

AI-Powered Digital Streamers in Online Retail: Empirical Insights and Design Strategies from Experiments

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Abstract: AI-powered digital streamers are transforming live streaming by autonomously interacting with consumers to promote products in real time. Leveraging advancements in artificial intelligence, virtual reality, and generative AI, these entities combine human-like visual design (form realism) and interactive capabilities (behavioral realism) to enhance consumer engagement. Despite their growing adoption, the economic impact of digital streamers on product sales and the optimal design strategies remain underexplored. This study addresses two critical questions: (1) What is the economic impact of digital streamers on product sales compared to no live streaming at all? (2) In what ways can form realism (visual appearance) and behavioral realism (verbal communication and human-AI interactions) enhance digital streamers' effectiveness in live streaming commerce? Using a quasi-experiment and a randomized field experiment, we first assess the baseline performance of digital streamers and subsequently evaluate specific design enhancements. Our findings reveal that unlike human streamers, current digital streamers do not significantly boost sales compared to no live streaming. However, incorporating behavioral realism strategies, such as enhanced real-time Q&A and lottery features, increases sales by 25% and 17%, respectively. Human-like voices and improved visual appearances also contribute to sales gains but to a lesser extent. Among all design strategies, only enhanced real-time Q&A enables digital streamers to achieve sales performance on par with human streamers. This research provides empirical evidence on the business value of digital streamers, advances understanding of anthropomorphic design in live commerce, and offers actionable insights for online retailers. By identifying cost-effective design strategies, this study highlights the transformative potential of digital streamers in digital marketing.

Keywords: AI-powered digital streamers, live streaming, anthropomorphic design, form realism, behavioral realism, human-AI interaction

1. Introduction

The advent of AI-powered digital streamers represents a significant evolution in live streaming commerce, leveraging cutting-edge advancements in artificial intelligence (AI), virtual reality (VR), and large language models (LLMs). These virtual entities offer businesses a scalable and cost-effective alternative to human streamers by automating content delivery and eliminating labor costs, thereby broadening accessibility for brands (Gordon 2024, Hu and Ma 2023). Operating continuously without errors, digital streamers ensure consistent brand presence and global accessibility, positioning themselves as reliable and transformative tools in reshaping the online retail landscape (Chen et al. 2024).

Moreover, digital streamers leverage technological innovations, such as 3D modeling, lifelike speech synthesis, and dynamic engagement features, to replicate human-like qualities such as real-time engagement and emotional connection, enhancing their ability to interact with consumers (Miao et al. 2022, Wu et al. 2023). These capabilities underscore their commercial potential, with the digital streamer market in China alone projected to reach 269.71 billion yuan by 2025, growing at an annual rate of 127.89% (Leadleo 2022). However, despite their growing adoption and the technological advantages they offer, the economic impact of digital streamers on product sales remains unclear. Furthermore, the optimal design strategies to enhance their performance, particularly in leveraging human-like qualities to drive consumer engagement and sales, are still underexplored, presenting a critical gap in the literature.

Thus, this paper focuses on two interrelated problems. First, while human streamers have demonstrated their ability to boost sales through emotional connection, trust-building, and engagement (e.g., Bharadwaj et al. 2022, Cheng et al. 2019), it is unclear whether digital streamers can replicate their results. Emerging behavior research on digital streamers have investigated outcomes like viewer acceptance (Chen et al. 2024), experiential value (Wu et al. 2023), and purchase intentions (Gao et al. 2023, Hu and Ma 2023), but limited studies has

empirically examined the sales performance of AI-powered digital streamers. This raises a critical question (*RQ1*): *What is the economic impact of digital streamers on product sales compared to no live streaming at all?*

Second, design plays a critical role in determining the effectiveness of digital streamers. Research in anthropomorphic AI suggests that human-like features, particularly in *form realism* (e.g., visual appearance) and *behavioral realism* (e.g., verbal communication and human-AI interactions), influence consumer perceptions and behaviors. While form realism enhances trust through human-like aesthetics (Parboteeah et al. 2009), behavioral realism leverages AI to enable dynamic, context-specific interactions (Miao et al. 2022, Wu et al. 2023). Despite progress in anthropomorphic AI research, the live streaming context remains an open question, especially regarding how these design elements influence sales outcomes. Thus, the second research question (*RQ2*) we aim to address is: *In what ways can form realism (visual appearance) and behavioral realism (verbal communication and human-AI interactions) enhance digital streamers' effectiveness in live streaming commerce?*

To address these gaps and answer our research questions, we conducted two complementary studies. Study 1 employed a quasi-experiment and used the Generalized Synthetic Control (GSC) method to evaluate the economic value of digital streamers in collaboration with a leading fashion retailer on Tmall.com. Surprisingly, we found that current digital streamers with low-realism design failed to boost product sales compared to a no-streaming control, while human streamers demonstrated substantial sales gains. These findings highlight the limited effectiveness of current digital streamers with low-realism design and underscore the need for strategic design improvements to unlock the potential of digital streamers. This study serves as a baseline, raising the critical question of how digital streamers might be improved and even optimized to achieve similar effectiveness as human streamers.

