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AI and people: A review of current research on human-machine interaction

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Abstract

As society becomes more reliant on intelligent machines, the nascent field of human-AI relations deserves more attention from academics, scientists, engineers and developers. There is growing employment of artificial intelligence and robots in medicine and healthcare, education, scientific research, military applications, business and other fields. It is in the interest of various stakeholders to conduct more research and experiments in human-machine studies. From looking at recent literature on the subject, I found three key points being discussed by scholars: the current state of research and how it can be developed; common weaknesses of AI/robots based on direct user experience; and the benefits and drawbacks of giving machines anthropomorphic characteristics.

Keywords: Human-Machine Communication; Human-AI Relations; Human-AI Interaction; Artificial Intelligence; Chatbots; AI Agents

1. Introduction

Arguably having its beginnings from Walter Lippman's ideas on public opinion and propaganda in the 1930s, Harold Lasswell's (1948) formula, the linear model by Claude Shannon and Warren Weaver (1949), and C.E. Osgood and Wilbur Schramm's (1954) circular communication process, communication studies branched off from the social sciences during the mid-20th century and evolved into a separate discipline of its own with more scholars introducing newer theories and models throughout the decades [1][2][3]. Coincidentally, this era in human history also saw the early days of artificial intelligence with Nobert Wiener's 1948 pioneering book, *Cybernetics* [4], and the invention of the integrated circuit, electronic calculators and digital computing (thanks to developments from the 1800s, such as electricity, Charles Babbage's vision of a programmable machine, George Boole's binary algebra, just to name a few) [5] starting in the 1940s with inventors like David Packard, Bill Hewlett, George Stibitz, Jack Kilby, Robert Noyce, Conrad Zuse, John Atanasoff and scientists such as Alan Turing and Gordon Moore.

This review article is the first of a series of continuous studies on the interaction, communication and relationship between people and intelligent machines. I devoted this entire first article to review literature on the subject in an attempt to find the current trends and common issues being discussed by researchers in the field plus the known and potential opportunities in the AI industry in which academic researchers could contribute to the betterment of human-AI interaction.

2. Methodology

Using keywords such as "*human AI communication*", "*human AI interaction*" and "*human machine communication*" on Google and DuckDuckGo search engines, I sifted ResearchGate, Taylor & Francis Online, Academia, Wiley Online and Google Scholar and selected twenty eight out of over fifty articles and research papers on subjects related to the

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communication and interaction between humans and intelligent machines. Each had to be a journal article or a thesis, written in English, with an active DOI or URL unless it happens to be in print, and published no later than 2019. I added another seven articles or books that are either on computers or communication theory. I will use certain terms interchangeably in this review article without distinction except when needed. These terms include *intelligent machines, artificial intelligence, AI, AI agents, robots, chatbots, artificial agents;* and *human-machine communication, human-AI communication, human-machine interaction,* and *human-AI interaction*. My review of the literature revealed three main issues. Firstly, there needs to be newer approaches, theories and methods specifically for studying this relatively new field. Secondly, while chatbots and AI agents have proven to be very good at certain tasks, even the most advanced technologies have shown to be wanting in other important areas. Thirdly, while anthropomorphism of AI and robots has its obvious advantages, they can counterintuitively be a turn-off for users.

2.1. Conventional Communication Theories and Paradigms Need to Be Revisited

Traditional theories may no longer suffice since they are based on the paradigm that communication is an act exclusively between humans. Even computer-mediated communication (CMC) [6] is founded on the same principle with machines limited to the role of medium between human agents, which arguably renders current CMC models unfit for human-machine communication studies. There are those who point to the need for a new set of theories and models. Some even call for a completely new discipline independent of computer-mediated communication or even communication studies altogether.

Ayub argued that "AI-mediation necessitates a re-conceptualization of classical models in which attention to meaning gets constructed algorithmically rather than through social negotiation" (7 p5). Three months' worth of data were collected from conversations, which revealed that: when talking to a machine or AI, people tend "to become quite concrete and use short sentences, simple vocabulary, and command-based wording."; AI were mostly "grammatically correct but contextually inappropriate" (7 p4); users could be satisfied or disappointed depending on its responses. These intelligent machines did well in task-oriented communication but fell short in displaying emotive interaction.

