Human-Machine Communication Scholarship Trends: An Examination of Research From 2011 to 2021 in Communication Journals

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Abstract

Despite a relatively short history, the modern-day study of communication has grown into multiple subfields. To better understand the relationship between Human-Machine Communication (HMC) research and traditional communication science, this study examines the published scholarship in 28 communication-specific journals from 2011–2021 focused on human-machine communication (HMC). Findings suggest limited prior emphasis of HMC research within the 28 reviewed journals; however, more recent trends show a promising future for HMC scholarship. Additionally, HMC appears to be diverse in the specific context areas of research in the communication context. Finally, we offer future directions of research and suggestions for the development of HMC.

Keywords: human-machine communication, HMC, journals, communication studies, human-robot interaction

Communication has a long history of examining best practices in various contexts. Most scholars trace the beginnings of the Communication Studies/Science field to the rhetorical traditions of the Greeks, the work of Shannon and Weaver, sociology, and others examining propaganda in World War II (Berger, 1991; Schramm et al., 1959; Song et al., 2020). Despite

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a relatively short history, the modern-day study of communication has grown into multiple subfields. For example, the International Communication Association (ICA) includes 33 divisions and interest groups. Mass communication is ICA's longest-standing division, and Human-Machine Communication is the most recent (Tenenboim-Weinblatt & Lee, 2020). Even within the breadth of the communication field, significant differences can be found in the larger and smaller contexts (e.g., interpersonal, organizational, health) (Erba et al., 2018). Newer fields have grown out of even relatively newer subfields. For example, crisis communication is growing out of organizational communication (Lachlan et al., 2019). The communication discipline and subfields are ever-changing.

The newest subfield, Human-Machine Communication (HMC), has developed out of many subfields both in communication and with sympathies to related fields. Most of the work examining machine actors is represented in other fields. Research in human-computer interaction (HCI), human-robot interaction (HRI), and human-agent interaction (HAI) have flourished in the last decades. The discipline of Communication Science/Studies has focused primarily on computer-mediated communication (CMC: technology mediates the interaction between people) (Westerman et al., 2020). The critical point in this research is that the channel of communication is mediated by technology. To better understand the relationship between human-machine communication research and traditional communication science, this study examines the published scholarship in communication-specific journals from 2011–2021 that are focused on HMC. In the following sections, the meaning of HMC and what research areas have been examined under the HMC umbrella are discussed. Specifically, HMC articles from a population of over 9,000 published articles are selected for further inquiry. The study then concludes through an analysis of the trends that emerge in HMC publications for the last decade.

What Is Human-Machine Communication?

Although communication technologies have long been studied as media or channels through which people communicate with one another, machine actors are increasingly being used as a source of communication for other humans. The subfield of HMC has developed to examine this space where machine actors can be communication partners. Although "communication with digital interlocutors ontologically is not the same thing as communication with another human," there are helpful human communication theories and paradigms to understanding HMC (Fortunati & Edwards, 2020, p. 7). As Westerman et al. (2020) note about the role of machine actors in communication, "social action is social action" (p. 394) and thus can be examined using traditional human communication theories as a starting place. Guzman (2018) argues that HMC is not a competitor to HCI, HAI, or HRI but rather subsumes them when communication is central to the investigation. She notes that "HMC can be thought of as an umbrella encompassing the many approaches to people's communication with various technologies" (Guzman, 2018, p. 7). These technologies "are not a medium through which humans interact, but rather a medium with which humans interact" (Zhao, 2006, p. 402). A. Edwards and Edwards (2017) note that "HMC involves communication with digital interlocutors including embodied machine communicators, virtual and artificially intelligent agents (e.g., spoken dialogue systems), and technologically

augmented persons, either in real or virtual and augmented environments" (p. 487). As such, technology is viewed as more than a channel or medium in HMC; it takes on the role of a communicator. This is the crucial distinction between HMC and CMC. While CMC focuses on technology as a medium between people, HMC focuses on a machine potentially serving as a communication partner.

Spence (2019) asked if there was a theory central to the study of HMC. Questions concerning a central theory in HMC have sparked many discussions, bolstering the case for treating HMC as a distinct subject. The interdisciplinary nature of this work is vital for HMC to help develop as a field (Fortunati & Edwards, 2021). In HMC, several existing ideas from other disciplines function well to answer critical questions (See Spence, 2019 for more details). Despite the examination of existing theories from diverse subfields, there is the development of theories specifically targeted at HMC (Craig & Edwards, 2021; A. Edwards et al., 2019; C. Edwards, Edwards, et al., 2016; Spence et al., 2014) and extensions on the CASA paradigm (Gambino et al., 2020; Lombard & Xu, 2021). More targeted and specific theories will be developed and tested as the field grows related to the HMC. We argue that this is necessary for continued growth.