Building on the insights from Study 1, Study 2 employed a randomized field experiment to

investigate the effectiveness of two anthropomorphic design strategies, including both form and behavioral realism. Five design features—one focusing on form realism (human-like visual appearance) and four on behavioral realism (human-like voice, scripted speech, real-time lottery features, and enhanced real-time Q&A)—along with a low-realism digital streamer and a proficient human streamer, were tested across seven experimental conditions. Results showed that behavioral realism significantly outperformed form realism in driving sales. Enhanced real-time Q&A delivered the largest sales increase (+25% in quantity and +86% in revenue), achieving sales performance comparable to human streamers. Lottery features also yielded notable sales improvements (+17% in quantity and + nearly 70% in revenue), followed by human-like voice and visual appearance enhancements. These findings demonstrate the critical role of interactivity and engagement in optimizing digital streamers.

Our research makes several theoretical contributions. First, it provides the first empirical evidence on the economic value of AI-powered digital streamers, addressing a gap in the live streaming commerce literature. While previous studies have extensively examined human streamers, this study is among the first to evaluate the sales impact of digital streamers. Second, it advances the understanding of anthropomorphic design by evaluating the multidimensional effects of both form and behavioral realism on sales outcomes. By demonstrating the relative importance of design features such as interactivity and human-like communication, this study enriches the literature on anthropomorphic AI design and consumer behavior.

From a practical perspective, this research offers actionable insights for online retailers and digital streamer designers, emphasizing the need to rethink current approaches to digital streamer design. The study highlights that low-realism designs fail to generate significant sales benefits, underscoring the necessity of incorporating advanced behavioral realism strategies for digital streamer designers. Moreover, our findings emphasize the importance of integrating interactive features and human-like communication to foster trust, engagement, and purchase

behavior. By identifying effective design strategies, this study provides a roadmap for retailers to optimize digital streamer performance, ensuring stable, engaging, and scalable live streaming experiences.

2. Prior Research and Theory

The focus of this paper is on digital streamers. In this section, we begin with summarizing current literature on digital streamers and the anthropomorphic design of digital agents. Then, based on social response theory, we develop hypotheses on how form realism as well as behavioral realism design strategies may affect product sales. Lastly, we present our empirical overview to highlight the connections between our two studies.

2.1 Digital Streamers and Anthropomorphic Design of Digital Agent

Digital Streamers. Live streaming has rapidly emerged as a powerful marketing tool, enabling real-time interaction between streamers and consumers (Lin et al. 2021, Wang et al. 2022). Extensive research on human streamers consistently demonstrates their effectiveness in driving consumer behavior and boosting sales through emotional expression, trustworthiness, and persuasive appeal (Bharadwaj et al. 2022, Gao et al. 2021). Building on this success, the advent of AI-powered digital streamers represents a significant technological advancement in the live streaming domain.

Digital streamers leverage advanced technologies to deliver performances that mimic human streamers, offering brands significant operational advantages such as cost-efficiency, 24/7 availability, and high scalability (Miao et al. 2022). Additionally, digital streamers are highly customizable, allowing businesses to align their design features, such as visual appearance, personality, and behavior with their target audience and brand identities (Hu and Ma 2023). This customizability enables companies to create streamers with specific attributes, such as age, gender, or language proficiency to appeal to different consumer segments (Wu et al. 2023). In addition to customization, digital streamers offer several operational advantages

over their human counterparts. They provide cost-efficient and round-the-clock availability without fatigue or errors, making them scalable and reliable options for continuous engagement (Ameen et al. 2024, Expert Panel 2024). These qualities are particularly beneficial for businesses seeking to maintain global accessibility or operate during off-peak hours. Furthermore, their consistent and controlled performance enhances brand representation and consumer trust (Wu et al. 2023).

Despite their potential, the economic value of digital streamers in driving actual product sales remains largely underexplored. Most existing research has either focused on human streamers or examined digital streamers from a behavioral perspective, investigating consumer acceptance (Chen et al. 2024), experiential value (Wu et al. 2023), and purchase intentions (Gao et al. 2023). However, there is little empirical evidence evaluating how digital streamers impact actual sales outcomes, a critical metric for their business value. Addressing this gap, our study contributes to the literature by providing the first empirical evaluation of the economic effectiveness of digital streamers, shedding light on their performance relative to traditional no-streaming conditions and directly tackling *RQ1*.

