications style was not perceived significantly more polite ($F(1, 131) = 1.79$, $p = .183$, $\eta_p^2 = 0.01$; polite: $M = 2.84$, $SD = 0.44$; non-polite: $M = 2.72$, $SD = 0.55$).

Results

The statistical analyses were conducted with IBM SPSS Statistics 29 including the PROCESS macro v4.3, significance was determined using the standard $p < .05$ criterium.

Communication Style Adaptation in Human-Machine Interaction

To investigate **H1** (Individuals adapt to a voice assistant's communication style *during* the interaction) and **H3** (There is an interaction effect of the voice assistant's politeness and machine-likeness communication style), we conducted a MANOVA with the voice assistant's communication styles (*polite* vs. *non-polite* and *machine-like* vs. *natural*) as factors and the participant's communication style (*structural elements* and *verbal markers* of politeness/machine-likeness) *during* the interaction as dependent variable. Using Pillai's trace, there was a significant main effect of the *politeness* of the voice assistant's communication style on the *politeness* of the participants' communication style, $V = 0.64$, $F(18, 99) = 9.66$, $p < .001$. Separate univariate ANOVAs on the different outcome variables revealed a significant effect on participant's usage of *redressing hedges*, $F(1, 116) = 8.93$, $p = .003$, $\eta_p^2 = 0.07$, and *thanking acts*, $F(1, 116) = 111.55$, $p < .001$, $\eta_p^2 = 0.49$, their consideration of the voice assistant as *social entity*, $F(1, 116) = 14{,}17$, $p < .001$, $\eta_p^2 = 0.11$, and their usage of *opening and closing acts*, $F(1, 116) = 10.94$, $p = .001$, $\eta_p^2 = 0.09$. There was no significant effect on the participants' usage of *mitigating verbs*, $F(1, 116) = 1.84$, $p = .178$, $\eta_p^2 = 0.02$, *forceful verbs*, $F(1, 116) = 3.08$, $p = .082$, $\eta_p^2 = 0.03$, the word *please*, $F(1, 116) = 0.66$, $p = .419$, $\eta_p^2 = 0.01$, *flattering*, $F(1, 116) = 2.94$, $p = .089$, $\eta_p^2 = 0.03$, *interrogatives*, $F(1, 116) = 2.00$, $p = .160$, $\eta_p^2 = 0.02$, and *imperatives*, $F(1, 116) = 2.37$, $p = .126$, $\eta_p^2 = 0.02$. Expressions of *appreciation* remained uncoded and were therefore not considered. For descriptive values, see Table 1. **H1a** is partly supported.

TABLE 1 Descriptive Values for the Structural Elements and Verbal Markers of Politeness During and After the Interaction With the Voice Assistant

