

# **Personalization of Conversational Agent-Patient Interaction Styles for Chronic Disease Management: Results from two studies with COPD patients**

Christoph Gross, Theresa Schachner, Andrea Hasl, Dario Kohlbrenner, Christian F Clarenbach, Tobias Kowatsch, Florian V Wangenheim

Submitted to: Journal of Medical Internet Research  
on: December 19, 2020

**Disclaimer:** © The authors. All rights reserved. This is a privileged document currently under peer-review/community review. Authors have provided JMIR Publications with an exclusive license to publish this preprint on its website for review purposes only. While the final peer-reviewed paper may be licensed under a CC BY license on publication, at this stage authors and publisher expressly prohibit redistribution of this draft paper other than for review purposes.

## *Table of Contents*

---

<b>Original Manuscript</b> .....	<b>5</b>
<b>Supplementary Files</b> .....	<b>38</b>
Multimedia Appendixes .....	<b>39</b>
Multimedia Appendix 1.....	<b>39</b>
Multimedia Appendix 2.....	<b>39</b>
Multimedia Appendix 3.....	<b>39</b>
Multimedia Appendix 4.....	<b>39</b>
Multimedia Appendix 5.....	<b>39</b>
Multimedia Appendix 6.....	<b>39</b>
Multimedia Appendix 7.....	<b>39</b>

# Personalization of Conversational Agent-Patient Interaction Styles for Chronic Disease Management: Results from two studies with COPD patients

Christoph Gross<sup>1\*</sup> BA, MA; Theresa Schachner<sup>1\*</sup> BA, BSc, MSc; Andrea Hasl<sup>2,3</sup> BSc, Mag.a; Dario Kohlbrenner<sup>4,5</sup> BA, MSc; Christian F Clarenbach<sup>4</sup> MD; Tobias Kowatsch<sup>6,7</sup> MSc, PhD, Dipl.-Inform. (FH); Florian V Wangenheim<sup>6</sup> Prof Dr

<sup>1</sup>MTEC ETH Zurich Zürich CH

<sup>2</sup>Department of Educational Sciences, University of Potsdam, Potsdam, Germany Potsdam DE

<sup>3</sup>International Max Planck Research School on the Life Course (LIFE), Berlin, Germany Berlin DE

<sup>4</sup>Department of Pulmonology, University Hospital of Zürich, Zürich, Switzerland Zürich CH

<sup>5</sup>Faculty of Medicine, University of Zurich, Zurich, Switzerland Zürich CH

<sup>6</sup>Center for Digital Health Interventions, Department of Management, Technology, and Economics, ETH Zurich, Zurich, Switzerland Zürich CH

<sup>7</sup>Center for Digital Health Interventions, Institute of Technology Management, University of St. Gallen, St. Gallen, Switzerland St. Gallen CH

\*these authors contributed equally

## Corresponding Author:

Theresa Schachner BA, BSc, MSc

MTEC

ETH Zurich

Weinbergstrasse 56/58

Zürich

CH

## Abstract

**Background:** Conversational agents (CAs) for chronic disease management are receiving increasing attention in academia and industry. However, long-term adherence to CAs is still a challenge and to be explored. Personalization of CAs has the potential to improve long-term adherence and, with it, user satisfaction, task efficiency, perceived benefits, and intended behaviour change. Research on personalized CAs has already addressed different aspects, such as personalized recommendations or anthropomorphic cues. However, detailed information on interaction styles between patients and CAs in the role of a medical healthcare professional is scant. Such interaction styles play an essential role for patient satisfaction, treatment adherence and outcome, as has been shown for physician-patient interactions. Currently, it is not clear (i) whether chronically ill patients prefer a CA with either a paternalistic, informative, interpretive, or deliberative interaction style, and (ii) which factors influence these preferences.

**Objective:** The objective of this paper, comprising of two consecutive studies, is to investigate preferences for CA-delivered interaction styles by chronically ill patients.

**Methods:** The first study was conducted paper-based and explored preferences of COPD-patients for paternalistic, informative, interpretive, and deliberative CA-delivered interaction styles. Based on these results, a second study assessed the effect of the paternalistic and deliberative interaction style on the relationship quality between the CA and patients via hierarchical multiple linear regression analyses in an online experiment with COPD patients. Patients' socio-demographic and disease-specific characteristics served as moderator variables.

**Results:** Study 1 with 117 COPD patients revealed a preference for the deliberative (50 out of 117) and informative (34 out of 117) interaction styles across demographic characteristics. The paternalistic style was preferred by persons with more severe COPD (GOLD 3/4 100%). Study 2 with 123 newly recruited COPD patients showed that younger persons and persons with a less recent COPD diagnosis scored higher on interaction-related outcomes when interacting with a CA that delivered the deliberative interaction style (Age and CA Type: Relationship Quality –  $b = -0.77$ , 95% CI = [-1.37, -0.18]; Intention to Continue Interaction –  $b = -0.49$ , 95% CI = [-0.97, -0.01]; Working Alliance Attachment Bond –  $b = -0.65$ , 95% CI = [-1.26, -0.04]; Working Alliance Goal Agreement –  $b = -0.59$ , 95% CI = [-1.18, -0.01]; Recency of COPD diagnosis and CA Type:

Working Alliance Goal Agreement –  $b = 0.57$ , 95% CI = [0.01; 1.13]).

**Conclusions:** Our results indicate that age and a patient's personal disease experience inform which interaction style the patient should be paired with to achieve increased interaction related outcomes with the CA. These results allow to design personalized healthcare CAs with the goal to increase long-term adherence to health-promoting behavior.

(JMIR Preprints 19/12/2020:26643)

DOI: <https://doi.org/10.2196/preprints.26643>

## Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**

Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.  
Only make the preprint title and abstract visible.

No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**

Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain visible to all users.

Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in [JMIR Publications](#)

**Original Manuscript**



## Personalization of Conversational Agent-Patient Interaction Styles for Chronic Disease Management: Results from two studies with COPD patients

Christoph Gross<sup>1\*</sup>, Theresa Schachner<sup>1\*</sup>, Andrea Hasl<sup>2,3</sup>, Dario Kohlbrenner<sup>4,5</sup>, Christian Clarenbach<sup>4</sup>, Tobias Kowatsch<sup>1,6+</sup>, Florian von Wangenheim<sup>1+</sup>

\*Equal contribution, +shared last authorship

<sup>1</sup> Center for Digital Health Interventions, Department of Management, Technology, and Economics, ETH Zurich, Zurich, Switzerland

<sup>2</sup> Department of Educational Sciences, University of Potsdam, Potsdam, Germany

<sup>3</sup> International Max Planck Research School on the Life Course (LIFE), Berlin, Germany

<sup>4</sup> Department of Pulmonology, University Hospital of Zürich, Zürich, Switzerland

<sup>5</sup> Faculty of Medicine, University of Zurich, Zurich, Switzerland

<sup>6</sup> Center for Digital Health Interventions, Institute of Technology Management, University of St. Gallen, St. Gallen, Switzerland

### Contact Person

Theresa Schachner

WEV G 228, Weinbergstr. 56/58, 8092 Zurich, Switzerland

E-mail: tschachner@ethz.ch

### Abstract

**Background:** Conversational agents (CAs) for chronic disease management are receiving increasing attention in academia and industry. However, long-term adherence to CAs is still a challenge and to be explored. Personalization of CAs has the potential to improve long-term adherence and, with it, user satisfaction, task efficiency, perceived benefits, and intended behaviour change. Research on personalized CAs has already addressed different aspects, such as personalized recommendations or anthropomorphic cues. However, detailed information on interaction styles between patients and CAs in the role of a medical healthcare professional is scant. Such interaction styles play an essential role for patient satisfaction, treatment adherence and outcome, as has been shown for physician-patient interactions. Currently, it is not clear (i) whether chronically ill patients prefer a CA with either a paternalistic, informative, interpretive, or deliberative interaction style, and (ii) which factors influence these preferences.

**Objective:** The objective of this paper, comprising of two consecutive studies, is to investigate

preferences for CA-delivered interaction styles by chronically ill patients.

**Methods:** The first study was conducted paper-based and explored preferences of COPD-patients for paternalistic, informative, interpretive, and deliberative CA-delivered interaction styles. Based on these results, a second study assessed the effect of the paternalistic and deliberative interaction style on the relationship quality between the CA and patients via hierarchical multiple linear regression analyses in an online experiment with COPD patients. Patients' socio-demographic and disease-specific characteristics served as moderator variables.

**Results:** Study 1 with 117 COPD patients revealed a preference for the deliberative (50 out of 117) and informative (34 out of 117) interaction styles across demographic characteristics. The paternalistic style was preferred by persons with more severe COPD (GOLD 3/4 100%). Study 2 with 123 newly recruited COPD patients showed that younger persons and persons with a less recent COPD diagnosis scored higher on interaction-related outcomes when interacting with a CA that delivered the deliberative interaction style (Age and CA Type: *Relationship Quality* –  $b = -0.77$ , 95%  $CI = [-1.37, -0.18]$ ; *Intention to Continue Interaction* –  $b = -0.49$ , 95%  $CI = [-0.97; -0.01]$ ; *Working Alliance Attachment Bond* –  $b = -0.65$ , 95%  $CI = [-1.26; -0.04]$ ; *Working Alliance Goal Agreement* –  $b = -0.59$ , 95%  $CI = [-1.18; -0.01]$ ; Recency of COPD diagnosis and CA Type: *Working Alliance Goal Agreement* –  $b = 0.57$ , 95%  $CI = [0.01; 1.13]$ ).