Anthropomorphic Design of Digital Agent. The effectiveness of digital agents, including digital streamers, hinges on their ability to emulate human-like qualities that foster trust, engagement, and social presence (Chen et al. 2024, Nguyen et al. 2023). Anthropomorphism, the attribution of human characteristics to non-human entities, has emerged as a key principle in designing digital agents, as it enhances user experiences by creating interactions that feel natural, intuitive, and socially engaging (Liu et al. 2024, Schanke et al. 2021). Anthropomorphic design has been widely studied in digital agents such as chatbots, virtual assistants, and digital streamers (Epley et al. 2007). The literature identifies two primary anthropomorphic design strategies: *form realism* and *behavioral realism* (Miao et al. 2022). Form realism focuses on the visual appearance of the digital agent, including features such as

human-like facial expressions, body movements, and spatial representation (Blascovich et al. 2002). Behavioral realism pertains to the agent’s ability to mimic human behavior, encompassing verbal communication, conversational tone, and real-time interactions (Miao et al. 2022). Together, these strategies shape consumer perceptions of trust, social presence, and engagement, which influence behavioral outcomes such as purchase decisions.

--- Insert Table 1 ---

While previous research has explored individual anthropomorphic features of digital agents (e.g., appearance in Chen et al. 2024, language in Yao et al. 2024), studies often focus on isolated effects without a comprehensive evaluation of both form and behavioral realism. Additionally, most research has been limited to consumer perceptions, such as intention to engage or use (Liu et al. 2024), rather than tangible outcomes like sales. Unlike prior work, our study provides a holistic analysis of how anthropomorphic design strategies impact real-world sales performance in live commerce. Specifically, we assess a comprehensive set of design features across both form realism (e.g., human-like appearance) and behavioral realism (e.g., voice, real-time Q&A, lottery interactions), offering new insights into their relative contributions to digital streamers’ effectiveness. This directly addresses RQ2 and sheds light on how specific anthropomorphic features can improve and optimize the sales effectiveness of digital streamers in live streaming.

To sum up, this study advances the literature on digital streamers and anthropomorphic design in two ways. First, it extends the nascent body of research on digital streamers by empirically evaluating their economic value, addressing a significant gap in the live streaming literature. Second, it provides a nuanced understanding of anthropomorphic design by examining the multidimensional effects of both form and behavioral realism on consumer behavior and sales outcomes. Unlike prior studies that emphasize consumer intentions or perceptions, we focus on actual purchase behaviors, demonstrating how specific design

strategies influence sales performance.

2.2 Theory and Hypotheses Development

Following Miao et al.'s (2022) framework, we examine the role of anthropomorphic design strategies, both the form realism and behavioral realism, in shaping the effectiveness of digital streamers. These strategies provide critical social cues of digital agents (Feine et al. 2019), which can evolve into social signals and subsequently shape consumer perceptions, interactions, and behavioral outcomes, including trust (Schanke et al. 2021), engagement (Nguyen et al. 2023), and purchasing decisions (Hu and Ma 2023). To understand their effects, we draw on social response theory, which posits that people apply social norms to interactions with technologies exhibiting human-like traits (Nass and Moon 2000, Moon 2003). By adopting this framework, we establish the theoretical basis for how anthropomorphic design features/cues enhance digital streamers' sales performance.

2.2.1 Social Response Theory

Social response theory suggests that when people interact with technology mimicking human characteristics, they naturally perceive this technology as a social actor. As a result, they apply the same social norms used in human-to-human interactions when interacting with anthropomorphic digital agents, leading to corresponding social responses and behavior (Nass and Moon 2000, Pelau et al. 2021). These social behaviors arise from the activation of anthropomorphic cues, such as human-like appearance, voice, and conversational style, which evoke a sense of social presence (Short et al. 1976). Social presence, defined as the "degree of salience of the other person in the interaction" (Schanke et al. 2021), plays a pivotal role in fostering trust, emotions, and social response toward digital agents. Different anthropomorphic cues elicit varying levels of social presence (Schuetzler et al. 2020). For example, visual and identity-based anthropomorphic cues may have a limited impact on social presence compared to communicative cues, as the latter create a stronger sense of being with a real person (Go and

Sundar 2019). Based on the different level of the sense of being present with the corresponding digital streamer, consumers will naturally elicit varying social responses (Miao et al. 2022).