Bhuiyan called for AI-mediated communication to be considered an independent discipline within Communication Studies and argued that with "the introduction of AI in interactions among people, there is a possibility for a transformation in communication, upending assumptions around agency and mediation, and introducing new ethical questions" (8 p41-42). As the technology advances, AI will be more widely used as a communications tool and intermediary while its influence on human society will be even more difficult to ignore.

Brandizzi studied how game design could be an essential aspect of emergent communication research and pointed to communication and choice of input representation as crucial components with both being employed in referential games. This activity tries to recreate the "environment in which language emerged, emphasizing the view that human language did not emerge as a goal itself but rather as a means of coordinating actions between humans" (9 p7). The author called for a balance between an artificial agent's high capacity for memorization and its ability to generalize, with a slightly higher emphasis on generalization to make it more akin to human-like learning. With reinforcement learning, artificial agents learn from interacting with a game environment similar to how animals and people adapt to changing circumstances while in supervised learning, agents learn from labeled data akin to how people learn from demonstration. The author also examined the different interaction types used to train agents, mainly, space-oriented and time-oriented; and the Theory of Mind, which "refers to our ability to form beliefs about how others might react to certain stimuli and update them with new observations" (9 p13).

Looking at previous experiments and field studies involving interactions between people with chatbots or voice assistants, a study by Greussing et al. [10] found a number of challenges: it is difficult to find human subjects with sufficient interaction with chatbots, voice assistants or social robots; there is a lack of ways to measure the meaning-making activity in human-machine communication; and the human subject's preconceived notions of the AI they are assigned to interact with in an experiment may likely affect the results. These experiments are better suited for certain types of study (e.g., those that require very controlled conditions) but not for research into real-life interactions. Vignette studies have passive human observers but exclude them interacting with the agent. The Wizard of Oz approach can be a good option under a controlled environment but is not an actual conversation between a human and a machine. Creating one's own agent for an experiment can be very technical, expensive and time-consuming while finding an existing one might turn out to be inadequate for the study. The authors also found a dearth in field studies.

Describing artificial intelligence-mediated communication (AI-MC) as a form of human-to-human communication that involves an agent (AI) which performs certain functions (suggesting, generating, modifying messages) that affect the exchange between the human communicators, Hancock et al. [11] listed six dimensions they propose could aide in

categorizing AI-MC interventions: *magnitude* (extent of the changes to messages made by AI), *media type* (text, audio, video), *synchronicity* (making real-time adjustments during a conversation), *optimization goal* (the purpose of using AI in the first place), *autonomy* (degree to which AI can act with minimal supervision), and *role orientation* (AI take the role of sender or receiver). Some questions include how AI-MC could shape human language and thought and how people adapt in their interpersonal communication as a result of the influence of agents; how human communicators will think or behave differently knowing that the messages they send or receive are modified by an AI; the impact of AI-MC on people's self-perception, image shifting, relationship building and intimacy; the presence of human biases in agents, the question of whether AI ought to reveal their involvement in a communication setting, misinterpretation and manipulation resulting from the employment of artificial agents; and other ethical issues.

Lee recommended analyzing if humans respond differently to intelligent machines than they do to other humans and going deeper into the why and how. The pre-AI era had the idea of computers as social actors (CASA) wherein people treat computers like humans. Ironically, with the advent of more advanced AI agents that can more closely mimic human speech, recent studies propose that users respond to AI differently than they do to other people. In light of this contradiction, the author scrutinized the research traditions of the mindlessness account and the machine heuristic to try and integrate both but also to make room for deviation. According to Lee, there hasn't been rigorous scientific scrutiny of the mindlessness account but was rather assumed as a legitimate theoretical explanation and either presumed or inferred from people's reactions to computers. Despite the amount of literature on the CASA paradigm, only a few studies attempted "to validate the mindlessness explanation directly, precisely conceptualize what 'social responses' are, and/or articulate the process through which mindlessness induces social responses" (12 p185). While machine heuristic is a good addition to CASA, a number of issues need to be addressed.