**Conclusions:** Our results indicate that age and a patient's personal disease experience inform which interaction style the patient should be paired with to achieve increased interaction related outcomes with the CA. These results allow to design personalized healthcare CAs with the goal to increase long-term adherence to health-promoting behavior.

**Keywords:** Conversational agents; chatbots; human-computer-interaction; physician-patient interaction styles; deliberative interaction; paternalistic interaction; digital health; chronic conditions; disease management; COPD

## Introduction

Chronic diseases are on the rise, due to greater longevity of the population, increasing exposure to environmental pollution and unhealthy lifestyles [1]. As chronic diseases are not curable, related care is directed towards improving functional status, reducing distressing symptoms, extending life duration through secondary prevention, and improving health-related quality of life [2,3]. This requires a comprehensive and personalized disease management based on an active, long-term collaboration between healthcare practitioners and chronically ill patients [1].

However, disease management is time-consuming, staff-intensive and, thus, oftentimes not sufficiently provided [1]. Conversational agents (CAs), i.e., computer programs that imitate the interaction with humans, have the potential to improve the status quo as they allow for cheaper and scalable patient support outside the clinical setting [4,5]. When deployed on a smartphone, CAs remain easily accessible and can accompany the patients in their daily lives [6,7]. Long-term adherence to interventions delivered by healthcare CAs and the effectivity of the interventions with regard to health-related outcomes remain, however, still a challenge [8,9].

To increase adherence and user value with respect to satisfaction, task efficiency, or the likelihood of sustained outcomes, personalization of CAs is viewed as promising to achieve these goals [10]. Despite numerous other design considerations [9] for healthcare CAs such as personalized recommendations [10], or anthropomorphic cues [11], it is still unclear which CA-delivered interaction styles chronically ill patients prefer and whether the preference has an impact on CA-related perceptions (e.g., working alliance) and health outcomes (e.g., change in health-promoting behaviors). Research has singled out the importance of the interaction style for treatment satisfaction, adherence, and subsequent outcome [12,13] in face-to-face encounters between physician and patient, but also in distance therapy via, e.g., phone or internet [14]. As people apply social behavior and expectations to computers or other media in the presence of anthropomorphic cues [Computers are Social Actors paradigm, 15], CA-delivered interaction styles are expected to be of high relevance, too.

This paper applies and investigates the following four interaction styles to healthcare CAs [16]: (i) paternalistic (the physician, as a guardian [16, p. 2222], decides alone about the most appropriate treatment based on the assumption of shared values); (ii) informative (the physician, as an expert [16, p. 2222], neutrally provides the patient with all treatment-related facts, so that the patient can choose); (iii) interpretive (the physician, as a counsellor [16, p. 2222], helps the patient to elucidate his preferences and then leave it to him to make his decision); and (iv) deliberative (the physician, as a teacher or friend [16, p. 2222] conjointly discusses with the patient the best way forward).

Contemporary medical research advocates the deliberative style [17,18], which can also be referred



to as shared decision making [19], as it is thought to consider patients' values and autonomy and the physician's caring role better than other interaction styles [16,19]. It is also the preferred interaction style by the majority of patients in preference studies [20,21]. However, there is evidence in literature that socio-demographic and disease-related variables have an impact on the preferred interaction style. Older patients, for instance, tend to prefer a paternalistic interaction style [22,23], based on the assumption that they are accustomed to physicians being traditionally seen as an authority figure [24]. Among men, there is also a preference for the paternalistic interaction style [22,23]. Fatigue, lacking expertise or knowledge about the condition, or the fear of making a wrong decision are additional reasons mentioned in literature that explain patients preferences for a paternalistic interaction style in case of a severe condition, newly diagnosed disease, or minor health literacy [25]. No influence of socio-economic variables has been found [26] that could explain a preference for the informative over the deliberative style. There seems to be no further evidence in the current literature base that talks about preferences for the interpretive interaction style.

To address these issues, we conducted two studies. The first study aimed to explore if there exist patient preferences for a paternalistic, informative, interpretive, or deliberative interaction style when a CA takes the role of the caregiver. The results of this study informed the second study that explored in more detail (i) which variables moderate preferences for the CA interaction style, and (ii) whether preferences have an impact on CA-related perceptions (e.g., working alliance) and health outcomes (e.g., change in health-promoting behaviors). Both studies were conducted with patients diagnosed with Chronic Obstructive Pulmonary Disease (COPD), one of the global top four leading causes of premature death from chronic diseases [27].

## Methods

### Study design

First, we conducted Study 1, a paper-pencil survey with COPD patients in treatment at a leading Swiss Hospital in the German-speaking part of Switzerland. Besides covering socio-demographic and health-related questions, the survey explored baseline differences of patients' preferences for a deliberative, informative, interpretive, and paternalistic interaction style with a hypothetical healthcare CA.

The outcomes informed Study 2, an online experiment. For this study, we recruited COPD patients

from four hospitals of the German-speaking part of Switzerland, from the Swiss Lung Association, and from an honorary led self-help association for COPD patients in the German-speaking part of Switzerland. We designed a between-subject online experiment where patients were randomly assigned to interact with a CA that follows either a deliberative or paternalistic interaction style. We chose these two styles since (i) we have already developed and experimentally tested the implementation of a deliberative and paternalistic CA interaction in a recent study [28], (ii) there is the most information in literature for these two styles regarding the moderating influences of socio-demographic and health-related variables, and (iii) we expected to find significant effects when choosing the most and least preferred interaction style as determined in Study 1. Both studies did not fall within the scope of Human Research Law, according to the local Swiss ethics authority, and thus did not require any formal authorization.

### Sample size considerations

The primary objective of Study 1 was to explore whether general differences between interaction style preferences of COPD patients for their interaction with a CA exist. Thus, this part of the study was exploratory by nature and did not contain a detailed power analysis.

We conducted an a priori power analysis for Study 2 using *R* (version 3.5.2) and the *R* package WebPower [29]. To identify a medium effect ( $f^2 = .15$ ) [30] in a hierarchical multiple regression at an alpha level of .05, statistical power of .80, a reduced model with 1 predictor and a full model with 13 predictors, a total of 127 participants was required.

### Inclusion criteria

For Study 1, we defined the following inclusion criteria: Patients needed to (1) have a COPD diagnosis, (2) be 18 years or older, and (3) speak German.

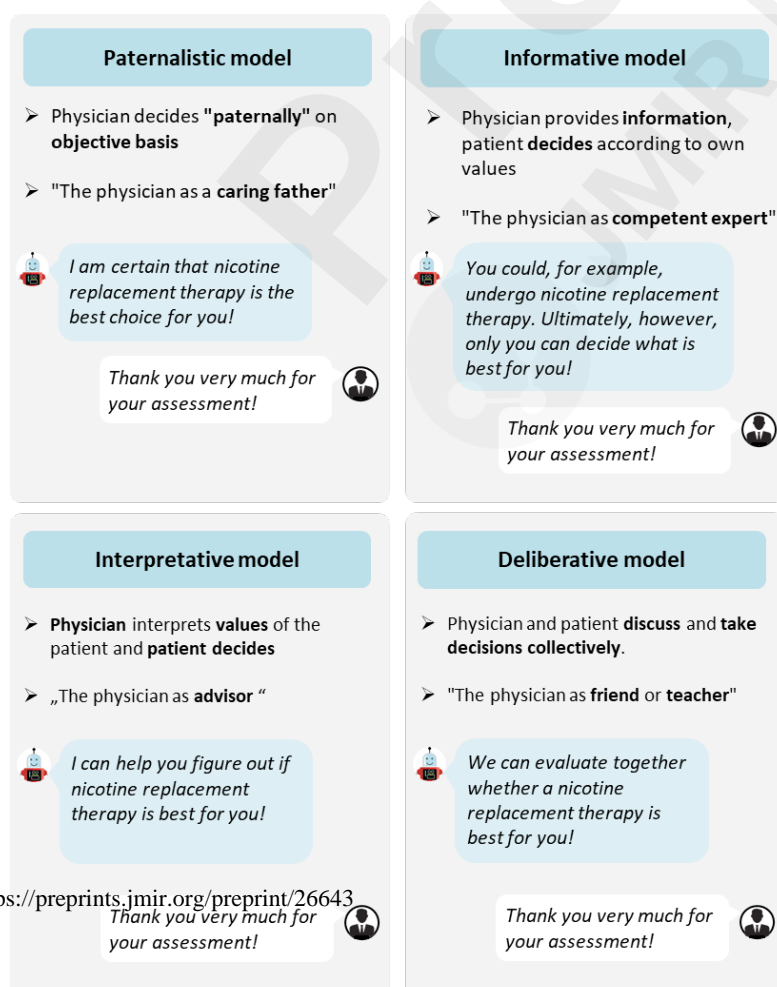
We defined the same inclusion criteria for Study 2. Here, the first inclusion criterion was checked before distributing the link to the online experiment; the link was only sent out to patients who were registered as COPD patients at any of the participating hospitals, the lung association, or the self-help association. In addition, patients also had to confirm that they suffer from COPD during the online experiment. The second and third inclusion criteria were checked at the beginning of the online experiment. Once patients did not confirm either being of age or being German-speaking, the experiment was automatically finished. There were no exclusion criteria.