Examining HMC Scholarship from 2011 to 2021

HMC has thus far followed a similar path to other older subfields, growing out of multiple communication fields as previously discussed. The HMC interest group at ICA was officially recognized in 2019. Early-career scholars are beginning to be formally trained in the field. More senior scholars have transitioned their former training and research agendas into the new HMC field. Since the beginning, HMC has grown each year regarding the number of submissions to the interest group. The *Human-Machine Communication* journal was started in 2020 as an open-access journal with an international editorial board to provide a central place for discussion and promotion of research. There have been two HMC workshops at IEEE's HRI conference, workshops and panels at AoIR (Association of Internet Researchers), special issues devoted to HMC in the Central States Communication Association's *Communication Studies*, the *Journal of Communication Pedagogy* journals, and preconferences about HMC at ICA. In short, the last few years have produced a massive increase in the amount of attention devoted to HMC. The same can be said for the areas of HMC research as well.

HMC has been expanding, incorporating subfields of communication. For example, instructional communication scholars have studied robots as teachers (e.g., Abendschein et al., 2021; C. Edwards, Edwards, et al., 2016; C. Edwards et al., 2021). Scholars have examined social robots as interpersonal relational partners (A. Edwards et al., 2019; Ling & Björling, 2020; Lutz & Tamò-Larrieux, 2020; Mattiassi et al., 2021; Rodríguez-Hidalgo, 2020) and chatbots (Banks & Van Ouytsel, 2020; Beattie et al., 2020; C. Edwards, Beattie, et al., 2016). Journalism scholars consider the implications for A.I. reporters (Carlson, 2015; Johanssen & Wang, 2021; Lewis et al., 2019), and crisis and strategic communication scholars consider behavioral outcomes from news from a human or robot (Rainear et al., 2021; Rainear et al., 2019). Moreover, scholars have been interested in issues of identity as it relates to HMC (Davis & Stanovsek, 2021; Dehnert & Leach, 2021; Guzman, 2020; Liu, 2021). Some scholars have focused on issues of automation and algorithms (Ishii et al., 2021; Piercy &

Gist-Mackey, 2021; Utz et al., 2021). Others have examined HMC regarding ethics and theories of mind (Banks, 2019, 2020; Gunkel, 2018, 2020). The larger context (e.g., instruction, interpersonal) and specific HMC context (e.g., humanoid, chatbot) are essential to consider because part of advancing any field is to recognize the collective efforts of its smaller parts (Berger, 1991). These contexts are examined for the current project.

HMC scholarship published from 2011 to 2021 was the central focus of the current study. This time frame was chosen to allow for a glimpse of the development of this work from near its beginning. Although there are earlier examples of HMC work (e.g., Rau et al., 2009; Zhao, 2006), this window demonstrates when mainstream communication science/ studies journals started to publish HMC work. Additionally, this 11-year period coincides with the development of technology utilized in HMC research. For example, Softbank's popular NAO robot was used extensively during this time frame. The same company produced a more robust social robot, Pepper, in 2015. For voice-based agents (VBAs), Amazon's Alexa was released in 2014, which spurred many studies examining this type of machine actor. The first consumer model of Google Glasses and the Oculus VR system started selling in 2014 and 2016, respectively. In other words, our time frame for the current study captures the availability of many of the research tools used. Furthermore, this 11-year window has been used by similar work examining the development of a new field (Beck et al., 2004; Lachlan et al., 2019; Spence & Baker, 2007).

HMC is an interdisciplinary field and focuses on the communication aspects of machine actors. Although relatively new, it has roots in early communication research but expands to new contexts. Examining the published scholarship over the last decade will allow researchers to see opportunities for gaps in the literature, understand how existing HMC research is being conducted, and what types of methods are being used. We will present a series of research questions addressing these issues in the following sections. The first set of research questions will examine where HMC research is published and what context.

> **RQ1:** What percentage of regional, national, and international communication journal articles host human-machine communication research?
>
> **RQ2:** Among the human-machine communication journal articles, what is the (a) larger and (b) specific human-machine communication context?