Studies on digital agents (i.e., chatbots) have frequently adopted the social response theory to explain users' cognitive, emotional, and behavioral responses to anthropomorphic cues (Adam et al. 2021, Nguyen et al. 2023, Song et al. 2024). In the context of live streaming, digital streamers are expected to fulfill the social roles traditionally held by human streamers, such as responding to questions, building rapport, and providing product recommendations. As the realism of their anthropomorphic design increases, consumers may perceive them as more sociable and trustworthy, resulting in stronger social responses and higher purchase likelihood (Wu et al. 2023). Consequently, understanding how design features such as form realism and behavioral realism contribute to this process is essential to optimizing their effectiveness in live commerce.

2.2.2 Form Realism

Form realism refers to the extent to which a digital agent's visual appearance resembles that of a human being. It encompasses features such as spatial representation (2D vs. 3D), demographic attributes (e.g., age, gender, ethnicity), and dynamic physical traits, including facial expressions and body movements (Blascovich et al. 2002, Miao et al. 2022). The degree of form realism is often categorized into two levels: low realism (simplistic, cartoon-like forms) and high realism (near-perfect human resemblance) (Zhou et al. 2024). High form realism enhances perceptions of trust and competence, as human-like appearances create a sense of familiarity and relatability (Qiu and Benbasat 2009). For example, avatars with lifelike facial features are more likely to evoke positive social responses and increase consumers' willingness to engage (Cascio Rizzo et al. 2023).

In live streaming contexts, where viewers are accustomed to human streamers, form realism in digital streamers may serve as a crucial factor in mimicking the interpersonal appeal

of human streamers. Unlike static virtual agents, digital streamers need to visually replicate the dynamism and expressiveness of human hosts to foster social presence—a user’s sense of being accompanied by another human (Short et al. 1976). Given that digital streamers are often embedded in visually rich, interactive environments, enhancing form realism may play a critical role in building consumer trust and improving product sales. This makes viewers more receptive to product recommendations from the digital streamer, which in turn increases the likelihood of making purchases and ultimately drives higher product sales. Thus, we propose the following hypothesis:

H1: Enhancing the form realism of digital streamers will increase product sales in live streaming context.

2.2.3 Behavioral Realism

Behavioral realism captures the extent to which a digital agent mimic human behaviors, including verbal communication (e.g., voice, language style) and interaction capabilities (e.g., responding to questions, initiating conversations) (Bailenson et al. 2008). In live streaming, behavioral realism is particularly impactful because it enables dynamic, context-specific interactions that simulate human-like responsiveness.

Verbal Communication. The verbal communication of digital streamers includes features such as human-like voice and conversational scripts. Human-like voice features, such as natural intonation, varied pitch, and emotional expressiveness, enhance the perceived warmth and authenticity of digital agents (Alabed et al. 2022). According to media richness theory, voice-based communication provides richer social cues compared to text-based interactions, fostering deeper user engagement (Zierau et al. 2023). Moreover, Luo et al. (2019) found that an undisclosed voice-based chatbot with optimized human-like voice features can perform as effectively as proficient human workers.

Additionally, the quality of a digital streamer’s narrative significantly influences

consumer perceptions. Well-crafted stream scripts that mimic human speech patterns and incorporate vivid product descriptions can evoke consumer trust and emotional connection (Hughes et al. 2016, Yao et al. 2024). The advent of AI-generated content (AIGC) further enables digital streamers to produce compelling narratives at scale, which can positively influence purchase intentions (Cao et al. 2023). However, mismatched or overly robotic scripts can detract from the overall experience, emphasizing the importance of aligning verbal communication with consumer expectations.

Human-AI Interaction. Human-AI interaction capabilities refer to the digital streamer's ability to engage consumers through real-time interactions, such as answering consumer questions, providing product recommendations, and facilitating interactive features such as games or lotteries. These interactions enhance the perceived sociability of the digital streamer, fostering a sense of social presence and user engagement (Miao et al. 2022).

Interactive features are particularly impactful in live streaming. For instance, real-time Q&A sessions allow digital streamers to address specific consumer queries, providing personalized recommendations that increase the perceived value of the shopping experience (Wu et al. 2023). Similarly, interactive features like lotteries incentivize viewer participation and create a sense of excitement and urgency to purchase (Zhang et al. 2024). While current digital streamers often rely on pre-trained responses, the integration of human-AI collaboration (e.g., a digital streamer supported by a human assistant) can significantly enhance the responsiveness and depth of these interactions.

Overall, behavioral realism of digital streamers allows for natural interactions through familiar voice and linguistic logic, as well as diverse real-time interactions. This can enhance consumers' perceived service quality and shopping satisfaction, leading to positive consumer behavioral responses (Pelau et al. 2021). Therefore, we predict that behavioral realism of digital streamers positively influences consumers' purchases, which then leads to higher product sales.