### Procedure of Study 1 and Study 2

Study 1 was administered as a paper-pencil survey and divided into four parts. Before starting with the actual questions, we provided general information about the survey, that is clarifying objective,

structure, and providing an illustrative explanation of a CA-based intervention. After querying socio-demographic and health-related questions, the survey explored patients' preferences regarding their interaction style with a hypothetical CA. Patients could choose from snippets portraying exemplary interactions with a CA, whereas each snippet depicted a different interaction style (for an overview, see Figure 1).

Figure 1. Illustrations outlining the four physician-patient interaction styles. The authors have



translated it from German to English for this article.

The procedure of Study 2 was as follows: Participants agreed to the study conditions and confirmed the study inclusion criteria (i.e., being of age and German-speaking). After querying standard demographic data (age, gender, mother tongue, and education), patients answered questions about their general health status and their COPD. Patients were then randomly assigned to interact either with a CA presenting a deliberative or a paternalistic interaction style. The interactions were text-based and followed by a pre-scripted dialogue based on two pre-developed scripts. These scripts were developed and assessed in a recent study, where they were verified to be perceived as eliciting a deliberative respective paternalistic interaction style [28]. During the conversation with the CA, patients could choose between one to three pre-defined answer options, which were identical in both conditions (i.e., deliberative, and paternalistic interaction style). Deviations between the answer options only occurred when needed to keep the conversational flow realistic. After the interaction with the CA, participants were asked to evaluate the interaction with the CA on several dimensions. Details about the measures can be found in the measures section below.

To conclude the experiment, patients had to answer a short COPD health literacy quiz. The questions were based on the standardized Bristol COPD Knowledge Questionnaire, a multiple-choice questionnaire developed to measure the disease-specific knowledge of COPD patients [31]. Finally, patients reported on their perception of the length of the study and could leave some free text feedback.

All questions of Study 2 can be found in Multimedia Appendix (“Online Experiment\_Study 2\_English”, translated by the authors into English for this paper).

## **Technical implementation of CAs for Study 2**

We used Qualtrics software, a software-based online survey, and data collection platform, for the online experiment and for randomly assigning patients to one of the two experimental settings (i.e., interaction with a CA using a deliberative interaction style and interaction with a CA using a paternalistic interaction style). We further used Collect.chat, a commercially available chatbot software, to develop the CA dialogues, and iframe to embed the CA into the Qualtrics HTML.

## **Recruitment and management of study participants**

We recruited the participants for Study 1 from the pulmonology department of a leading Swiss Hospital. Their patient database constituted of around 1300 patients, whom we all contacted by mail.

The eligible patients received the printed survey and a letter containing information about the survey and participation conditions. We also provided a pre-franked return envelope to reduce the necessary effort to reply to the survey and to minimize financial expenses for the participants. The postal send out took place on April 9, and 10, 2019 and we started to receive responses one week later. We received replies for two months in total, whereas the majority reached us in the first three weeks.

The patients of Study 2 were recruited during a three-month period from February to April 2020 at the six study sites in Switzerland. The study sites were the pulmonology departments of four hospitals in the German-speaking part of Switzerland, the Swiss lung association, and an honorary led self-help association for COPD patients. Participants were either recruited via e-mail, by postal mail or in-person by participating healthcare professionals on-site. When they were recruited in person, participating healthcare professionals handed out a flyer to potential participants. This flyer contained some information on the study and a link to the online experiment (for the flyer, see “COPD Chatbot Study ETH\_\_Flyer\_English” in the Multimedia Appendix, it has been translated by the authors into English for this paper). Participating healthcare professionals had previously received study instructions by the study authors. When patients were recruited via e-mail, they received an e-mail either by the participating hospital, the Swiss lung association, or the self-help association. In this e-mail, the participating contact person explained the study and asked for voluntary participation. The e-mail further contained the same flyer as used for the on-site recruiting. When participants were recruited via postal mail, they received a letter from the participating hospital with study information and a link to the online experiment, which they had to type into a web browser. For the postal letter, see the Multimedia Appendix (“COPD Chatbot Study ETH\_\_Letter\_English”, translated by the authors into English for this paper).

To start the online experiment, participants had to either click on the study link in the e-mail or type the URL in their browser in case they received a postal letter. A simplified URL (i.e., only portraying a shorter number of signs) was created with the software Bitly, Inc. to access the online experiment and to reduce barriers to participate. The experiment was available online from April to August 2020.

### Measures of Study 1

For Study 1, we gathered basic socio-demographic (age, gender, and education) and health-related data [GOLD COPD level, 32]. Patients reported socio-demographic and health-related data before being presented with the four main physician-patient interaction styles.

*Socio-demographic data.* For the item *age*, patients reported their birth year. To derive patients'

actual age, their birth year was subtracted from 2020 in the descriptive analyses. For the item *gender*, patients could choose their gender from a tick box with answer options "female", "male", "no answer". For the item *education*, patients could choose between four different options: *No formal education*, *secondary 1 (sec 1)*, *secondary 2 (sec 2)*, and *tertiary*.

*Health-related data.* We queried the *GOLD COPD level* for each patient with the item "What is your GOLD rating" (translation by authors) on a 5-point scale ranging from 1 (GOLD 1) to 5 (I do not know), whereas the highest and most severe GOLD level is GOLD 4. GOLD stands for Global Initiative for Chronic Obstructive Lung Disease and is an internationally used scale for classifying the severity of COPD [32].

Next, we introduced the four main physician-patient interaction styles as per [16], and patients were asked which of the four they would prefer for their interaction with a CA. We provided a definition of the respective role of the physician in the interaction style.

## Measures of Study 2

Study 2 was pre-tested with two pulmonologists of a leading Swiss Hospital, both specialized in COPD, one advanced practitioner nurse in lung disease, and ten PhD students of the Swiss Federal Institute of Technology in Zurich. We aimed to identify possible problems in terms of clarity, accuracy, and relevance for assessing health-related measures that are specific for COPD. Based on the feedback, a few changes were made to improve the wording of the questions and the order of the items.

For the main analyses and to assess the various aspects of the two interaction styles, we gathered basic socio-demographic data (age, gender, and education), health-related data (GOLD COPD level, years since COPD diagnosis, and disease literacy), and interaction-related data (willingness to change, relationship quality, intention to continue interacting, and working alliance).

Socio-demographic data were gathered before the interaction with the CA. For the item *age*, patients could choose their birth year from a dropdown menu, ranging from 1900 to 2020. To derive patients' age, their birth year was subtracted from 2020 in the analyses. For the item *gender*, patients could choose their gender from a tick box with answer options "female", "male", "no answer". For the item *education*, patients could choose from 12 different options from a dropdown menu (e.g., "Apprenticeship", translation by authors, all original German measures can be found in the Multimedia Appendix ("Online Experiment\_Study 2\_German", German original)). For the analyses,

educational attainment was recoded to years of education based on the 2011 International Standard Classification of Education (ISCED) Scheme [33].

Health-related data were gathered before the interaction with the CA. Just as in Study 1, we first queried the *GOLD COPD level* for each patient with the item "What is your GOLD rating" (translation by authors) on a 5-point scale ranging from 1 (GOLD 1) to 5 (I don't know), whereas the highest and most severe GOLD level is GOLD 4. Second, we measured *years since COPD diagnosis* with the item "Have you been diagnosed with COPD?" (translation by authors) with answer options "yes" and "no" to ensure that patients confirm their COPD disease and the following item "If so, in which year?" (translation by authors) with a dropdown menu to select a year between 1900 and 2020. To derive patients' years of experience with the disease, their diagnosis year was subtracted from 2020 in the analyses. Third, we measured *disease literacy*. Disease literacy was assessed by the Bristol COPD Knowledge Questionnaire (BCKQ) [31]. To keep the handling time for patients as short as possible, we selected 10 items of the BCKQ after consultation with two nurses who frequently use the questionnaire themselves with their patients. For example, patients had to mark the statement "COPD is commonly an inherited disease" (translation by authors) as "true", "false", or "I don't know". If they evaluated the statement correctly, they were given 1 point, in case of a false or "don't know" answer, they got 0 points. We built a sum score over the 10 items, with higher values indicating higher disease literacy.

Interaction related data were gathered after the interaction with the CA Robo. We first measured *willingness to change* with the item "Was Robo able to motivate you for the proposed exercise?" (translation by authors) with answer options yes and no. This item was adapted from [34]. We further measured *relationship quality* with the German adapted item of [35] "How would you characterize your relationship with Robo?" (translation by authors) with answers on a move scale from 1 "complete stranger" to 5 "close friend", and the German adapted item of [36] "I think Robo liked me" (translation by authors) with answers fixed on a 5-point Likert scale from 1 "not at all" to 5 "very much". Next, we measured *intention to continue interacting* with the German adapted item of [37] "I would like to continue using Robo" (translation by authors) with answer options anchored on a 6-point Likert scale ranging from 1 "strongly disagree" to 6 "strongly agree". Finally, we measured *working alliance* between the patients and the CA Robo with a German-adapted version of the Working Alliance Inventory-Short Revised [WAI-SR, 38]. Here, we measured the two subscales attachment bond and goal agreement (e.g., "Robo and I respect each other", translation by authors) with answers fixed on a 5-point Likert scale ranging from 1 "rarely" to 5 "always" (see Multimedia

Appendix, “Online Experiment\_Study 2\_German”, German original). We decided to omit measuring the third subscale task agreement from the WAI as it does not directly relate to our research questions. For secondary analyses (not included in the main paper, see “Secondary Analyses” in the Multimedia Appendix for details), we measured further interaction-related data (e.g., satisfaction with interaction and recommendation to a friend).