Just as scholars have carried over prior studied contexts of interest, they have transitioned traditional human-to-human communication research methodologies over to HMC. So much so, the inaugural article of the HMC journal was titled "Opening space for theoretical, methodological, and empirical issues in human-machine communication" (Fortunati & Edwards, 2020, p. 1). Methodology of interest generally includes quantitative, qualitative, rhetorical, or some combination of the broad methodology (i.e., mixed-methods). Even within a seemingly homogeneous, more extensive method such as quantitative, a specific sub-method like survey can vary greatly. For example, the channel the survey is distributed through (e.g., asynchronous online, synchronously administered by the researcher over the phone or in-person), when it is distributed (e.g., cross-sectional, longitudinal over years or days), and who it is distributed to (e.g., one person, dyad, students, workforce). These small but meaningful differences in study design can significantly impact

individual research studies, thus making meta-analyses which are an important method, difficult to apply for now (Schmidt & Hunter, 2015).

Traditional meta-analyses can be valuable tools in correcting study artifacts (e.g., sampling error, error of measurement) and providing a comprehensive review of quantitative results. However, traditional meta-analyses cannot summarize nonempirical arguments. HMC research is influenced by various epistemological and methodological concerns (Guzman & Lewis, 2020), including nonempirical scholarship. For example, HMC scholars have applied rhetorical (Coleman, 2021) and philosophical approaches to machine ethics (e.g., Gunkel, 2012). Therefore, we choose to be inclusive rather than exclusive of our colleagues' work when considering the following research question. We do not know beyond anecdotal evidence of the diverse research methodology techniques, including settings and participant samples used within HMC research. Such knowledge will highlight potential research gaps and point to future research directions. Therefore, the third research question is given.

> **RQ3**: Among the human-machine communication journal articles, what (a) methodological techniques, (b) settings, and (c) samples are most often used?

Method

A census of articles in 28 communication journals spanning 11 years (2011–2021) was completed, resulting in examining 132 HMC articles. To be included, an article was required to be a regular article, editorial, or part of a colloquium. Statements from association presidents, errata, and book reviews were not included in the article count. From the 9,497 articles that fit that criterion, articles then had to be classified as either HMC in focus or not. To be classified as an HMC article, the coder needed to identify the article as fitting into the following criteria: (a) "Human-machine communication as a process is an exchange of messages between people and technology, but in the course of the interaction and as a result of it, both the machine and human may also take on other roles" (Guzman, 2018, p. 17), (b) "HMC involves communication with digital interlocutors including embodied machine communicators, virtual and artificially intelligent agents (e.g., spoken dialogue systems), and technologically augmented persons, either in real or virtual and augmented environments" (A. Edwards & Edwards, 2017, p. 487), and (c) the author(s) identified the article as dealing with HMC in the title, abstract, or keywords. From these criteria 132 Human-Machine Communication emerged from the population defined. Articles were then subject to additional coding to address the research questions in this study.

The 28 journals that were selected for analysis were: *Asian Journal of Communication*, *Communication, Culture and Critique*, *Communication and Critical/Cultural Studies*, *Communication Education*, *Communication Studies*, *Communication Monographs*, *Communication Quarterly*, *Communication Reports*, *Communication Research*, *Communication Research Reports*, *Communication Teacher*, *Communication Theory*, *Critical Studies in Media Communication*, *First Amendment Studies/Communication and Democracy*, *Human Communication Research*, *Human-Machine Communication*, *Journal of Applied Communication Research*, *Journal of Communication Pedagogy*, *Journal of Communication*, *Journal of Computer Mediated Communication*, *Journal of International and Intercultural Communication*,

Mobile Media & Communication, *New Media & Society*, *Quarterly Journal of Speech*, *Review of Communication*, *Southern Communication Journal*, *Text and Performance Quarterly*, and *Western Journal of Communication*. The selection of periodicals included in this analysis was based on previous studies and literature in citation analysis (see Bolkan et al., 2012; Griffin et al., 2018; Hickson et al., 2009; Lachan et al., 2019; Spence & Baker, 2007) and were chosen to give the most substantial representation to HMC within the literature in the field of communication. Whereas other journals may have HMC articles represented, their absence of a direct focus on communication removed them from the analysis.

Measures

Type of Measurement

Articles were classified broadly based on the measurement used; therefore, classifications included quantitative measures, qualitative measures, mixed measures/methods, or no measures. If an article was classified as HMC, subsequent coding determined whether it was quantitative when using meaningful numeric symbols. In contrast, an article was considered qualitative if it presented and discussed results coming from methods such as focus groups, thematic analysis, interviews, or ethnography. An article was coded as mixed measurement if a combination of quantitative or qualitative measures was used as indicated above. A study was coded as having no measurement if there was no attempt to employ an analysis from any criteria or system of measurements; articles fitting this criterion include theory development or literature reviews.