Furthermore, the effects brought by real-time interaction will surpass those of verbal communication. This is because real-time interaction represents higher realistic behaviors, and gives consumers a stronger sense of social presence (Miao et al. 2022), which is more likely to stimulate consumer behavioral responses. Thus, we propose the following hypothesis:

H2: Enhancing behavioral realism of digital streamers will positively influence product sales, and the effects of human-AI interaction will exceed those of verbal communication.

2.2.4 Form vs. Behavioral Realism

While both form and behavioral realism contribute to the effectiveness of digital agents, behavioral realism often has a more significant impact on consumer behavior. According to social response theory, behavioral cues such as voice tone, conversational style, and interactive capabilities evoke stronger social presence compared to static visual features, making them more influential in driving engagement and purchase decisions (Go and Sundar 2019, Pelau et al. 2021).

Moreover, high form realism without corresponding behavioral realism may result in unmet consumer expectations, leading to negative consumer perceptions (Miao et al. 2022). For instance, a visually realistic digital streamer that fails to engage dynamically may be perceived as artificial or awkward, diminishing its effectiveness. Conversely, digital streamers with strong behavioral realism, such as interactive capabilities and natural communication, can achieve significant consumer engagement, even with less sophisticated visual designs. Thus, we predict:

H3: The behavioral realism of digital streamers has a stronger positive effect on product sales than form realism.

By integrating social response theory with insights from anthropomorphic design, this study establishes a robust framework for evaluating the effects of form and behavioral realism on digital streamers' performance. These hypotheses guide our investigation into how specific

design features can optimize digital streamers' impact on sales, offering theoretical and practical insights for the evolving landscape of live streaming commerce.

2.3 Empirical Overview

AI-powered digital streamers represent a promising innovation in live streaming commerce. Despite the growing adoption of digital streamers, little is known about their economic value and design effectiveness remain underexplored. This research addresses these gaps through two complementary studies that build upon one another to provide a comprehensive evaluation of digital streamers' performance and identify strategies to enhance their effectiveness.

Notably, digital streamers currently adopted by the industry feature low-realism design characterized by cartoon-like appearances, machine-synthesized voices, basic scripted functionalities, and minimal interactivity. Therefore, the goal of Study 1 (a quasi-experiment) is to examine the economic value of digital streamers with current low-realism designs. Specifically, this study aims to determine whether adopting digital streamers can enhance product sales compared to no live streaming, thereby addressing *RQ1*.

Building on the insights from Study 1, Study 2 aims to address a critical question of how digital streamers can be improved and even optimized to achieve effectiveness comparable to that of human streamers, thus tackling *RQ2*. Leveraging a field experiment, Study 2 uses the low-realism digital streamer from Study 1 as a baseline to investigate how two anthropomorphic design strategies, high-form realism and high-behavior realism, can enhance the effectiveness of digital streamers in driving sales. Regarding the specific design features of these realisms, we have made certain adjustments in this paper to better align with real practices in the live streaming industry. The detailed design features and their respective realism levels are presented in Table 2.

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As shown in Figure 1, the two studies are progressively linked to provide a comprehensive

framework for understanding and enhancing digital streamers' performance. Study 1 establishes a foundational benchmark, demonstrating the limitations of current low-realism designs and identifying a need for improvement. Study 2 builds upon this baseline by systematically testing and evaluating specific anthropomorphic design strategies to determine how digital streamers can achieve comparable effectiveness to human streamers. Together, these studies not only quantify the economic value of digital streamers but also offer actionable insights into the design strategies that maximize their impact.