## Results

### Study 1: Paper-and-pencil survey

Preferences for either the paternalistic/informative/deliberative/interpretive style are depicted by gender, age, educational levels, and severity of the disease. Out of 181 participants who started the survey, only those 139 participants who completed the CA preference task were included in the final sample of Study 1. 22 additional participants were excluded because they reported not having COPD. The final sample consisted of 117 participants with an average age of 65.7 years and a mean GOLD classification of 2.9. 66 of the 117 participants were male. Descriptive Statistics can be found in (Table 1). R scripts for all tables can be found in Multimedia Appendix (“Study1\_R scripts”).

Table 1. This table describes the descriptive statistics of Study 1.

	N	Mean (SD)
<b>Gender</b>		
Male	66	
Female	51	
<b>Age</b>	117	65.67 (10.92)
<b>Education</b>		
None	7	
Sec I	15	
Sec II	56	
Tertiary	36	
<b>COPD severity</b>		
GOLD 1	7	
GOLD 2	20	
GOLD 3	24	
GOLD 4	24	



*Gender.* Across CA categories, women most often chose the deliberative CA type; men preferred the informative and deliberative CA types (26 vs. 24; see (Table 2)). Within each category of deliberative/paternalistic/interpretive CA type, men and women were fairly equally represented. Men constituted nearly 80% (26 of 34 persons) of persons who preferred the informative CA type.

Table 2. This table describes the chosen CA preferences by gender, both in absolute numbers as well as percentages by CA category.

	N (% by CA category)				
	Paternalistic	Informative	Interpretive	Deliberative	Sum
Male	4 (0.57)	26 (0.77)	12 (0.46)	24 (0.48)	66
Female	3 (0.43)	8 (0.24)	14 (0.54)	26 (0.52)	51
Sum	7 (1)	34 (1)	26	50	117

*Note.* Numbers in cells represent absolute N of participants. Percentages of male/female participants present in each CA category are given in parentheses.

*Age.* Younger participants (40-50 years old) preferred the deliberative over the paternalistic CA type. Participants in age groups 51-60 preferred the informative type. Participants in both age groups 61-70 and 71-80 most often chose the deliberative type, the oldest participants of the sample (81-90 years old) were fairly equally distributed across the informative/interpretive/deliberative CA type. Within categories, more than 50% (4 of 7 persons) of all subjects who chose the paternalistic CA type were in the youngest age category (40-50 years old). Contrarily, in the interpretive and deliberative group, 70% (interpretive: 20 of 26 persons, deliberative: 35 of 50 persons) of all participants were older than 60 years (see (Table 3)).

Table 3. This table describes the chosen CA preferences by age, both in absolute numbers as well as percentages by CA category.

	N (% by CA category)				
	Paternalistic	Informative	Interpretive	Deliberative	Sum
40-50 years	4 (0.57)	1 (0.03)	1 (0.04)	6 (0.12)	12
51-60 years	2 (0.29)	12 (0.35)	5 (0.19)	9 (0.18)	28

61-70 years	0 (0)	9 (0.27)	9 (0.35)	14 (0.28)	32
71-80 years	1 (0.14)	9 (0.27)	9 (0.35)	19 (0.38)	38
81-90 years	0 (0)	3 (0.09)	2 (0.08)	2 (0.04)	7
Sum	7 (1)	34 (1)	26 (1)	50 (1)	117

*Note.* Numbers in cells represent absolute N of participants. Percentages of age categories present in each CA category are given in parentheses.

*Educational Levels.* Participants without any formal education preferred the informative CA style. Participants who finished Sec I were fairly equally distributed across categories; subjects with higher educational levels (Sec II and Tertiary) preferred the deliberative CA type (see (Table 4)). This pattern was more distinct for Sec II than Tertiary, where participants also often chose the informative CA type. Within categories, participants who attended Sec II and Tertiary constituted nearly 90% (40 of 47 persons) of patients who chose the deliberative type; the same was true for participants who preferred the interpretive CA type. In the paternalistic condition, only the first three educational levels were represented (no formal education, Sec I, Sec II).

Table 4. This table describes the chosen CA preferences by educational level, both in absolute numbers as well as percentages by CA category.

	N (% by CA category)				
	Paternalistic	Informative	Interpretive	Deliberative	Sum
Sec I	3 (0.43)	4 (0.12)	3 (0.12)	5 (0.11)	15
Sec II	3 (0.43)	14 (0.41)	14 (0.54)	25 (0.53)	56
Tertiary Education	0 (0)	12 (0.35)	9 (0.35)	15 (0.32)	36
No formal education	1 (0.14)	4 (0.12)	0 (0)	2 (0.04)	7
Sum	7 (1)	34 (1)	26 (1)	47 (1)	114

*Note.* Numbers in cells represent absolute N of participants. Percentages of educational levels present in each CA category are given in parentheses.

*Severity of COPD.* Across CA categories, subjects with less severe disease (GOLD 1) preferred the informative and interpretive CA type. Participants with a mid-severe disease (GOLD 1 + 2) preferred the deliberative CA type. Persons with a severe disease level (GOLD 4) preferred the deliberative

and informative CA types. Within categories, subjects with higher disease levels (GOLD 3 + 4) constituted 100 % (3 of 3 persons) of those who preferred the paternalistic CA type (see (Table 5)).

Table 5. This table describes the chosen CA preferences by GOLD classification both in absolute numbers as well as percentages by CA category.

	N (% by CA category)				
	Paternalistic	Informative	Interpretive	Deliberative	Sum
GOLD 1	0 (0)	3 (0.11)	3 (0.25)	1 (0.03)	7
GOLD 2	0 (0)	7 (0.26)	4 (0.33)	9 (0.27)	20
GOLD 3	2 (0.67)	6 (0.22)	3 (0.25)	13 (0.39)	24
GOLD 4	1 (0.33)	11 (0.41)	2 (0.17)	10 (0.30)	24
Sum	3 (1)	27 (1)	12 (1)	33 (1)	75

*Note.* Numbers in cells represent absolute N of participants. Percentages of GOLD classification categories present in each CA category are given in parentheses.

### Study 2: Online Experiment

We conducted hierarchical multiple regression modelling to predict participants' self-reported interaction quality with the CA, that is, *willingness to change*, *relationship quality*, *intention to continue interaction*, and *working alliance*, based on (1) the type of CA (paternalistic/deliberative), (2) patients' demographics (age, gender, education), and (3) COPD-related measures (GOLD, COPD disease literacy, experience with COPD). Each outcome was predicted in a three-step procedure. The first block added to the model was the CA type (labelled "model 1" in the results tables). The second block contained the CA type and participants' demographics (labelled "model 2" in the results tables), and the third block consisted of the type of CA, participants' demographics, and COPD-related measures (labelled "model 3" in the results tables). *Relationship quality*, *intention to continue interaction*, and *working alliance* were measured on a metric scale. We calculated hierarchical linear regressions for those outcomes and logistic regression for the binary outcome *willingness to change*.

The descriptive statistics of the experiment are shown in (Table 6). Out of 168 participants who started the survey, 124 completed the survey. One additional subject was excluded because of age (< 18 years old), leading to a final sample of 123 participants. Of those 123 participants, 76 participants were male, with an average of 67.8 years and 8.4 years since their COPD diagnosis. The mean GOLD classification was 3.7.

Table 6. This table describes the descriptive statistics of the experiment of Study 2.

	N	Mean (SD)
<b>Gender</b>		
Male	76	
Female	47	
<b>Age</b>	123	67.82 (9.37)
<b>Education</b>	123	14.28 (2.37)
<b>COPD severity</b>		
GOLD 1	6	
GOLD 2	24	
GOLD 3	29	
GOLD 4	14	

### Main Analyses

For our analysis, we introduce interaction-related outcomes, defined in terms of the outcome variables *Willingness to change*, *Relationship quality*, *Intention to continue interaction*, and two dimensions of *Working alliance* (*Attachment Bond* and *Goal Agreement*). Better interaction related-outcomes indicate a higher willingness to change one's behavior after the interaction with the CA, a higher perceived relationship quality, a higher motivation to continue interacting with the CA, and a higher-rated reported working alliance with the CA in terms of perceived close attachment bond and common goal agreement. Please consult Multimedia Appendix ("Secondary Analyses") for results of further interaction-related data (e.g., satisfaction with interaction and recommendation to a friend). You can find the R scripts for all analyses in Multimedia Appendix ("Study2\_R scripts").

*Willingness to change*. Overall, participants who interacted with a paternalistic CA reported being more willing to change their behavior based on the CA intervention, than those who worked with a deliberative CA (Table 7). There were no substantial interaction effects of either CA type and participants' demographics or CA type and patients' COPD-related characteristics.