Data Collection and Setting

The procedures of data collection and the research setting also were explored. Eleven categories for how data were collected emerged from discussions between the coders and influence of previous studies (Lachlan et al., 2019; Spence & Baker, 2007). These included experiments, survey research, archival data (including rhetorical analysis, case studies, content analysis, and other texts), meta-analysis, interviews, ethnography, focus groups, literature reviews (including commentaries and theory development), observation, and multiple data collection procedures.

For the research setting, 10 categories were used; these included laboratory research, online experimental research, mail survey, human-assisted surveys, online survey research, online data collection (including social media harvesting), focus groups, field research (including interviews outside a laboratory), multiple settings, and no research setting (such as literature reviews or textual analysis).

Context of the Study

The specific context of both the study and the context of HMC were examined. Ten contexts emerged from discussions between two coders; these included studies focused on interpersonal relationships, small groups, organizational studies, education studies including classroom and instructional communication, journalism, health care, intercultural studies, mass media, rhetoric or analysis of a text, and general communication studies.

Specific context to the role of HMC included the following nine categories: Human-Robot Interaction (HRI), Human-Agent Interaction (HAI), Virtual or Augmented Reality, Automation, Human-Computer Interaction (HCI), Artificial Intelligence (A.I.), General Studies, Algorithms, and Cybernetics.

Participants Within the Examined Studies

Also under investigation were the participants that made up the examined studies. These included student samples, completely volunteer/compensation not specified, social media recruitment, mechanical recruitments (such as MTurk/Qualtrics), multiple recruitment methods, no participants, or participants that receive financial compensation (without mechanical recruitment). The decision to have mechanical recruitment, which involves paid compensation, as a category separate from monetary compensation was based on two reasons provided by Lachlan et al. (2019): These recruitment methods are increasing in popularity, and the debate surrounding their use (see Kees et al., 2017; Sheehan & Pittman, 2016) provides a good avenue of investigation. Moreover, this analysis contributes to a baseline of using this type of recruitment which is distinct from other forms of paid research participation.

Additional Measures

Other information collected was author name and affiliation, Altmetric score, and citation count from Crossref.

Intercoder Reliability

To determine the reliability of the coding of the articles and content between the three coders, a reliability check was completed. Three coders completed categorization of all content within *Communication Research Reports* for the 11-year period. This coding yielded 450 articles for the reliability check concerning categorizing the articles as HMC. A perfect agreement was found between the three coders concerning if an article was classified as an HMC article or not. Then two of the coders completed an analysis of all categories of interest in the 14 articles that were coded as HMC. Intercoder reliability was assessed using ReCal2 (Freelon, 2010). Perfect agreement (Scott's Pi = 1.0) was found for all variables involving coder judgments: general context, HMC context, research setting, type of measurement, data collection, and participants. After perfect agreement was met, the authors independently coded the remaining journals: first author ($N = 13$), second author ($N = 2$), and third author ($N = 12$).

Primary Results

To answer the first research question inquiring the percentage of regional, national, and international communication journal articles devoted to HMC research, several analyses were completed. Full descriptive statistics are reported in Table 1, Table 2, Table 3, and Table 4.

The number of HMC articles was first determined in the census of 9,497 entries published in the investigated time period. Approximately 1.39% of the articles were classified as HMC ($N = 132$). *Human-Machine Communication* published the most articles ($N = 25$) and had the highest percentage of HMC articles published (100%). In reference to the number of HMC articles published, the top four journals after *Human-Machine Communication* were *New Media & Society* ($N = 21$), *Communication Studies* ($N = 20$) with *Communication Research Reports* ($N = 13$), and *Journal of Computer Mediated Communication* following ($N = 13$). By percentage of articles, and after the journal *Human-Machine Communication*, it was again *Communication Studies* and *Journal of Communication Pedagogy* (4.5%) with the *Journal of Computer Mediated Communication* (4.1%) and *Communication Research Reports* (2.9%) following. Both *Communication Studies* and the *Journal of Communication Pedagogy* had special issues that contributed to their numbers during the examination period. Of the 132 articles that were classified as HMC, 26, or 19.7%, appeared in some type of special issue (not necessarily a special issue related to HMC).

HMC articles began to receive increased recognition in the literature starting in 2018 when the number of published articles tripled and began an ascent in representation. In addition, the year 2021 had the highest number of HMC articles published ($N = 57$), followed by 2020 ($N = 26$), 2018 ($N = 14$), and 2019 ($N = 12$). This increase in published articles began 2 years before the launch of the *Human-Machine Communication* journal and highlights both the need for the journal and the emergence of the field of study.