	During the interaction					After the interaction				
	Polite	Non-polite	Natural	Machine-like	Total	Polite	Non-polite	Natural	Machine-like	Total
Structural elements										
Interrogative M (SD)	0.34 (0.92)	0.59 (1.03)	0.57 (1.03)	0.33 (0.91)	0.46 (0.98)	0.02 (0.13)	0.00 (0.00)	0.02 (0.13)	0.00 (0.00)	0.01 (0.09)
Imperative M (SD)	0.92 (1.28)	1.21 (1.52)	0.46 (0.74)	1.72 (1.66)	1.06 (1.40)	0.11 (0.57)	0.10 (0.55)	0.16 (0.68)	0.05 (0.39)	0.11 (0.56)
Opening/ closing acts M (SD)	0.37 (0.58)	0.72 (0.64)	0.49 (0.56)	0.60 (0.70)	0.54 (0.63)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Verbal markers										
Mitigating verbs M (SD)	1.42 (1.49)	1.10 (1.20)	1.49 (1.31)	1.02 (1.38)	1.27 (1.36)	0.06 (0.30)	0.07 (0.26)	0.08 (0.27)	0.05 (0.29)	0.07 (0.28)
Forceful verbs M (SD)	0.08 (0.33)	0.26 (0.64)	0.29 (0.63)	0.04 (0.27)	0.17 (0.51)	0.70 (1.19)	0.67 (1.37)	0.68 (1.33)	0.69 (1.22)	0.69 (1.27)
Redressing hedges M (SD)	1.24 (1.39)	0.64 (0.91)	1.24 (1.37)	0.63 (0.94)	0.95 (1.22)	0.43 (0.67)	0.28 (0.70)	0.33 (0.60)	0.38 (0.77)	0.36 (0.68)
Appreciation M (SD)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Thanking acts M (SD)	1.42 (0.88)	0.10 (0.36)	0.81 (1.00)	0.75 (0.89)	0.78 (0.95)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Saying please M (SD)	0.26 (0.54)	0.17 (0.53)	0.16 (0.41)	0.28 (0.65)	0.22 (0.54)	0.00 (0.00)	0.02 (0.13)	0.00 (0.00)	0.02 (0.13)	0.01 (0.09)
Flattering M (SD)	0.00 (0.00)	0.07 (0.32)	0.04 (0.18)	0.04 (0.27)	0.03 (0.22)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Consider. as social entity M (SD)	2.61 (2.04)	1.48 (1.35)	2.49 (2.19)	1.60 (1.16)	2.07 (1.83)	0.38 (0.91)	0.41 (1.06)	0.46 (1.08)	0.33 (0.87)	0.40 (0.98)

Using Pillai's trace, there was a significant main effect of the *machine-likeness* of the voice assistant's communication style on the *machine-likeness* of the participants' communication style, $V = 0.54$, $F(18, 99) = 6.48$, $p < .001$. Separate univariate ANOVAs on the different outcome variables revealed a significant effect on participant's disclosure of *personal preferences*, $F(1, 116) = 42.57$, $p < .001$, $\eta_p^2 = 0.27$, the *functionality* of their communication style, $F(1, 116) = 19.29$, $p < .001$, $\eta_p^2 = 0.14$, their *Type-Token-Ratio*, $F(1, 116) = 8.71$, $p = .004$, $\eta_p^2 = 0.07$, and their *word count*, $F(1, 116) = 15.68$, $p < .001$, $\eta_p^2 = 0.12$. The effect of the voice assistant's machine-likeness was not significant regarding participants' disclosure of *intentionality*, $F(1, 116) = 2.96$, $p = .088$, $\eta_p^2 = 0.03$, their usage of *list-style* communication, $F(1, 116) = 2.39$, $p = .125$, $\eta_p^2 = 0.02$, their *verbosity*, $F(1, 116) = 3.19$, $p = .077$,

TABLE 2 Descriptive Values for the Structural Elements and Verbal Markers of Machine-Likeness During and After the Interaction With the Voice Assistant