Table 7. This table describes the regression of CA type, demographics, and COPD related characteristics on participants' willingness to change their behavior after CA interaction.

	Model 1	Model 2	Model 3
Intercept	0.833 (0.724, 0.943)	0.840 (0.699, 0.980)	0.840 (0.640, 1.039)
CA Type	<b>-0.183</b> (-0.338, -0.029)	-0.179 (-0.388, 0.030)	-0.074 (-0.350, 0.203)
Gender		-0.024 (-0.283, 0.235)	0.041 (-0.325, 0.406)
Age		-0.037 (-0.161, 0.088)	-0.010 (-0.207, 0.188)
Education		-0.108 (-0.229, 0.012)	-0.064 (-0.231, 0.103)
Gender*CA Type		-0.035 (-0.387, 0.317)	-0.163 (-0.627, 0.301)
Age*CA Type		0.003 (-0.162, 0.169)	-0.145 (-0.386, 0.095)
Education*CA Type		0.091 (-0.078, 0.259)	0.055 (-0.157, 0.268)
GOLD			0.053 (-0.105, 0.210)
COPD Literacy			0.165 (-0.047, 0.377)
Experience			-0.127 (-0.294, 0.040)
GOLD*CA Type			-0.040 (-0.261, 0.181)
COPD Literacy*CA Type			-0.058 (-0.311, 0.194)
Experience* CA Type			0.152 (-0.078, 0.381)
Observations	120	113	67
Akaike Inf. Crit.	142.880	146.953	83.496

*Note.* CA= Conversational agent. Logistic regression coefficients with 95% confidence intervals in parentheses. The smaller the Aikake Information Criterion, the better the model fit. Experience is experience with COPD in years since COPD diagnosis. Education is measured in years of formal education. CA Type is coded 0 = paternalistic, 1 = deliberative. Willingness to change behavior after interaction is coded 0 = not willing, 1 = willing. Gender is coded 0 = male, 1 = female. Age in years. Experience in years since COPD diagnosis. Significant results are printed in bold font indicating that the 95% Confidence interval does not contain 0.

*Relationship Quality.* On average, older subjects reported a better relationship quality with the CA than younger subjects, irrespective of the CA type. Participants with a more severe COPD reported a better relationship quality with the CA than participants with a less severe COPD, irrespective of the CA type. There was a negative interaction effect between CA type and age, implying that older subjects preferred a paternalistic CA, younger subjects a deliberative CA with respect to relationship quality (Table 8).

Table 8. This table describes the regression of CA type, demographics, and COPD related characteristics on participants' relationship quality with CA.

	Model 1	Model 2	Model 3
Intercept	-0.073	-0.030	-0.284
	(-0.326, 0.181)	(-0.350, 0.290)	(-0.774, 0.206)
CA Type	0.146	-0.007	0.176
	(-0.213, 0.504)	(-0.482, 0.469)	(-0.504, 0.857)
Gender		-0.399	0.262
		(-0.988, 0.191)	(-0.637, 1.161)
Age		0.155	<b>0.615</b>
		(-0.129, 0.438)	(0.129, 1.100)
Education		-0.031	0.240
		(-0.306, 0.243)	(-0.171, 0.652)
Gender*CA Type		0.546	-0.377
		(-0.255, 1.347)	(-1.519, 0.764)
Age*CA Type		-0.215	<b>-0.774</b>
		(-0.592, 0.162)	(-1.366, -0.181)
Education*CA Type		0.057	-0.018
		(-0.326, 0.440)	(-0.541, 0.504)

GOLD			<b>0.398</b>
			(0.011, 0.786)
COPD Literacy			0.324
			(-0.198, 0.846)
Experience			-0.220
			(-0.631, 0.191)
GOLD*CA Type			-0.132
			(-0.675, 0.411)
COPD Literacy*CA Type			-0.031
			(-0.652, 0.590)
Experience* CA Type			0.194
			(-0.370, 0.759)
Observations	120	113	67
R <sup>2</sup>	0.005	0.039	0.283

Note. CA= Conversational agent. Standardized regression coefficients with 95% confidence intervals in parentheses. Experience is experience with COPD in years since COPD diagnosis. Education is measured in years of formal education. CA Type is coded 0 = paternalistic, 1 = deliberative. Gender is coded 0 = male, 1 = female. Age in years. Experience in years since COPD diagnosis. Significant results are printed in bold font indicating that the 95% Confidence interval does not contain 0.

*Intention to Continue Interaction.* Disease severity positively predicted participants' intention to continue interacting with the CA after the interaction ended. The higher a participant's GOLD classification, the higher was his or her intention to continue (Table 9). Subjects with fewer years of experience with COPD reported a higher intention to continue the interaction, irrespective of the assigned CA type. Older participants reported being more likely to continue the CA interaction when working with a paternalistic CA, younger participants when working with a deliberative CA.

Table 9. This table describes the regression of CA type, demographics, and COPD related characteristics on participants' intention to continue interacting with CA.

	Model 1	Model 2	Model 3
Intercept	0.112	0.046	0.134
	(-0.140, 0.365)	(-0.277, 0.369)	(-0.263, 0.531)

CA Type	-0.224	-0.169	-0.279
	(-0.581, 0.133)	(-0.649, 0.311)	(-0.831, 0.272)
Gender		-0.037	0.404
		(-0.632, 0.558)	(-0.325, 1.133)
Age		-0.075	0.178
		(-0.361, 0.211)	(-0.216, 0.572)
Education		0.053	0.019
		(-0.224, 0.331)	(-0.314, 0.353)
Gender*CA Type		-0.011	-0.637
		(-0.819, 0.797)	(-1.563, 0.288)
Age*CA Type		-0.063	<b>-0.485</b>
		(-0.444, 0.317)	(-0.965, -0.005)
Education*CA Type		-0.162	-0.084
		(-0.549, 0.224)	(-0.507, 0.340)
GOLD			<b>0.420</b>
			(0.106, 0.734)
COPD Literacy			0.199
			(-0.224, 0.622)
Experience			<b>-0.391</b>
			(-0.724, -0.058)
GOLD*CA Type			-0.153
			(-0.593, 0.287)
COPD Literacy*CA Type			0.277
			(-0.226, 0.781)
Experience* CA Type			0.277
			(-0.181, 0.735)
Observations	120	113	67
R <sup>2</sup>	0.013	0.026	0.411

Note. CA= Conversational agent. Standardized regression coefficients with 95% confidence intervals in parentheses. CA Type is coded 0 = paternalistic, 1 = deliberative. Gender is coded 0 = male, 1 = female. Age in years. Experience in years since COPD diagnosis. Significant results are printed in bold font indicating that the 95% Confidence interval does not contain 0.



*Working alliance (attachment bond).* We found a substantial negative interaction effect between age, CA type, and reported attachment bond with the CA. This indicates that older participants had a higher attachment bond when working with the paternalistic CA type, younger participants, when working with the deliberative CA type. Overall, subjects who had a higher disease literacy of COPD also reported a better attachment bond (Table 10), irrespective of the assigned CA type.

Table 10. This table describes the regression of CA type, demographics, and COPD related characteristics on participants' working alliance (attachment bond) with CA.

	Model 1	Model 2	Model 3
Intercept	-0.123	-0.161	-0.424
	(-0.375, 0.129)	(-0.482, 0.161)	(-0.932, 0.083)
CA Type	0.245	0.339	0.526
	(-0.111, 0.602)	(-0.138, 0.817)	(-0.178, 1.231)
Gender		0.001	0.721
		(-0.591, 0.593)	(-0.210, 1.651)
Age		0.141	0.302
		(-0.144, 0.425)	(-0.200, 0.805)
Education		-0.094	0.061
		(-0.370, 0.181)	(-0.365, 0.487)
Gender*CA Type		-0.186	-0.939
		(-0.990, 0.619)	(-2.121, 0.242)
Age*CA Type		-0.284	<b>-0.650</b>
		(-0.662, 0.095)	(-1.263, -0.037)
Education*CA Type		0.047	-0.022
		(-0.338, 0.432)	(-0.563, 0.518)
GOLD			0.278
			(-0.123, 0.679)
COPD Literacy			<b>0.595</b>
			(0.055, 1.135)
Experience			-0.307
			(-0.732, 0.118)

GOLD*CA Type			-0.420
			(-0.982, 0.142)
COPD Literacy*CA Type			-0.405
			(-1.048, 0.237)
Experience* CA Type			0.537
			(-0.047, 1.122)
Observations	120	113	67
R <sup>2</sup>	0.015	0.044	0.221

*Note.* CA= Conversational agent. Standardized regression coefficients with 95% confidence intervals in parentheses. Experience is experience with COPD in years since COPD diagnosis. Education is measured in years of formal education. CA Type is coded 0 = paternalistic, 1 = deliberative. Gender is coded 0 = male, 1 = female. Age in years. Experience in years since COPD diagnosis. Significant results are printed in bold font indicating that the 95% Confidence interval does not contain 0.