The number of citations an article received and the Altmetric score of each article was also examined. Article citations were based on Crossref citations listed on the journal landing page for each article if available. At the time of data collection, the three most cited articles appeared in the *Journal of Communication*, *New Media & Society*, and *Communication Research Reports* (Ho et al., 2018; Guzman & Lewis, 2020; Spence, et al., 2014, with 79, 78, and 69 citations, respectively). For Altmetric scores, two of the three top scores also appeared in *New Media & Society* and one in *Critical Studies in Media Communication* (Woods, 2018; Guzman & Lewis, 2020; and Yan et al., 2021 with scores of 143, 111, and 78, respectively). The article by Guzman & Lewis (2020) in *New Media & Society* is represented in both the top 3 of citations and Altmetric scores of HMC articles, highlighting this article's heuristic provocation and possibly the perception of interest from readers.

The second research question focused on the context of both the larger scope of the selected studies and the HMC context itself. When examining the context of the study itself, results reveal that interpersonal communication/relationships are the most examined area of HMC, accounting for 32.6% ($N = 43$) of the articles published. An intercultural context accounted for 22% ($N = 29$) of the articles. Mass media (14.4%, $N = 19$), health care (9.1%, $N = 12$), and education (8.3%, $N = 11$), including instructional communication and classroom settings, were the contexts with the most frequency of analysis.

The specific HMC context analysis revealed that virtual/augmented reality (25.7%, $N = 34$) was the most examined context. Followed closely by human-robot interaction (18.9%, $N = 25$), and human-agent interaction (15.9%, $N = 21$) with artificial intelligence (13.6%, $N = 18$) and general studies (13.6%, $N = 18$) also receiving increased attention.

The third research question concerned the methodological techniques, data collection settings, and participants' characteristics in HMC studies. Concerning measurement of data, studies using quantitative data collection methods accounted for almost half of all

studies (48.5%, *N* = 64), followed by studies using no measurement (35.6%, *N* = 47). Qualitative studies (12.1%, *N* = 16) and mixed-method approaches accounted for the smallest number of studies (3.8%, *N* = 5).

The most used type of data collection was an experiment (40.2%, *N* = 53). The second most type coded in the current study did not collect any kind of data (32.6%, *N* = 43). Studies using archival data (8.3%, *N* = 11) and survey data (8.3%, *N* = 11) had the third-highest frequency of occurrence in the sample. All other categories of data collection were under 5% each.

The place where the research took place was labeled the research setting. Studies that did not involve a research setting, such as articles developing theory or literature review, accounted for 39.4% of all articles (*N* = 52). This was followed by studies taking place in a laboratory (30.3%, *N* = 40) and online experiments (12.1%, *N* = 16), and field research (6.8%, *N* = 9) were represented. All other categories were 3% or less.

Post Hoc Analysis

Due to the recent and rapidly growing HMC field, a baseline of research productivity has yet to be determined. To inform the HMC research community of trends and provide evidence for tenure, promotion, and/or funding agencies, a post hoc analysis of authorship trends was conducted. The study identified prominent authors across the field of HMC. There were 264 different authors within the analysis, with nine authors having three or more publications each and 22 authors having two publications. The analysis included authorship regardless of author order, and therefore in some instances, articles were co-authored by two or more individuals with more than three publications. The results of this analysis suggest clusters of HMC scholars at specific departments. The top nine scholars in the analysis were identified by the total number of publications. Among these authors, three have current or one-time affiliations with Western Michigan University, and three also had been an editor for an HMC-related publication. One scholar with more than three HMC publications was a doctoral student at the time of this analysis. For this analysis, please see the following link: https://osf.io/gh7z2.

Discussion

Machine communicators have rapidly developed in the past decade from humanoids (e.g., NAO and Peppers by Softbank) to VBAs (e.g., Amazon's Alexa) and VR (e.g., Oculus). HMC scholars' research agendas have differed while still falling under the same umbrella (Guzman, 2018). This study reviewed the HMC publications in 28 communication journals over the past decade to consider where HMC as a field has been to understand where the field should go (Berger, 1991).