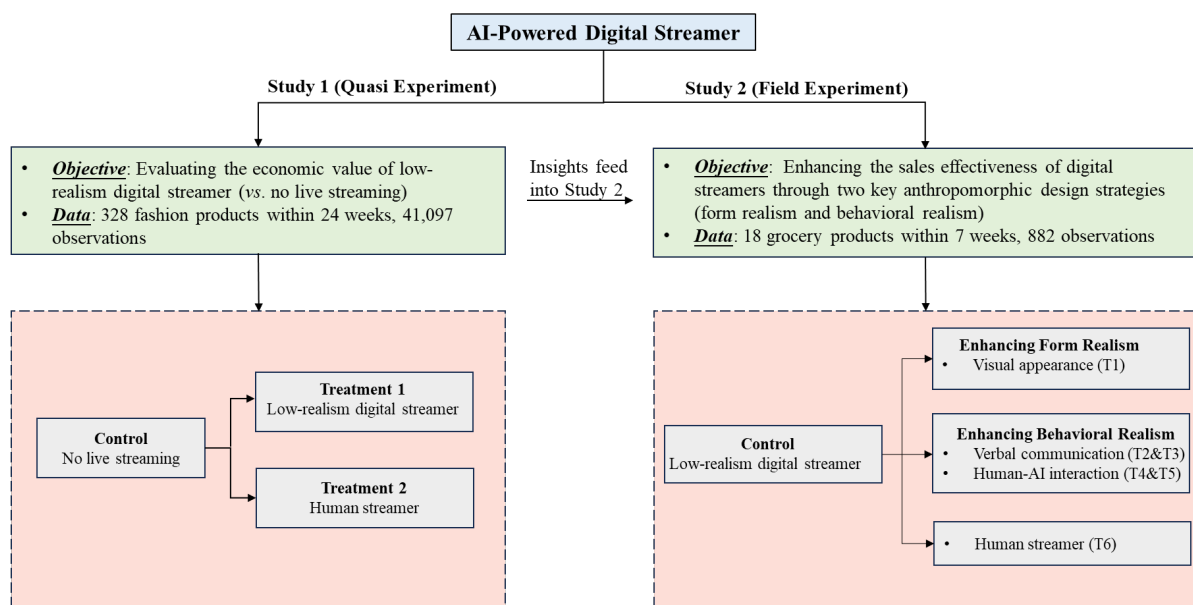


Figure 1. Empirical Overview

By combining empirical evaluation with experimental testing, this research bridges the gap between understanding the current limitations of digital streamers and identifying practical pathways for their optimization. This integrated approach contributes both theoretically and practically, guiding future development and deployment of digital streamers in live streaming.

3. Study 1 Quasi Experiment: The Economic Value of Digital Streamer

AI-powered digital streamers are increasingly being adopted by businesses as a scalable and cost-effective alternative to human streamers. However, the economic value of these digital entities in live streaming commerce remains unclear. Study 1 addresses this gap by evaluating

the baseline effectiveness of digital streamers in driving product sales compared to no live streaming. This quasi-experiment establishes a foundational understanding of their current performance, providing the groundwork for investigating potential improvements in Study 2.

3.1 Research Setting

To assess the economic impact of digital streamers, we cooperated with a well-known fashion retailer that mainly sells sports-related products (e.g., shoes, T-shirts, bags) via its official store on Tmall.com, one of the world's largest business-to-consumer (B2C) e-commerce platforms. Tmall.com introduced its live streaming platform, Taobao Live, in 2016, enabling retailers to integrate live streaming sessions into their online storefronts (Alizila 2020). Online Appendix A briefly introduces this Taobao Live platform.

The fashion retailer began using human streamers in May 2019 and introduced its first digital streamer on May 18, 2021. The digital streamer adopted by this retailer had a low-realism design, featuring cartoon-like visual appearances, machine-synthesized voices, and limited interactivity (as shown in Table 2). This retailer disclosed that they chose relatively popular products with higher sales to live streaming. Because the retailer was not certain about which type of streamer would lead to higher sales, the chosen products were then randomly assigned to different types of streamer sessions. Thus, there were no product-related differences between human and digital streamer sessions. Online Appendix B summarizes how live streaming works for this retailer and Online Appendix C presents the user interfaces of digital and human streamers.

3.2 Data, Variables, and Summary Statistics

To investigate the impact of digital streamers on product sales, we collected daily online transaction data from this fashion retailer from March 1st to August 17th, 2021. Total we have 11 weeks before and 13 weeks after the launch of the digital streamer on May 18, 2021. During this data collection period, the retailer had 925 products sold online, of which 442 were

livestreamed. And then, we tried our best to relax the selection criteria for the sample selection and the details are provided in Online Appendix D.

Products were livestreamed in either digital-only, human-only, or mixed type. In this study, to clearly identify the impact of digital and human streamers on product sales respectively, we decided to focus on the products introduced only by human or digital streamers in our main analysis¹ and the results for the mixed type are summarized in Online Appendix E. Thus, our final data set included 328 products, with 72 in the digital streamers group, 74 in the human streamers group and 182 in the control group with no live streaming. As shown in Online Appendix F, randomization checks showed that the products were randomly assigned to the three groups and there were no significant differences in terms of product characteristics (i.e., subcategories, prices) and sales outcome (Lu et al. 2021) across three groups.

Our dependent variable in Study 1 was each product's daily *Sales*. *Sales* referred to the product's total online sales on Tmall.com, which was the sum of both live streaming sales² and traditional online sales³. This approach accounts for the fact that the control group did not have live streaming sales. Thus, we used the total online sales as our dependent variable to measure the effect of different streamers on product sales. Additionally, product characteristics, such as the tag price for each product and its discount rate, were included as control variables. Table 3 presents the descriptive statistics of our main variables.

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3.3 Empirical Model

To examine the economic value of digital streamers, we compared the product sales from the digital streamer group with the product sales from the control group, before and after the launch

¹ We included the sales performance of human streamers to determine whether live streaming with human streamers significantly boosts product sales compared to no live streaming. This provides comprehensive insights into the business value of both types of streamers in live streaming.