Peter and Kuhne found it surprising that communication researchers have not invested in human-robot interactions since "in any interaction between social robots and humans some type of communication is essential, regardless of whether this communication is verbal or non-verbal" (13 p73). They presented three reasons to justify an increase in academic attention to this phenomenon. Firstly, social robots should make us rethink the idea of media. These machines have progressed from transmitters of messages to creators and receivers of messages. Secondly, traditional communication theories regard people as communication partners, but now we have social robots fulfilling the exact same role. It is imperative to include non-human communication partners in theoretical frameworks. Thirdly, this brings into question the boundaries of communication. Robots can take on human-like, animal-like, cartoonish or machine-like features and may someday surpass people in language and visual skills. This new phenomenon could possibly challenge face-to-face communication as the gold standard.

Wang and Goel [14] proposed the Mutual Theory of Mind (MTom) as a framework to provide an account of human-AI communication that emphasizes the repetitious mutual shaping of each party's interpretations and feedback. MToM includes three elements needed to achieve mutual understanding between human and AI. One is *interpretation* of what's on the other party's mind. Another is *feedback* (verbal or behavioral cues), which is based on the party's interpretation of their counterpart. A third is *mutuality*. Since communication is two-way, both parties mutually shape each other's interpretations of each other's minds through feedback. MToM also includes three stages. The first stage, *AI's construction of its ToM*, sees it attempting to interpret what is on the user's mind based on the latter's feedback. This could include the artificial intelligence trying to comprehend the human's needs, goals or preferences. The intelligent machine's response is followed by the second stage, the *user's recognition of AI's ToM*. The human figures out how well they were understood and how the AI thinks and replies. In the third stage, the *AI's revision of its ToM*, the AI aims to update or modify its interpretation based on the human's feedback.

To contribute to future designs of what they referred to as conversational agents (CA), Zheng et al. collected literature on dyadic and polyadic human-AI interaction, with a heavier concentration on the polyadic. With mixed-method analysis, they developed tools to evaluate and measure the effects of artificial intelligence on the four aspects of human-to-human communication: communication, engagement, connection and relationship maintenance. Results suggested the importance of considering privacy, disclosure and identification when designing these systems. The authors mentioned the lack of studies on polyadic conversational agents (compared to dyadic), which they deemed unfortunate given the growth of polyadic human-AI interaction and the potential benefits this could offer. The authors concluded the major challenges in polyadic interaction were inefficient communication, inactive engagement, maintaining positive relations, and finding common ground. They also found shared aspects between polyadic and dyadic CAs: application domain, modality, agent characteristics, design originality, design method, and evaluation methods. On the other hand, polyadic CAs have their own unique aspects due to their multi-user nature: relationship types, social scale, theories and frameworks that have been applied to the study of polyadic CAs. The authors referred to studies which suggest "polyadic CAs can help with consensus-reaching, aid communication comprehension, enhance task management, and save the time and energy of human collaborators from tedious work...benefit group dynamics through encouraging engagement

and balancing uneven participation...regulating emotions and relationships to maintain harmonized group dynamics" (15 p10). There, too, are overlooked issues in terms of appropriateness, privacy and ethics in the designs of conversational agents: lack of users' awareness of the CA; making sure CAs are not intrusive or annoying; and if CAs should be held accountable.

Pentina et al. [16] noticed a dearth of literature on the subject which simultaneously suffers from inconsistent findings. They argued there isn't a single existing theory that accurately explains the relationship development process. Their study explored the underlying mechanism of post-adoption human-AI relationship development specifically with social companion chatbots. They suggested a new theoretical framework that takes concepts from the human-computer interaction knowledge stream (e.g., anthropomorphism and social presence theories), the social-psychology interpersonal relationship scholarship (e.g., attachment), and communications research (Uses and Gratifications Theory).

Spence [17] justified human-machine communication (HMC) as a distinct field of study by pointing to academic programs, dissertations and laboratories involved in HMC and cited previous researchers who suggested HMC encompasses other categories of communication involving people and technology. Spence suggested there are theories from other related fields that can and do work for HMC studies while stating that newer models of HMC are being developed. There is the debate on whether human-to-human communication and face-to-face communication are still the gold standards. For example, can substituting a human with a machine in a communications experiment offer researchers insight to improve communication overall?

Recognizing the difficulties of reconciling human-AI interaction with more traditional communication paradigms in human-to-human communication, Guzman and Lewis [18] attempted to introduce a theoretical basis to deal with these conditions in the form of scholarship within human–machine communication (HMC) to outline a research agenda built around three main aspects of communicative AI, which the authors called the functional dimensions, relational dynamics and metaphysical implications.