The results from the first research question show a limited past emphasis (1.39%) within the 28 reviewed journals. However, more recent trends show a promising future for HMC scholarship. The number of HMC-related article publications in the reviewed journals grew yearly. Specifically, from 2019 to 2020, the amount of HMC publications grew by 116% and from 2020 to 2021, it grew 119%. The significant growth is likely due to the HMC interest group being established at ICA in 2019 along with the *Human-Machine*

Communication journal in 2020. Roughly 19% of the reviewed HMC articles were published in the *Human-Machine Communication* journal in 2020–2021. There were meaningful contributions in special issues published in *Communication Studies* (2020 and 2021) and the *Journal of Communication Pedagogy* (2021). These special issues in non-HMC specific journals are expected to educate and potentially attract non-HMC scholars who would not usually read the *Human-Machine Communication* journal. With publication trends and the advancement in machine communication technology, we expect HMC publications to grow as they have in the past 2 years exponentially. To help facilitate this growth, we offer insight into the existing strengths and potential opportunities for growth in terms of context and methodology.

Communication has always been interdisciplinary and communication scholars have taken pride in the fact (Zhu & Fu, 2019). This strength is highlighted by the field's interdisciplinary stances across broader and specific HMC contexts and the epistemological and methodological approaches scholars have applied (e.g., Guzman & Lewis, 2020). However, previous reviews have critiqued the focus of interdisciplinary scholarship in that subfields may not successfully work together (e.g., R. T. Craig, 1999). Additionally, scholars may overly compensate by applying other disciplines' principles (e.g., theories) to communication, and the field will not have its unique perspective (Berger, 1991).

Based on the current study's second research question findings, HMC has defied R. T. Craig's (1999) prediction of drastically diverse fields not being able to work together. Over 60% of the reviewed HMC articles were taken from the relational perspective but not limited to a specific context. The larger contexts of interpersonal (32.6%), intercultural (22%), and health care (9.1%) made up the majority of reviewed studies in comparison to "one-to-many" such as mass media (14.4%) and instructional (8.3%) made up a smaller percentage. Within the specific HMC context, 25.7% of the reviewed articles focused on VR or AR, 18.9% HRI, 15.9% HAI, and 13.6% A.I. No one larger context or HMC-specific context makes up over half of the current field. The current balance between communication context and the machine communicator under consideration is well done. We urge future reviews, like ours, to consider the balance across diverse contexts. If an imbalance is dedicated, this review may offer a spark for minority perspectives to contribute more holistically or encourage a special issue.

In comparison to contexts, the results from the methodological analysis (RQ3a–c) showed an imbalance. Over half (64.4%) of the reviewed articles were empirically-based compared to the nonempirical (35.6%). Such nonempirical articles provided a literature review or begin to generate HMC theory (e.g., A. Edwards et al., 2019; C. Edwards, Edwards, et al., 2016; Gambino et al., 2020; Lombard & Xu, 2021). The present literature reviews and initial HMC theoretical ideas are important and practical to an extent. However, we are reminded of Lewin's (1951) famous quote "there is nothing so practical as a good theory" (p. 169). A fully fleshed-out HMC theory with its theoretical propositions will serve the community well. Such action will further define our field, respond to Berger's (1991) critique of the communication discipline, begin to answer Spence's (2019) question about what the central question HMC scholars are working toward, and open new lines of research inquiry.

Of the reviewed empirical articles, three quarters (75.3%) were quantitative, while qualitative (18.8%) and mixed methods (5.9%) made up a significantly smaller portion. The imbalance is strong but is in line with other related analyses. For example, roughly 85% of

interpersonal scholarships is quantitative, while 13% is qualitative (Braithwaite et al., 2015). Reviews of mobile communication scholarship (a subset of mediated interpersonal scholarship) find 59% of the scholarship is quantitative, while 37% is qualitative and 4% is mixed methods (Kim et al., 2017). When considered together, the strong presence of quantitative methods makes sense given interpersonal was the most common context. Beyond specific communication context, a review of ICA's flagship journal, the *Journal of Communication* revealed roughly 79% of all manuscripts were quantitative. In comparison, 16% were qualitative, and 4% mixed-method (Walter et al., 2018), suggesting HMC methodology aligns with specific contexts and the broader communication field. Or rather, HMC scholars are likely transitioning their former research methods training and applying the same analytical skills to the new HMC context.

More imbalances were found concerning specific methods within the more significant epistemology, thus offering some immediate practical suggestions. The majority (82.8%) of quantitative studies were experiments and surveys, making up a smaller (17.2%) portion. Results are similar but appear to be more experimental focused when compared to other communication technology research (Erba et al., 2018). Of the experiments, three quarters (75.5%) were conducted in-person in a research lab, while the remaining quarter (24.5%) was conducted online. Thus, the majority of our current knowledge stems from cause-and-effect studies. We did not code if individual studies were cross-sectional or longitudinal. Anecdotally, the reviewed experiments considered direct effects instead of lagged or longitudinal. This begs the question, what important nuances of HMC may have been missed that a grounded qualitative (e.g., interviews, observation) or longitudinal quantitative approach would reveal? For example, a user's motive(s) to communicate with a machine (e.g., Choi & Drumwright, 2021) and how, if at all, that changes over time.