² Live streaming sales refer to the number of products sold through live streaming sessions.

³ Traditional online sales refer to the number of products sold through the retailer's official store on Tmall.com.

of the digital streamer. We also performed the same analysis for the human streamer group. Following Krijestorac et al. (2020), we adopted the GSC method to identify the impact of digital streamers as well as that of human streamers on product sales.

GSC is built on a factor model that assumes the observed outcomes are influenced by observed and unobserved factors (Xu 2017). By modeling the influence of unobserved factors, GSC attempts to isolate the effects of the treatment from these unobserved confounders that might cause endogeneity (Wang et al. 2021). Moreover, GSC allows for interactive fixed effects, which can capture unobserved heterogeneity that varies over time and across units. Furthermore, GSC constructs a synthetic control group as a weighted combination of control units. The weights are chosen to minimize the difference between the treated unit and the synthetic control on the pre-treatment characteristics and outcome (Guo et al. 2020). This allows us to estimate the average treatment effect (ATT) while accounting for unobserved heterogeneity, including product-specific trends and time-fixed effects.

By closely matching these pre-treatment characteristics and outcomes, GSC reduces the bias from endogeneity due to observed factors (i.e., product sales outcome, price, and discount) (Krijestorac et al. 2020). Please see Online Appendix G for a detailed introduction about the GSC method. After controlling product characteristics (i.e., price and discount), we matched products in the treatment groups with a synthetic control group based on sales. This helps us to address the most important endogeneity concern, namely, how products were chosen to be livestreamed or not, as well as which type of streamer to adopt. We specify our GSC model as follows:

$$Y_{it} = \delta_{it}D_{it} + X'_{it}\beta + \lambda'_if_t + \varepsilon_{it} \quad (1)$$

where the outcome Y_{it} refers to *Sales* for product i on day t . D_{it} is a binary treatment indicator, which equals 1 if product i on day t has been sold in live streaming and 0 otherwise. δ_{it} represents the heterogeneous treatment effect for each product i on day t , with $\bar{\delta}_{it}$ being the

average treatment effect (ATT). X'_{it} is a vector of observed covariates regarding product characteristics (i.e., price and discount). λ'_i is the unknown factor loadings, and f_t is a vector of unobserved common factors. Specifically, $\lambda'_i f_t$ covers various unobserved heterogeneities, which include the product-fixed (i.e., absorb all cross-sectional differences that are constant across time) and time-fixed effects (i.e., absorb common intertemporal changes across all products), product-specific linear or quadratic time trends, and autoregressive components (Xu 2017). Lastly, ε_{it} is the error term for product i on day t .

3.4 Results

We first examined the effect of digital streamers on sales and reported the estimation results in Table 4. The results indicate that digital streamers with current low-realism design did not have a significant impact on product sales compared to no live-streaming ($\beta = -1.571, p > 0.1$). To better understand the treatment effect, we presented the observed and counterfactual sales of the treated products, and the average treatment effect of the digital streamers (ATT) in Online Appendix H. Figure H1 further validates our findings above.

We then explored the impact of human streamers on product sales. Results in Table 4 suggest that human streamers significantly boosted product sales ($\beta = 10.35, p < 0.000$), which is consistent with findings in previous studies (Wongkitrungrueng et al. 2020). Figure H2 in Online Appendix H presents similar findings. The above results together indicate that, compared to the case with no live-streaming, digital streamers with current low-realism design have no impact on improving product sales, while human streamers show a significant advantage in boosting product sales. We also conducted several falsification tests and robustness checks and reported these results in Online Appendix I.

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Our comprehensive empirical analysis reveals that current digital streamers in the live streaming domain fall short of driving significant product sales. However, these streamers offer

valuable advantages including cost-effective, work-round-clock operation and high customization (Li et al. 2021). With the rapid advancement of technology, we have anthropomorphized the current design of digital streamers and adopted more human-like design features with the hope to optimize it as good as human streamer in Study 2. For online retailers and designers of digital streamers, exploring innovative approaches to augment the sales efficacy of digital streamers is crucial. By fully leveraging this AI-powered, cost-effective tool, businesses can unlock new potential across diverse applications and maximize the strategic value of digital streamers in modern commerce.

4. Study 2 Randomized Field Experiment – Various Design Strategies

Study 2 investigates how specific anthropomorphic design strategies can enhance their sales performance. This study explores whether improving form realism (visual appearance) and behavioral realism (verbal communication and human-AI interactions) can enable digital streamers to achieve sales outcomes comparable to human streamers. By testing multiple design features in a controlled experimental setting, Study 2 aims to identify the most effective strategies for optimizing digital streamers in live streaming while leveraging the advantages of their low cost and operational risk.