*Working alliance (Goal agreement).* Irrespective of the CA type they were working with, participants with a higher disease literacy reported a higher perceived support to achieve their goals by the CA. Participants with fewer years of experience with COPD reported a higher perceived support to achieve their goals by the CA. Older subjects reported higher support by the CA when in the paternalistic condition, younger subjects when in the deliberative condition. A positive interaction effect between CA type and experience with COPD implied that participants who were more experienced with COPD reported a better perceived support in achieving their goals when interacting with a deliberative CA, participants who were less experienced with COPD when working with a paternalistic CA.

Table 11. This table describes the regression of CA type, demographics, and COPD related characteristics on participants' working alliance (goal agreement) with CA.

	Model 1	Model 2	Model 3
Intercept	0.017	0.001	-0.101
	(-0.237, 0.271)	(-0.322, 0.323)	(-0.585, 0.383)
CA Type	-0.034	0.120	0.219
	(-0.394, 0.325)	(-0.358, 0.599)	(-0.453, 0.891)
Gender		-0.066	0.515

		(-0.660, 0.528)	(-0.373, 1.402)
Age		-0.000	0.247
		(-0.286, 0.285)	(-0.233, 0.726)
Education		-0.126	-0.201
		(-0.402, 0.151)	(-0.608, 0.206)
Gender*CA Type		-0.256	-0.840
		(-1.063, 0.551)	(-1.967, 0.287)
Age*CA Type		-0.134	<b>-0.592</b>
		(-0.514, 0.245)	(-1.176, -0.007)
Education*CA Type		0.158	0.233
		(-0.228, 0.544)	(-0.283, 0.748)
GOLD			0.163
			(-0.219, 0.546)
COPD Literacy			<b>0.690</b>
			(0.175, 1.205)
Experience			<b>-0.435</b>
			(-0.841, -0.029)
GOLD*CA Type			-0.324
			(-0.860, 0.212)
COPD Literacy*CA Type			-0.384
			(-0.997, 0.229)
Experience* CA Type			<b>0.570</b>
			(0.012, 1.128)
Observations	120	113	67
R <sup>2</sup>	0.0003	0.030	0.273

Note. CA= Conversational agent. Standardized regression coefficients with 95% confidence intervals in parentheses. Experience is experience with COPD in years since COPD diagnosis. Education is measured in years of formal education. CA Type is coded 0 = paternalistic, 1 = deliberative. Gender is coded 0 = male, 1 = female. Age in years. Experience in years since COPD diagnosis. Significant results are printed in bold font indicating that the 95% Confidence interval does not contain 0.

In summary, we found evidence that age and experience with COPD inform the participants'

preferences for a deliberative or paternalistic interaction style of the CA. Older participants reported better interaction-related outcomes when interacting with a paternalistic CA, younger participants when interacting with a deliberative CA. Subjects with fewer years of personal experience with COPD reported better interaction-related outcomes when interacting with a paternalistic CA, subjects with more years of personal experience when interacting with a deliberative CA. We did not find evidence for gender, disease level, and disease literacy. Irrespective of the CA type, disease literacy positively predicted both dimensions of working alliance, subjects with fewer years of experience with COPD reported higher perceived support in goal agreement by the CA and were more motivated to continue the interaction with the CA. A more severe disease level was associated with a higher motivation to continue the interaction with the CA. Participants who worked with a paternalistic CA were more likely to change their behavior based on the intervention. Thus, our results indicate that knowing age and years of experience of a patient with COPD can help to decide which interaction style to choose for which patient to increase interaction related outcomes for the patient at hand.

## Discussion

In this work, we investigate the preferences of patients with COPD for specific interaction styles of healthcare CAs. Interaction styles between healthcare professionals and patients have long been recognized as a key success factor for chronic disease management and final treatment success [39,40]. Given the rising number of chronically diseased patients and the herewith associated financial and personal burden, CAs represent scalable and ubiquitous digital tools to support chronic patients and relieve human healthcare professionals. A systematic approach for inducing two specific interaction styles into CAs in a healthcare setting has previously been developed and validated [28].

With our first study, we determine baseline differences for preferred interaction styles between 117 COPD patients and CAs. We show that differences in preferences for specific interaction styles for the interaction between chronically diseased patients and CAs exist. In a second study, we explore patterns of preferences for two specific interaction styles with 123 COPD patients. We find evidence that younger patients report better interaction-related outcomes when interacting with a deliberative CA, while older COPD patients report better interaction-related outcomes when interacting with a paternalistic CA. COPD patients with longer personal experience with the disease report better interaction-related outcomes when interacting with a deliberative CA. COPD patients with lower COPD disease literacy report better interaction-related outcomes when interacting with a paternalistic CA. However, neither gender, disease severity, nor disease literacy effect any

preferences for specific interaction styles. Nevertheless, we find evidence that disease literacy, in general, positively predict both dimensions of working alliance independent of the interaction style. This paper is especially important for the development of personalized CAs in the context of digital healthcare, focusing on chronic diseases. To our knowledge, this is the first investigation that systematically evaluates the preferences of chronic patients for their interaction style with CAs. While CAs have primarily been developed portraying a single interaction style for every human counterpart interacting with them, medical research has long stated the crucial importance of deploying personal interaction styles in order to improve patient satisfaction [35], treatment adherence, and final treatment outcome [41,42]. Addressing the gap in literature regarding differentiated and personalized interaction styles for patient-CA interaction and adding to the growing body of literature on CA personalization [10,11], this paper now provides first evidence that chronic patients report better interaction-related outcomes when interacting with CAs that display personalized interaction styles.

The findings of these two studies further inform the pairing of chronic patients to CAs that are personalized on the level of their interaction style. While medical research postulates the relevance of five factors (gender [22,23], age [22,23], disease level [25,43], personal experience with a disease [44], and disease literacy [45,46]) that influence the patient-physician interaction, we can show that not all of these aspects are similarly important when it comes to coupling chronic patients with CAs. Our first results indicate that knowing age and personal experience with a patient's disease is sufficient to decide which interaction style results in increased interaction related outcomes for the patient at hand. While these are first results from a restricted sample in an experimental setting, the implications for CA deployment could be significant. Especially from a privacy perspective, this finding would reduce the amount of personal patient data needed to achieve an advantageous CA-patient allocation as only these two data points are gathered instead of asking a whole plethora of personal data. In addition, these two data points can be easily collected at the start of the patient-CA interaction, without any specific (medical) knowledge needed for assessing them. This could relief the work of healthcare professionals, whose time is limited and costly, as the allocation to the best-fitting CA could be delegated to a simple digital questionnaire at the beginning of the patient-CA interaction.

### **Strengths and Limitations**

This paper has several strengths. First, we followed a two-step approach by determining baseline differences of COPD patients' preference for their interaction with a CA in Study 1 and subsequently

expanding to Study 2, a between-subject online experiment. Second, we deployed a systematic and validated approach for inducing two specific interaction styles into the patient-CA interaction [28]. Third, we continuously ensured an objective approach by integrating both theoretical knowledge as well as applied medical expertise into the development of the experiment. We did this by closely collaborating with medical professionals. Here, we worked together with medical experts on COPD, the chronic disease subject of this paper, but also with healthcare professionals from other fields to reduce the risk of bias. In addition, we integrated the views of both senior and novice healthcare professionals to reflect the traditional paternalistic-based training and the current shared-decision making-based training. Fourth, we focused on investigating the preferences of a specific target population, that is, patients suffering from COPD. This focus on a relatively homogeneous patient group allows us to delve into depth and gain a profound understanding of their preferences.

This work also has limitations. First, we tested baseline differences between all four major interaction styles with Study 1, the paper-pencil study, whereas we only tested personal preferences for the deliberative and the paternalistic interaction style in Study 2, the online experiment. These are the two interaction styles where a systematic and validated approach for inducing a specific interaction style into the CA-patient interaction for a digital online setting exists. They further represent the start- and endpoint of a hypothetical ethical development process of a model patient-physician interaction [47]. Nevertheless, the results from Study 1 indicate that some patients might have personal preferences for other interaction styles than these two. The preferences for these interaction styles need to be investigated by future research. Second, the study population only consisted of German-speaking patients based in one country. It could be that other languages or regions influence different interaction style preferences and personal requirements. Given the usage of a purely text-based CA, interaction styles are instantiated in written form in this study, which in turn are guided by the deployed language, respectively its regional form. Third, we only modelled the first part of an initial interaction between a patient and a CA. In reality, patients would need to interact over a prolonged period of time when a CA supports their (chronic) disease management. Forth, we used a paper-based snippet of a hypothetical patient-CA interaction in Study 1 and a pre-scripted and rule-based CA in Study 2. While these two approaches were necessary due to the study condition in Study 1 – we send a physical letter to the patients – and to control the experimental condition in Study 2, both approaches have their limitations when it comes to emulating a naturalistic patient-physician interaction. We are aware of the increasing number of Artificial Intelligence (AI)-based CAs [4] as well as voice-based CAs for healthcare purposes [48]. We believe this could be an interesting path for future research in this context of personalized patient-CA interaction styles. AI-

based CAs could not only interact in a more naturalistic way by utilizing unconstrained written, spoken, or visual input [4], but could further adapt dynamically to personal developments for example on the level of disease literacy of their human users.

### Suggestions for future research

In general, we advise future research to put a stronger focus on the investigation of patients' personal preferences for specific interaction styles when interacting with CAs based on the long-known importance of this factor in human patient-human physician context. In detail, we see specific possibilities for future research motivated by the limitations of this study and as an extension of it.