	During the interaction					After the interaction				
	Polite	Non-polite	Natural	Machine-like	Total	Polite	Non-polite	Natural	Machine-like	Total
Structural elements										
Direct address M (SD)	1.21 (1.43)	1.47 (1.66)	1.56 (1.42)	1.08 (1.64)	1.33 (1.54)	0.94 (2.09)	1.05 (2.70)	1.17 (2.57)	0.79 (2.18)	0.99 (2.39)
Word count M (SD)	67.58 (33.86)	61.88 (34.81)	75.89 (37.28)	52.60 (25.89)	64.83 (34.29)	67.48 (20.09)	65.12 (20.88)	67.59 (21.60)	65.00 (19.16)	66.35 (20.42)
Type-Token-Ratio M (SD)	0.71 (0.08)	0.69 (0.08)	0.68 (0.07)	0.73 (0.08)	0.70 (0.08)	0.65 (0.09)	0.62 (0.08)	0.63 (0.08)	0.64 (0.09)	0.64 (0.09)
Verbal markers										
Pers. preferences M (SD)	1.87 (1.51)	1.62 (1.49)	2.48 (1.50)	0.95 (1.01)	1.75 (1.50)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Intentionality M (SD)	0.16 (0.41)	0.16 (0.45)	0.22 (0.52)	0.09 (0.29)	0.16 (0.43)	0.03 (0.18)	0.03 (0.18)	0.03 (0.18)	0.03 (0.18)	0.03 (0.18)
List structure M (SD)	0.52 (0.74)	0.67 (0.85)	0.70 (0.87)	0.47 (0.68)	0.59 (0.79)	0.11 (0.32)	0.09 (0.28)	0.06 (0.25)	0.14 (0.35)	0.10 (0.32)
Verbosity M (SD)	0.55 (1.07)	0.41 (0.92)	0.63 (1.26)	0.32 (0.54)	0.48 (1.00)	0.10 (0.30)	0.17 (0.38)	0.19 (0.40)	0.07 (0.26)	0.13 (0.34)
Functionality M (SD)	7.34 (4.85)	8.24 (4.49)	6.13 (4.33)	9.60 (4.40)	7.78 (4.68)	0.33 (0.48)	0.38 (0.49)	0.35 (0.48)	0.36 (0.49)	0.36 (0.48)

$\eta_p^2 = 0.03$, and their *direct address* of the voice assistant, $F(1, 116) = 2.55$, $p = .113$, $\eta_p^2 = 0.02$. For descriptive values, see Table 2. **H1b** is partly supported. Using Pillai's trace, there was no significant interaction effect of the *politeness* and *machine-likeness* of the voice assistant's communication style on the participants' communication style, $V = 0.13$, $F(18, 99) = 0.80$, $p = .702$. Therefore, **H3** needs to be rejected.

To explore **H2** (individuals adapt to a voice assistant's communication style *after* the interaction), another MANOVA was conducted with the voice assistant's communication styles as factors and the participant's communication style that was assessed *after* the interaction as dependent variable. Using Pillai's trace, there was no significant main effect of the voice assistant's communication style, neither of *politeness*, $V = 0.10$, $F(14, 104) = 0.78$, $p = .687$, nor of *machine-likeness*, $V = 0.10$, $F(14, 104) = 0.85$, $p = .614$, on the participants' communication style. Consequently, **H2** needs to be rejected. For descriptive values, see Table 1 (politeness) and Table 2 (machine-likeness).

Summing up, *during* the interaction with a voice assistant that displays a polite compared to a non-polite communication style, individuals display less *opening and closing acts* (structural elements of *politeness*), more *redressing hedges*, more *thanking acts*, and more *consideration as social entity* (verbal markers of *politeness*). When interacting with a voice assistant that displays a machine-like compared to a natural communication style, individuals disclose fewer *personal preferences* and less *intentionality*, use less *verbosity*, and more *functionality* (verbal markers of *machine-likeness*). They also display a lower *word count*, but

TABLE 3 Descriptive Values of the Evaluation of the Voice Assistant

	Polite		Non-Polite		Natural		Machine-Like		Total	
	M	SD	M	SD	M	SD	M	SD	M	SD
Task Attraction (IAS)	3.85	0.56	3.76	0.83	3.78	0.70	3.83	0.70	3.81	0.70
Competence	3.45	0.58	3.41	0.64	3.43	0.61	3.43	0.61	3.43	0.61
Social Attraction (IAS)	2.24	0.77	2.29	0.89	2.31	0.86	2.22	0.80	2.27	0.83
Sociability	3.67	0.55	3.56	0.54	3.73	0.58	3.50	0.50	3.62	0.55

a higher *Type-Token-Ratio* (structural elements of *machine-likeness*). There is no interaction effect of the voice assistant's *politeness* and *machine-likeness* on their human interaction partners' communication style *during* the interaction and no effect of the voice assistant's communication style on individuals' communication style *after* the interaction.