HMC research has increased exponentially; however, the present rate offers scholars time to learn a new method or analysis technique and stay up-to-date with the research trends. Intentionally learning a new research method to fulfill a unique project will inherently take more time than using the research methods scholars have formerly used or were formally trained in. Based on our post hoc analysis of authorship trends, the most published HMC scholars, at least in the journals reviewed, such as those in the top 3.8% ($N = 9$), had three or more publications. In comparison, the top 13.1% ($N = 31$) had two or more HMC publications. We expect this metric to provide significant value to our colleagues pursuing academic employment, promotion, tenure, and research funding. Additionally, we hope such data provides evidence of clarity and excitement for junior scholars considering this new and budding field. As for the over 90% of authors who had one HMC publication, we encourage them to keep contributing. Prior, non-HMC reviews have revealed it is more common for authors to publish once within a specific time frame (e.g., Bolkan et al., 2012; Hickson et al., 2009). Although not limited to HMC expressly, understanding why most scholars only publish once on a given topic would be insightful for many reasons.

The present study has clarified the field but is not without its limitations. Given the small sample ($N = 132$) of included articles in the present study, if enough HMC-related articles exist in non-communication-specific journals, it would undoubtedly impact the results. Future similar studies should consist of, or at least consider, HMC articles in non-communication-specific journals. Such change may remove any bias in results such as included scholarship that is HMC but not from communication scholars and thus is

published in their home discipline. Alternatively, our emphasis was on assessing the degree to which regional (Central States, Eastern States, Southern States, and Western States Communication Association), national (National Communication Association), international (ICA) journals, and high-impact communication journals included HMC-related articles. Our focus emphasized the communication aspect of HMC and led us to use specific conceptual definitions of HMC (e.g., A. Edwards & Edwards, 2017; Guzman, 2018). Our results could differ if we expanded upon our inclusion criteria; likewise, they would differ if we based on inclusion criteria by only one definition. Future studies must carefully consider how and why they collect and assess articles and the impact it will have on results. For example, *Computers in Human Behavior* would be one such journal where there is HMC research published.

If we can make two calls to action to our colleagues, it is the importance of theory and innovation. First, acknowledging if certain theories are more common than others and thus steering our understanding and the academic conversation. Unfortunately, the present study did not code for if articles were founded in theory or not (i.e., atheoretical). Such information in future studies would be fruitful. Prior reviews of communication journals have established that 50 to 70% of all articles are atheoretical (Borah, 2017; Walter et al., 2018). Anecdotally, we do not expect HMC articles to have such a high atheoretical ratio; however, that assumption should still be tested. Future studies should examine the theoretical frames chosen by HMC scholars as the community seeks to develop HMC-specific theories.

Second, the lifeblood of any business (Taneja et al., 2016), or in our case academic field, is innovation. We fear if the dominant methodology (laboratory cross-sectional experiment) continues on its trajectory and new scholars solely use and/or are trained in the method, it will lead to naivete in our understanding of HMC. We believe by purposely keeping to our interdisciplinary nature will prevent such an event. Areas of interest that were not discovered in our analysis include, but are not limited to, intersectionality and marginalized individuals and communities (e.g., ethnicity, class, gender identity, sexuality, sexual orientation, physical ability), critical cultural (e.g., prejudice, discrimination), and relational and group development. We suspect these areas to be formally trained in the non-HMC dominant methodology, such as ethnography, focus groups, naturalistic observations, field and case studies, and rhetorical methods. Like all group work, more diverse ideas being contributed through synergistic methods will lead to creative and beneficial outcomes (Towe, 1996).

The purpose of this study was to examine the published scholarship in 28 communication-specific journals from 2011–2021 to uncover the work that has been done in HMC. Findings suggest a strong beginning to this subfield and one that is inclusive of many other subfields in communication. Additionally, this study highlights the need for a HMC-specific journal to foster the continued growth of this research. Future scholars should keep broadening the scope of HMC research into other methodologies (e.g., more qualitative and rhetorical studies) and should seek to develop HMC-specific theories.