Natale [19] examined publications on artificial intelligence and communication and concluded the importance of the human component in human-machine communication (HMC) and that HMC challenges the traditional idea of intelligent machines as mere channels since AI can also function as a creator of messages. The author reminded readers of the need to consider HMC as a growing area of study in communication and media studies.

There needs further research into how humans perceive and interact with artificial intelligence. Westerman et al. [20] discussed a number of communication theories that they recommended would be useful in future studies on the subject.

2.2. Intelligent Machines Have Improved Greatly But Still Require More Development in Order to Be Integrated Into and Be Fully Accepted By Society

Robots and machines have come a long way from their humble beginnings and are now an ever growing part of daily human lives. Their continuing development will only make them even more useful and arguably necessary for future human progress. But while artificial intelligence excels in various functions such as computation and data storage, they fall short in others including the ability to show empathy or understand context, two very sought after qualities in conversational agents. Chatbots and AI agents are used, to great effect, as service representatives in product marketing, sales, education, mental health, tech and other fields. They have surpassed humans in a number of technical skills and will most likely do so in even more tasks in the future. On the other hand, data reveal users' frustration and disappointment with artificial agents, citing weaknesses in their ability to understand nuances or human emotions.

Research by Boucher et al. looked at the deployment of AI chatbots in digital mental health interventions (DMHIs) and the possible future applications and issues. They pointed to the lack of empirical research amidst thousands of mental health apps. Despite the decade-old presence of DMHIs, AI have only been recently incorporated into existing platforms and products. These include "health communication, virtual reality, symptom and biomarker monitoring, mental health triage, digital phenotyping to predict outcomes, and personalization of content" (21 p38) and chatbots. AI are now used for mental health-related services, such as depression, substance abuse, PTSD, phobias and can perform a number of functions including "assistance, screening, psychoeducation, therapeutic intervention, monitoring behavior changes, and relapse prevention" (21 p39). There are reports of user dissatisfaction with using chatbots that may affect motivation to continue the program. Some include misunderstandings on the part of either the user or the chatbot, the tendency of chatbots to be repetitive, or their inability to feel empathy. There is limited research suggesting users do find emotional support from certain chatbots in some cases. The authors concluded the mental health industry needs

to embrace chatbots for their adoption to be scalable and pointed to the continuous improvement of AI that may someday include the ability to convey empathy.

AI are being employed as communication automation tools for many network operators. They are able to solve real-world problems in seemingly superhuman fashion. Danso et al. identified the four most common AI technologies used to enhance human communication: machine learning (ML) involves "analysing and interpreting patterns and structures in data to enable communication, learning, reasoning, and decision making"; human-machine communication (HMC) "focuses on the study of the creation of meaning among humans and machines...theory related to people's interactions with technologies"; computer-mediated communication (CMC) includes "AI technology that can be used between people using network-connected digital devices to exchange messages"; while ChatGPT is "pre-trained based on a vast corpus of human-generated text, and further extensively fine-tuned on specific tasks...excellent at using natural language, trained to guess the next word, generating highly human-like text, or performing other human language tasks" (22 p1398). The growing availability of monitoring data, advancements in computing platforms, and AI's ability to address a wide suite of challenges have led to their continuous adaptation and integration.

Gomez et al. [23] introduced a taxonomy to study human-AI interaction that would lead to better systems and protocols to enhance collaboration between people and intelligent machines. A point of concern is the effectiveness of AI in aiding humans with decision-making, which involves the AI finding, selecting, analyzing and presenting the best data required by the human. One area of disconnect is the difference between the user's expectations and the algorithm's suggestions. In addition to the what, how and when, the authors insisted AI be able to justify its suggestions plus its mode and sequence of presenting them. Their taxonomy includes seven categories of interaction patterns: (1) *AI-first assistance* (the decision-making problem and AI-predicted outcome are presented to the human user; (2) *AI-follow assistance* (the user compares his/her independent judgment with that of the AI's; (3) *Secondary assistance* (the AI provides supplementary information); (4) *Request-driven AI assistance* (the user actively seeks the AI's input); (5) *AI-guided dialogue user engagement* (the AI gives instructions to be followed by the user and followed by the AI predicting an outcome); (6) *User-guided interactive adjustments* (the user provides the AI feedback such as changes or corrections); and (7) *Delegation* (the AI and user complement each other with contributions based on the abilities of each party). For practical purposes, selecting the most appropriate categories to apply to a certain situation (for example, diagnosing a medical condition, predicting student grades, labeling bird subspecies, or image classification) is dependent on the capabilities of the AI, the particular need of the users and their familiarity with the technology.