Perception of the Voice Assistant Influencing the Communication Style Adaptation

To investigate **H4** (A voice assistant's communication style influences individuals' communication style adaptation during the interaction via the voice assistant's perceived *competence*) and **RQ1** (Do individuals [. . .] show differences in communication style adaptation depending on how they evaluated the voice assistant's *sociability*?), we first conducted a MANOVA to test for the influence of the voice assistant's communication style on its perceived *competence* (task attraction, competence) and *sociability* (social attraction, sociability). Pillai's trace revealed no significant effect of the voice assistant's *machine-likeness*, $V = 0.07$, $F(4, 126) = 2.32$, $p = .061$, and no significant effect of its *politeness*, $V = 0.02$, $F(4, 126) = 0.70$, $p = .594$ (see Table 3 for descriptive values). Since we found no significant effect of voice assistant's communication style on its perceived competence, **H4** needs to be rejected and **RQ1** needs to be negated. Summing up, the results suggest that neither the voice assistant's perceived competence nor sociability are influenced by its communication style.

Discussion

Against the background of the rising prevalence of voice assistants, the main question of this paper was whether and to what extent individuals adapt their communication style to the communication style of a voice assistant, during and after the interaction with it. From previous research, two theories that are used to explain communication style adaptation processes are considered and further investigated in the current study: grounding and priming theory (Riordan et al., 2014). While grounding would be based on the aim to ensure an efficient communication with the current communication partner and therefore only take place during the interaction (Clark & Brennan, 1991), priming could endure and influence subsequent interactions (Ferreira & Bock, 2006). We therefore conducted a pre-registered lab study to record and analyze the communication style of 133 participants during and after interacting with a voice assistant that displays a machine-like vs. natural and a polite vs. non-polite communication style.

Communication Style Adaptation in Human-Machine Interaction

The results show that communication style adaptation takes place largely during the interaction, but not after. During the interaction, participants were observed to use more *redressing hedges* and more *thanking acts* while they also consider the voice assistant more as *social entity* when it displays a polite compared to a non-polite communication style. When interacting with a voice assistant that displays a machine-like compared to a natural communication style, individuals appear to adapt by using fewer *words*, disclosing fewer *personal preferences* (e.g., "I would like warm dishes" or "I do not like fish") and *intentionality*, using fewer *verbose* and more *functional* expressions (e.g., one-word phrases).

Two findings contradicted what we expected: there were fewer *opening and closing acts* in the politeness compared to the non-politeness conditions and a higher *Type-Token-Ratio* (indicating a higher lexical diversity) in the machine-like compared to the natural conditions. The occurrence of *opening and closing acts* may have been influenced by the script's design. For instance, in the polite conditions, the voice assistant concluded the recipe interaction with "Enjoy!" and the entire interaction with "Have a pleasant rest of the day!" Here, people might not have replied with goodbye, but rather thank you (coded as thanking act). In the non-polite conditions, it concluded by saying goodbye, which may have triggered saying goodbye in return resulting in more closing acts. An explanation for having a higher *Type-Token-Ratio* in the machine-like conditions could be that people functionally report their preferences (e.g., "Preferences: tomatoes, mushrooms, dislike: onions, garlic"), thus having few repeated words resulting in a higher Type-Token-Ratio, while users in the natural conditions might repeat sentence structures such as "I like tomatoes and mushrooms, and I don't like onions and garlic" resulting in a lower Type-Token-Ratio.

The remaining results paint a clear picture of people adapting to a voice assistant's politeness and machine-likeness *during* the interaction. These findings support the grounding theory (Bock, 1986; Branigan et al., 2000; Clark & Brennan, 1991). The reduction in word quantity, increased functionality, and decreased verbosity are in line with Riordan et al.'s (2014) idea of audience design, according to which users adopt expressions to fit the device's perceived constraints. Evidence for the priming theory as an explanation for communication style adaptation (Ferreira & Bock, 2006; Riordan et al., 2014) could not be found as adaptations processed were only observed during the interaction with the voice assistant and not in a subsequent interaction with an imagined person. Furthermore, the hypothesized interaction effect leading to greater politeness adaptation when speaking to a voice assistant displaying a more machine-like communication style was not found. Thus, the politeness adaptation appears not to depend on the voice assistant's machine-likeness. A potential explanation could be that politeness is a concept that runs automatically so that users adapt to it independent of the interaction partner's perceived constraints. In future studies, it would be interesting to investigate whether other communication style aspects are affected by a technological interaction partner's machine-likeness.