First, we advise future research to expand and test the used systematic approach for inducing two specific interaction styles to more interaction styles. This could provide valuable insights into how many different interaction styles for patient-CA interactions are needed. In addition, we recommend future research to study the development of patients' preferences over time. It would be highly relevant to determine whether such preferences stay stable or dynamically evolve over time. Second, we suggest the development and evaluation of CAs in other languages than German and in more diverse geographical settings to investigate the effect of language and regional specificities on patient-CA interaction styles. Third, we recommend focusing on the preferences of patients suffering from different diseases, of both acute and chronic nature. We suggest focusing on differences within as well as between diseases to understand any influencing factor of the medical condition at hand in detail. Fourth, future research could expand our experiment and develop a more extended interaction between patients and an interaction-style personalized CA. This could bear interesting findings for further understanding of dynamic developments of personal preferences for interaction styles between patients and CAs.

Fifth, we believe the development and implementation of AI-based CAs that are able to interact more naturally and adapt dynamically to the patient at hand to yield interesting results in the field of patients' personal preferences for their interaction with a CA.

### Conclusions

The interaction style between patients and physicians is recognized as a critical parameter for patient satisfaction, treatment adherence, and subsequent treatment outcome and as such, also plays a paramount role for chronic disease management. So far, CAs as ubiquitous and scalable digital tools have mainly utilized one single interaction style for every patient, thus ignoring the relevance of personalized interaction styles. With this paper, we show that chronically diseased patients exhibit

preferences for different interaction styles when conversing with a digital health CA. Our results provide evidence that patients' age and personal experience with the disease inform their preferences for a specific interaction style. Hereby, this work provides insights into the rising trend of personalized CAs in healthcare. We envisage a future where every (chronic) patient gets paired with a CA exhibiting the right interaction style at the right moment, dynamically adapting to the needs of the patient, and thereby allowing for a satisfying and fulfilling patient-CA interaction that supports best possible treatment outcomes and disease management.

### **Conflicts of interest**

FW co-chairs the Center for Digital Health Interventions (CDHI), a joint initiative between the Department of Management, Technology and Economics at ETH Zurich and the Institute of Technology Management at the University of St. Gallen. The CDHI is funded in part by the Swiss health insurer CSS. TK is scientific director at the CDHI and a co-founder of Pathmate Technologies, a university spin-off company that delivers digital clinical pathways with the help of CAs. Neither CSS nor Pathmate Technologies were involved in the study described in this paper in any way. None of the healthcare professionals mentioned in this study were involved in the data analysis in any way. CG, TS, AH, and DK report no conflicts of interest.

### **Acknowledgements**

We want to express our deepest gratitude to the hospitals across Switzerland, the Swiss Lung Association, and the self-help association for COPD patients ([www.copd-sauerstoffpatienten.ch](http://www.copd-sauerstoffpatienten.ch)) that allowed us to recruit study participants from their patient population respectively member base. Without them, a study of this scale would not have been possible. We would also like to thank our fellow researchers at ETH Zurich, who helped us pre-test the online experiment to guarantee a seamless experience for the study participants. We would also like to show our gratitude to Marcia Nießen of ETH Zurich for her considerations to the questionnaire of study 1.

### **Abbreviations**

AI = Artificial Intelligence

CA = Conversational Agent

COPD = Chronic Obstructive Pulmonary Disease

GOLD = Global Initiative for Chronic Obstructive Lung Disease



## References

1. Milani RV, Lavie CJ. Health care 2020: reengineering health care delivery to combat chronic disease. *The American journal of medicine*. 2015 Apr 1;128(4):337-43. PMID: 25460529
2. McColl-Kennedy JR, Vargo SL, Dagger TS, Sweeney JC, Kasteren YV. Health care customer value cocreation practice styles. *Journal of Service Research*. 2012 Nov;15(4):370-89.
3. Kvedar JC, Fogel AL, Elenko E, Zohar D. Digital medicine's March on chronic disease. *Nat Biotechnol* 2016 Mar;34(3):239. PMID:26963544
4. Schachner T, Keller R, von Wangenheim F. Artificial Intelligence-Based Conversational Agents for Chronic Conditions: Systematic Literature Review. *JMIR* 2020 Sep 14;22(9):e20701
5. Herring SC. Slouching toward the ordinary: Current trends in computer-mediated communication. *New media & society*. 2004 Feb;6(1):26-36.
6. Jacobs RJ, Lou JQ, Ownby RL, Caballero J. A systematic review of eHealth interventions to improve health literacy. *Health informatics journal*. 2016 Jun;22(2):81-98. PMID: 24916567
7. Car LT, Dhinakaran DA, Kyaw BM, Kowatsch T, Joty S, Theng YL, Atun R. Conversational agents in health care: Scoping review and conceptual analysis. *Journal of medical Internet research*. 2020;22(8):e17158. PMID: 32763886
8. Kramer JN, Künzler F, Mishra V, Smith SN, Kotz D, Scholz U, Fleisch E, Kowatsch T. Which Components of a Smartphone Walking App Help Users to Reach Personalized Step Goals? Results From an Optimization Trial. *Annals of Behavioral Medicine*. 2020 Jul;54(7):518-28. PMID: 32182353
9. ter Stal S, Kramer LL, Tabak M, op den Akker H, Hermens H. Design Features of Embodied Conversational Agents in eHealth: a Literature Review. *International Journal of Human-Computer Studies*. 2020 Feb 7:102409.
10. Kocaballi AB, Berkovsky S, Quiroz JC, Laranjo L, Tong HL, Rezazadegan D, Briatore A, Coiera E. The personalization of conversational agents in health care: Systematic review. *Journal of medical Internet research*. 2019;21(11):e15360. PMID: 31697237

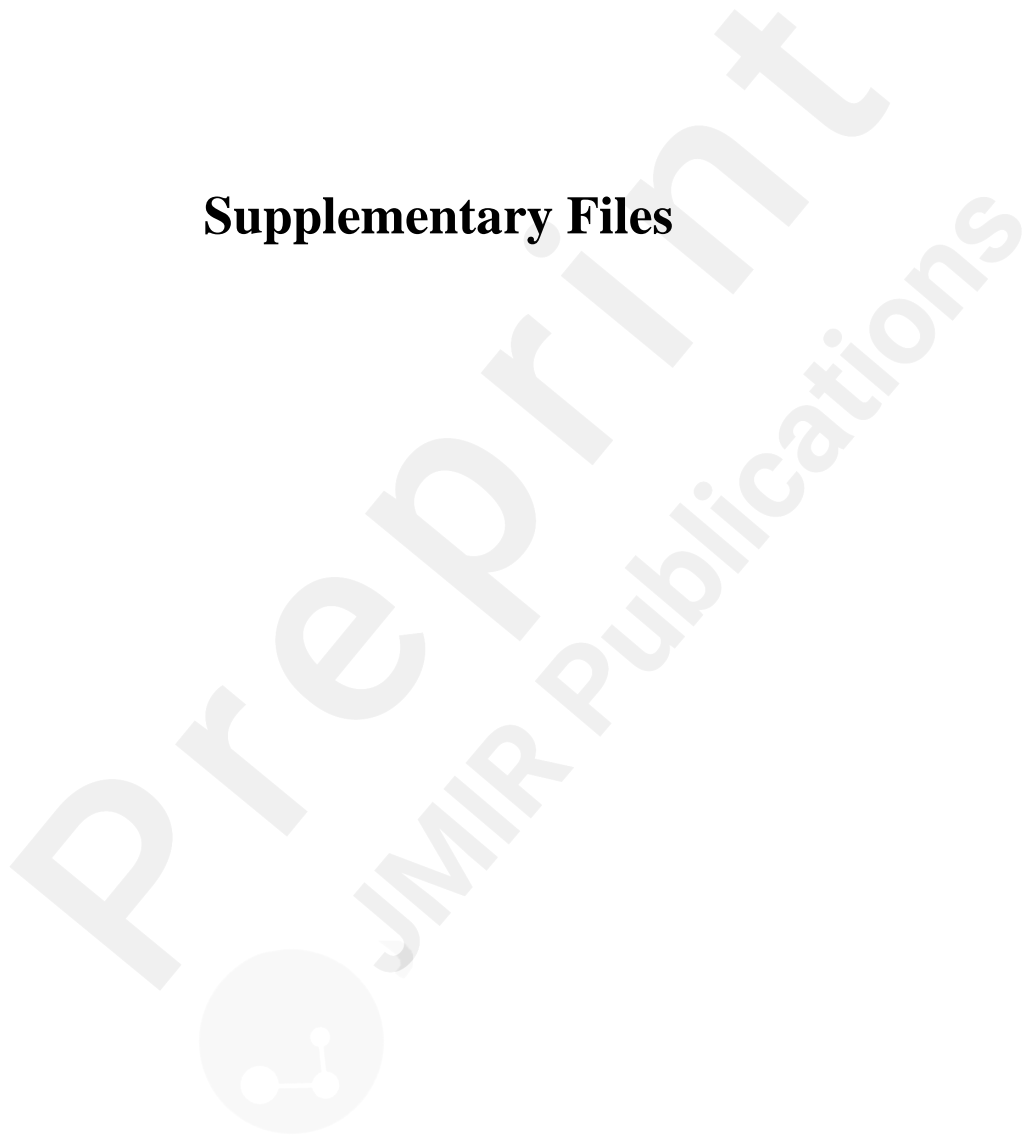
11. Kang SH, Feng AW, Leuski A, Casas D, Shapiro A. The effect of an animated virtual character on mobile chat interactions. In Proceedings of the 3rd International Conference on Human-Agent Interaction 2015 Oct (pp. 105-112)
12. Ong LM, De Haes JC, Hoos AM, Lammes FB. Doctor-patient communication: a review of the literature. *Soc Sci Med* 1995; Apr;40(7):903-18. PMID: 7792630
13. Kaplan SH, Greenfield S, Ware Jr JE. Assessing the effects of physician-patient interactions on the outcomes of chronic disease. *Med Care* 1989 Mar;110-27 PMID: 2646486
14. Flückiger C, Del Re AC, Wampold BE, Horvath AO. The alliance in adult psychotherapy: A meta-analytic synthesis. *Psychotherapy* 2018 Dec;55(4):316. PMID: 29792475
15. Nass C, Steuer J, Tauber ER. Computers are social actors. In Proceedings of the SIGCHI conference on Human factors in computing systems 1994 Apr 24 (pp. 72-78).
16. Emanuel EJ, Emanuel LL. Four models of the physician-patient relationship. *Jama* 1992 Apr;267(16):2221-6. PMID: 1556799
17. Heritage J, Maynard DW. Problems and Prospects in the Study of Physician-Patient Interaction: 30 Years of Research. *Annu Rev Sociol.* 2006 Aug; 32(1):351–374.
18. Borza LR, Gavrilovici C, Stockman R. Ethical Models Of Physician–Patient Relationship Revisited With Regard To Patient Autonomy, Values And Patient Education. *The Medical-Surgical Journal.* 2015 Jun 30;119(2):496-501.
19. Charles C, Gafni A, Whelan T. Shared decision-making in the medical encounter: what does it mean? (or it takes at least two to tango). *Social science & medicine.* 1997 Mar 1;44(5):681-92. PMID: 9032835
20. Bieber C, Müller KG, Blumenstiel K, Schneider A, Richter A, Wilke S, Hartmann M, Eich W. Long-term effects of a shared decision-making intervention on physician–patient interaction and outcome in fibromyalgia: A qualitative and quantitative 1 year follow-up of a randomized controlled trial. *Patient education and counseling.* 2006 Nov 1;63(3):357-66. PMID: 16872795
21. Deber RB, Kraetschmer N, Urowitz S, Sharpe N. Do people want to be autonomous patients? Preferred roles in treatment decision-making in several patient populations. *Health Expectations.*