Psychotherapy finds both opportunities and risks in its adoption of conversational artificial intelligence (CAI) according to Sedlakova and Trachsel [24] whose study focused on ethical issues concerning the use of AI in mental healthcare. Their two objectives included the question of whether CAI should be considered a tool or agent and a call for further analysis of human-AI interaction as a framework for defining the role and status of AI in psychotherapy. They argued for a balance in the treatment of CAI as both tool and therapist and that AI's role in conversations need to be limited to a set of clearly defined functions. They pointed to studies suggesting the many benefits of using AI in the industry but reminded readers of the need for proper ethical standards.

AI systems are now able to understand and respond with social cues based on inferences made from a human's implicit or explicit behavioral and verbal cues and play a wider spectrum of social roles, such as matchmakers or assistants. It is critical for AI designers to understand user experience and impression and to satisfy their needs. People's high but unrealistic expectations sometimes lead to disappointment and outright abandonment, meaning, there is a mismatch between user expectation and experience. There are benefits of having an AI that can correctly understand users' perceptions of it and adjust its communication accordingly. One study [14] used an AI agent as a virtual teaching assistant to students in a ten-week experiment, collecting students' perceptions of the agent's perceived anthropomorphism, intelligence and likeability. Linguistic cues were extracted from questions that students asked the agent, and linear regression models were used to predict the student community's perceptions. Results suggested verbosity led to negative perceptions of the AI while linguistic cues like readability, sentiment, diversity and adaptability positively associate with anthropomorphism, intelligence and likeability. In another experiment [14], people were found to be forgiving or accepting of an AI's misrepresentation of their personal profiles. Some believed there was an element of truth while others blamed themselves. These results mandate AI be equipped to realize and correct its errors in misrepresentation.

There are many types of AI that fulfill various roles including shopping, customer service, healthcare and companionship; the resulting emotional dependence of some users on these intelligent machines; and the adoption of chatbots as relationship partners which mandates an investigation into their relationship development capacity, the process, antecedents and consequences. Potential negative implications for individuals and society also need further evaluation [16].

On the issue of human-machine communication in education, Edwards et al. [25] endorsed the importance of including artificial intelligence and machine agents in instructional scholarship within and outside the traditional classroom.

In their study of over 300 nonclinical samples, Lee et al. [26] examined how rapport works between a human user and a chatbot acting as counselor to see if it lowers psychological barriers due to the fear of being judged and whether it encourages self-disclosure. Their study sought to provide practical implications for employing artificial intelligence in psychotherapy.

2.3. Anthropomorphism of AI agents and Chatbots Seems to Be a Requisite to Adoption By Users But Can Undermine Their Acceptance When Not Done Properly

Human-like characteristics make machines more likeable and deemed more trustworthy by users but only to an extent according to research. Anthropomorphic characteristics seem vital in persuading users to adopt industry use of chatbots and artificial agents in what used to be roles reserved solely for people. Adding more human-like features will serve to increase the adoption of robots in ever more roles and industries. Yet, some studies suggest users can also find it off-putting in certain cases when the machines with whom they interact behave in somewhat human-like ways but still convey a sense of unnaturalness.

There is growing human-centrism in the development of AI and how these can be improved to provide a better experience for users in what is sometimes referred to as emergent communication. Multi-Agent Systems (MAS) and Reinforcement Learning (RL) are being used to make AI speech more human-like [9].