Perception of the Voice Assistant Influencing the Communication Style Adaptation

The different communication styles did not affect how competent and sociable the voice assistant was perceived. An explanation could be that participants' communication style adaptation to that of the voice assistant might take place on an unconscious level and therefore does not influence how it is evaluated consciously. This is partly in line with the manipulation checks which revealed that, when asked directly, people were not fully aware of the voice assistant's polite versus non-polite communication style. Potentially, the consistently friendly tone of the voice assistant in all conditions may have led the participants to evaluate the voice assistant with the non-polite communication style—on a conscious level—as polite as well. Nevertheless, people in the polite conditions adapted to its communication style for instance by using more *redressing hedges* and more *thanking acts* which implies an unconscious communication style adaptation. We therefore argue that people do not deliberately process and evaluate the interaction partner's communication style before adapting to it. In other words, people register and adapt to a communication style automatically and do not make a conscious decision to accommodate. Since a behavioral change was expected but not necessarily a cognitive evaluation beforehand and significant differences in the participants' communication style depending on the voice assistant's communication style were measured, we are confident that the manipulation was successful. Considering that humans mindlessly treat machines socially when presented with human-like cues such as natural language (Nass & Brave, 2005; Nass & Moon, 2000; Reeves & Nass, 1996), our findings are also in line with the Media Equation Theory.

Limitations and Future Research

There was no baseline condition which surveyed users' communication behavior without manipulating the voice assistants' communication style, which could have helped with putting the findings into context. Regarding the experimental setting, the focus of this study was on a task to be accomplished, a more openly designed social experience could deliver further insights. Furthermore, the communication with the imagined person was short and resulted in only a few codes, which may have restricted the measurement of communication style adaptation after the interaction with the voice assistant. For future studies, an interaction with a real person instead of an imagined one could be more effective. As in many studies, the sample consisted mainly of students and was conducted in a lab setting, therefore the generalizability of the results for other age groups and in the real world is limited. Especially the last aspect calls for future research. Children, for instance, should be looked at in detail, not least because of the prevailing worry that interactive devices could teach children impolite or machine-like communication behavior. As voice assistants neither require nor encourage politeness (Curry & Rieser, 2018) and even tend to misunderstand copious requests (e.g., including phrases such as "could you" or "if you don't mind"), children who still need to learn the rules of social communication could be particularly prone to adapting negatively connotated communication. While we did not find any evidence for politeness having a strong effect on users' communication behavior, it would be valuable to investigate how people behave over a longer period of interacting with the device. Furthermore, adding a condition with a clearly impolite communication style could lead to different effects, particularly since this behavior is not common and therefore unexpected. Future research should also investigate whether there are circumstances under which people do not adapt or even diverge with their communication style as it has been observed in interactions between humans (e.g., Giles et al., 1991).

Conclusion

Our aim was to investigate whether individuals adapt their communication style to a voice assistant's communication style in terms of politeness and machine-likeness and whether (if at all) the communication style adaptation only takes place during the interaction with the voice assistant or also in a subsequent interaction with an imagined person. In line with the grounding theory, which suggests that communication style adaptation serves the purpose of establishing and maintaining a successful communication, individuals were observed to adapt to the voice assistant‘s politeness as well as machine-likeness during the interaction with it but not in subsequent interactions with others. Furthermore, this adaptation process appears to take place unconsciously as the voice assistant's different communication styles did not affect how it was consciously evaluated.

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