- 2007 Sep;10(3):248-58. PMID: 17678513
22. Blanchard CG, Labrecque MS, Ruckdeschel JC, Blanchard EB. Information and decision-making preferences of hospitalized adult cancer patients. *Soc Sci Med* 1988;27(11):1139–1145. PMID: 3206248
  23. Benbassat J, Pilpel D, Tidhar M. Patients' preferences for participation in clinical decision making: a review of published surveys. *Behavioral medicine*. 1998 Jan 1;24(2):81-8. PMID: 9695899
  24. Beisecker AE. Aging and the desire for information and input in medical decisions: Patient consumerism in medical encounters. *The Gerontologist*. 1988 Jun 1;28(3):330-5. PMID: 3396915
  25. Say R, Murtagh M, Thomson R. Patients' preference for involvement in medical decision making: a narrative review. *Patient education and counseling*. 2006 Feb 1;60(2):102-14 PMID: 16442453
  26. Murray E, Pollack L, White M, Lo B. Clinical decision-making: Patients' preferences and experiences. *Patient education and counseling*. 2007 Feb 1;65(2):189-96. PMID: 16956742
  27. World Health Organization. Noncommunicable diseases country profiles 2018.
  28. Schachner T, Gross C, Hasl A, Kowatsch T, von Wangenheim F. Deliberative and paternalistic interaction styles for conversational agents in digital health: Procedure and validation through an online experiment. *J Med Internet Res* (forthcoming). doi:10.2196/22919
  29. Zhang, Z., Mai, Y., & Yang, M. (2018). Package 'WebPower'. <https://cran.r-project.org/web/packages/WebPower/WebPower.pdf>
  30. Cohen J. *Statistical power analysis for the behavioral sciences*. 1988.
  31. White R, Walker P, Roberts S, Kalisky S, White P. Bristol COPD Knowledge Questionnaire (BCKQ): testing what we teach patients about COPD. *Chronic respiratory disease*. 2006 Jul;3(3):123-31. PMID: 16916006
  32. Global Initiative for Chronic Obstructive Lung Disease. *Pocket guide to COPD diagnosis,*

- management, and prevention: a guide for health care professionals. Edition. 2018.
33. Bundesamt für Statistik, 2020. <https://www.bfs.admin.ch/bfs/de/home/statistiken/bildung-wissenschaft/bildungssystem.html>
  34. Komiak SY, Benbasat I. The effects of personalization and familiarity on trust and adoption of recommendation agents. *MIS quarterly*. 2006 Dec 1:941-60.
  35. Bickmore TW, Mitchell SE, Jack BW, Paasche-Orlow MK, Pfeifer LM, O'Donnell J. Response to a relational agent by hospital patients with depressive symptoms. *Interact Comput* 2010 Jul;22(4):289–298. PMID: 20628581
  36. Kiluk BD, Serafini K, Frankforter T, Nich C, Carroll KM. Only connect: the working alliance in computer-based cognitive behavioral therapy. *Behaviour research and therapy*. 2014 Dec 1;63:139-46. PMID: 25461789
  37. Lee S, Choi J. Enhancing user experience with conversational agent for movie recommendation: Effects of self-disclosure and reciprocity. *International Journal of Human-Computer Studies*. 2017 Jul 1;103:95-105.
  38. Hatcher RL, Gillaspay JA. Development and validation of a revised short version of the Working Alliance Inventory. *Psychotherapy research*. 2006 Jan 1;16(1):12-25.
  39. Frey U, Suki B. Complexity of chronic asthma and chronic obstructive pulmonary disease: implications for risk assessment, and disease progression and control. *Lancet*. 2008;372(9643):1088–1099. PMID: 18805337
  40. Van Dulmen AM, Bensing JM. Health promoting effects of the physician-patient encounter. *Psychology, Health & Medicine*. 2002 Aug 1;7(3):289-300.
  41. Ma T, Sharifi H, Chattopadhyay D. Virtual Humans in Health-Related Interventions: A Meta-Analysis. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* 2019 May 2 (pp. 1-6).
  42. Fadhil A, Gabrielli S, Kessler FB. Addressing challenges in promoting healthy lifestyles: the AI-chatbot approach. In *Proceedings of the 11th EAI international conference on pervasive computing technologies for healthcare* 2017 May (pp. 261-265).

43. Gibson PG, Talbot PI, Toneguzzi RC. Self-management, autonomy, and quality of life in asthma. *Chest* 1995 Apr;107(4):1003–1008. PMID: 7705105
44. Arora NK. Interacting with cancer patients: the significance of physicians' communication behavior. *Social science & medicine*. 2003 Sep 1;57(5):791-806. PMID: 12850107
45. Montori VM, Gafni A, Charles C. A shared treatment decision-making approach between patients with chronic conditions and their clinicians: The case of diabetes. *Heal Expect* 2006 Mar;9(1):25–36
46. Ousseine YM, Durand MA, Bouhnik AD, 'Ben'Smith A, Mancini J. Multiple health literacy dimensions are associated with physicians' efforts to achieve shared decision-making. *Patient Education and Counseling*. 2019 Nov 1;102(11):1949-56.
47. Reach G. Patient autonomy in chronic care: solving a paradox. *Patient Preference and adherence* 2014;8:15. PMID: 24376345
48. Bérubé C, Schachner T, Keller R, Fleisch E. Voice-based Conversational Agents for the Prevention and Management of Chronic and Mental Conditions: A Systematic Literature Review.

## Supplementary Files



## Multimedia Appendixes

COPD Chatbot Study ETH\_\_Flyer\_English.

URL: <https://asset.jmir.pub/assets/8e61ead17f1adbdc2c16bf626871d76.pdf>

COPD Chatbot Study ETH\_\_Flyer\_German.

URL: <https://asset.jmir.pub/assets/b7a732a7cfb8005a16e89d8b07ea252c.pdf>

COPD Chatbot Study ETH\_\_Letter\_English.

URL: <https://asset.jmir.pub/assets/75da62b251b884a239dd6ccb4b692650.pdf>

COPD Chatbot Study ETH\_\_Letter\_German.

URL: <https://asset.jmir.pub/assets/c36265b762d0477eddcfd0e600bd835.pdf>

Online Experiment\_Study 2\_English.

URL: <https://asset.jmir.pub/assets/b5f286423d9f8a0a686c99331347c8ad.pdf>

Online Experiment\_Study 2\_German.

URL: <https://asset.jmir.pub/assets/f9034007ab397237dba32efab7063dd3.pdf>

Secondary Analyses.

URL: <https://asset.jmir.pub/assets/afc0225cf0fc677c9b46159275b9f921.docx>