Social presence and image processing result when consumers attach anthropomorphic characteristics (human-likeness, animacy, intelligence) to chatbots, which leads to psychological ownership of the product from the user's perspective and ultimately to the latter's intention to continue engaging with the AI, which can build customer engagement and enhance relations between the customers and the brand. An important role of chatbots is to provide potential buyers a positive "pre-consumption experience" that increases the likelihood of making a sale. Being able to not only speak human language but to speak like a human is one means to give chatbots appealing attributes. Jin and Youn focused on user experience with chatbots in the context of fashion and tourism marketing. They found: (1) "human-likeness dimension of anthropomorphic AI-powered chatbots is a positive predictor of consumers' social presence and imagery processing and the intelligence dimension of anthropomorphic chatbots has a positive influence on imagery processing; (2) consumers' social presence is a positive predictor of imagery processing; (3) imagery processing is a positive predictor of psychological ownership of the product/service endorsed by the AI-powered chatbots (4) social presence and imagery processing are positive predictors of AI-chatbot continuance intention" (27 p1880).

Human-AI relationship is a new social phenomenon where communication between people and intelligent machines results in a novel type of interaction. A study on social chatbots, Replika in particular, identified the anthropomorphism and authenticity of AI as antecedents, social interaction with the AI as a mediator, with the outcome being attachment to the AI [16].

Chaves and Gerosa [28] proposed that chatbots ought to be given social characteristics that cohere with users' expectations to avoid frustration and dissatisfaction. They suggested a conceptual model of social characteristics for chatbots in hopes of contributing to the advancement of human-chatbot interaction.

Chen et al. [29] conducted an eye-tracking experiment to test how the appearance and conversational style of chatbots affected users' perception and visual behaviors. Their results suggested human-like appearance and conversational style can attract users and improve their perception of the chatbots.

Analyzing how the anthropomorphic characteristics (gender, personality, visual interface cue) of chatbots that play counseling roles in the psychological health field affect user self-disclosure and companionship and the differences caused by user characteristics, Kang and Kang [30] found no significant effects caused by the gender or personality dimensions of the chatbot. However, visual interface cue did seem to have an impact on the self-disclosure and companionship of the participants.

Kim and Hur [31] investigated the effects of AI's human-like characteristics on consumers' acceptance of chatbots in shopping using the AI device use acceptance (AIDUA) model to test how the relationship between variables (competence, warmth, empathy) differs depending on a customer's need for human interaction. They found AI's personalization and anthropomorphism greatly increase perceived competence and warmth, leading to empathy and,

thus, positively affects consumers' willingness to accept the services of AI, which point to the idea that human-like characteristics in chatbots affect both cognitive and emotional reactions.

In one experiment by Park et al. [32], close to 500 adults discuss a fundraising event with an AI-powered chatbot to test if chatbot empathy and identity disclosure had an effect on people's willingness to donate (WTD) to a fundraiser. Findings showed neither had a significant effect on WTD though data did suggest a considerable interaction effect between chatbot empathy and identity disclosure on WTD and that this interaction effect would be mediated through human likeness and social presence.

In a study of conversational agents (CAs), Schuetzler et al. [33] had 450 people talk to CAs with varying conversational skills to see if conversational skill influences perceived social presence and anthropomorphism of a chatbot. Using Social Presence Theory as a framework, their results indicated that users judge a more skilled CA to be more socially present and anthropomorphic than a chatbot that was not as competent in conversations.

3. Conclusion

Scientists and academics alike are starting to realize the significance of conducting more studies on the communication and interaction between people and artificial intelligence. Intelligent machines are no longer mere robots that function under instruction but are now advancing in their ability to analyze messages, convey ideas and offer suggestions. Many researchers in the field argue similarly that current methods and theories are insufficient, thereby, making it requisite to build new, more relevant approaches and frameworks. This is a task mainly for academics. On the other hand, developers and engineers will need to make improvements on the obvious weaknesses of current AI systems that frustrate users and lead to losses for companies and institutions that employ these technologies. They also need to work with designers on the proper development of AI's human-like features in order to make them more acceptable to users. And not only will people be speaking to chatbots and using the services of artificial agents, machines may someday become part of our physical bodies such as the case of augments [34]. Needless to say, there could be a host of other issues and needs that ought to be addressed though I find the three main ideas above to be the most commonly discussed and arguably some of the most critical that require immediate attention. These are also likely, though not exclusively, the three topics I shall use as a starting point for my subsequent studies. I intend to conduct primary research to collect and analyze new data from either the field, through questionnaires or in lab experiments. Finally, my future research will be under the context of modern, Asian societies due to my present location and since research on this subject is lacking in this part of the world.

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