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TABLE 1 Total Number of HMC Articles by Journal Ranked by Percentage of HMC Articles			
Journal	Amount of HMC Articles	Total Articles in Journal	Percentage of HMC Articles
Human-Machine Communication (HMC)	25	25	100%
Communication Studies (CS)	20	444	4.5%
Journal of Communication Pedagogy (JCP)	4	88	4.5%
Journal of Computer Mediated Communication (JCMC)	13	314	4.1%
Communication Research Reports (CRR)	13	447	2.9%
First Amendment Studies/Communication and Democracy (FAS)	2	117	1.7%
New Media & Society (NM&S)	21	1,320	1.6%
Communication Education (CE)	4	267	1.4%
Review of Communication (RC)	4	278	1.4%
Mobile Media & Communication (MM&C)	3	220	1.3%
Quarterly Journal of Speech (QJS)	3	222	1.3%
Critical Studies in Media Communication (CSMC)	4	342	1.1%
Communication Reports (CR)	1	132	0.75%
Communication, Culture and Critique (CCC)	3	431	0.69%
Communication Research (CRE)	3	490	0.61%
Communication and Critical/Cultural Studies (CCCS)	2	348	0.57%
Human Communication Research (HCR)	1	251	0.39%
Journal of Communication (JOC)	2	527	0.37%
Communication Quarterly (CQ)	1	348	0.28%
Asian Journal of Communication (AJC)	1	365	0.27%
Communication Theory (CT)	1	272	0.26%
Communication Teacher (CTE)	1	453	0.2%
Communication Monographs (CM)	0	268	0.0%
Journal of Applied Communication Research (JACR)	0	307	0.0%
Journal of International and Intercultural Communication (JIIC)	0	230	0.0%
Southern Communication Journal (SCJ)	0	291	0.0%
Text and Performance Quarterly (TPQ)*	0	326	0.0%
Western Journal of Communication (WJC)	0	374	0.0%
Total	132	9,497	1.39%

Note. For the year 2021 issues 3 and 4 of *Text and Performance Quarterly* were not completed at the time of analysis.

TABLE 2   HMC Articles by Year and Journal

	HMC	CS	CRR	SJC	CQ	CR	WJC	HCR	JCMC	CT	JOC	CE	JACR	CM	CRE	NM&S	AJC	MM&C	JCP	QJS	CCCS	CTE	CSMC	FAS	JIIC	TPQ	RC	CCC	Total
2011	Np	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	Np	0	0	1	0	0	0	0	0	0	3
2012	Np	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Np	0	0	0	0	0	0	0	0	0	0
2013	Np	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	Np	0	0	0	0	0	0	0	0	0	1
2014	Np	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	Np	0	0	0	1	0	0	0	0	0	4
2015	Np	0	1	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	Np	0	0	0	0	0	0	0	0	0	4
2016	Np	2	1	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	Np	1	0	0	0	0	0	0	0	0	7
2017	Np	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	Np	0	1	0	0	0	0	0	1	0	4
2018	Np	0	5	0	0	0	0	0	0	0	1	1	0	0	0	3	0	0	0	0	0	0	2	1	0	0	1	0	14
2019	Np	1	1	0	0	0	0	0	1	0	0	0	0	0	0	3	0	2	0	1	0	0	1	0	0	0	0	2	12
2020	8	7	1	0	0	0	0	0	3	0	0	1	0	0	1	2	0	0	0	1	0	0	0	1	0	0	0	1	26
2021	17	10	3	0	1	1	0	0	4	1	0	2	0	0	0	10	1	0	4	0	1	0	0	0	0	0*	2	0	57
Total	25	20	13	0	1	1	0	1	13	1	2	4	0	0	3	21	1	3	4	3	2	1	4	2	0	0*	4	3	132

Note. For the year 2021 issues 3 and 4 of *Text and Performance Quarterly* were not completed at the time of analysis. Np = Not published.

TABLE 3 Top 3 Most Cited Articles			
Author	**Year**	**Journal**	**Times Cited (Crossref)**
Ho, A., Hancock, J. T., & Miner, A. S.	2018	JOC	79
Guzman, A. L., & Lewis, S.C.	2020	NM&S	78
Spence, P. R., Westerman, D., Edwards, C., & Edwards, A.	2014	CRR	69

TABLE 4 Top 3 Articles in Altmetric Score			
Author	**Year**	**Journal**	**Altemtric Score**
Woods, H. S.	2018	CSMC	143
Guzman, A. L., & Lewis, S. C.	2020	NM&S	111
Yan, H. Y., Yang, K. C., Menczer, F., & Shanahan, J.	2021	NM&S	78