4.1 Experiment Design

We partnered with a newly established online grocery retailer on Tmall.com, which sells food, drinks, and daily necessities. This retailer recently adopted digital streamers for live streaming but remained uncertain about which design features could maximize sales effectiveness. Leveraging this opportunity, we implemented a randomized field experiment with seven experimental conditions, each representing a unique combination of design features.

Serving as the baseline, the design of digital streamer in the control group was consistent

with the low-realism digital streamer design in Study 1⁴. Compared to the control group, Treatment 1-5 altered only the corresponding feature while keeping other characteristics the same as the control. Specifically, the five treatment groups included enhancements in specific design features: Treatment 1 with human-like visual appearance (form realism), Treatments 2-3 with human-like voice or naturalistic scripts (verbal communication as a form of behavioral realism), Treatments 4-5 with real-time lottery or enhanced Q&A functionalities (human-AI interaction as form of behavior realism). Additionally, Treatment 6 was the group with a proficient human streamer, incorporating all the features from Treatment 1 to Treatment 5. The comprehensive experiment design with specific setup for each group is presented in Table 5.

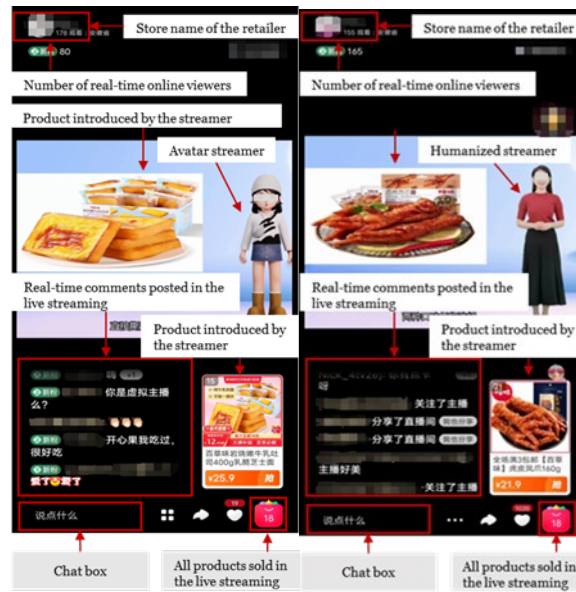
--- Insert Table 5 ---

As shown in Figure 2, the control group represented the current design of a digital streamer that was used by the retailer, similar to the one used in Study 1. This design featured a low realism appearance and a machine-synthesized voice. In addition, the current digital streamer introduced products based on the scripts provided by the retailer, and the level of interaction with viewers was restricted to only a few pre-trained topics (e.g., welcoming newcomers, responding to a given set of questions), which was very limited compared to that of human counterparts. Moreover, it lacked the feature of releasing real-time lotteries.

Keeping the other design features the same as the control group, Treatment 1 (T1) used a more human-like appearance design of the digital streamer (see example in Figure 2b) to examine whether enhancing the streamer's form realism improves its sales performance. The next four groups focused on evaluating the effectiveness of improving behavioral realism.

⁴ The digital streamer in Study 2 was comparable to the one in Study 1. Both streamers were deployed on the same e-commerce platform and shared similar key design characteristics, including a low level of form realism and a low level of behavioral realism. Specifically, both were characterized by cartoon-like appearances and machine-synthesized voices. They introduced products based on retailer-provided scripts, with limited interactivity confined to a few pre-trained topics (e.g., welcoming newcomers). Neither streamer included features like real-time lotteries or other advanced engagement mechanisms. The only variation lied in the specific streaming scripts, which were tailored to the respective products being promoted.

Specifically, Treatment 2 (T2) modified the stream scripts of product introductions based on the scripts from a proficient human streamer presenting the same product. Treatment 3 (T3) adopted a human streamer voice, instead of a machine-synthesized voice. Both T2 and T3 aimed to enhance the behavioral realism of the digital streamer from the perspective of verbal communication.



(a) Low-realism appearance (left) and (b) High-realism appearance (right)
Figure 2. The User Interface for Different Appearances⁵

Furthermore, Treatment 4 (T4) introduced one type of human-AI interaction, the real-time lottery during the digital live streaming session. Previously, this lottery feature was only available during the human streamers' sessions. We adopted this feature in T4, and the lottery was drawn every 20 minutes to send out a gift. Viewers can participate in the lottery by simply sending the message "Let's join the lottery" in the chat box during the live streaming session. Treatment 5 (T5) adopted the enhanced real-time Q&A, as another type of human-AI interaction, a human assistant engaging in real-time interaction with viewers through the chat box to answer questions and engage in one-on-one interactions (e.g., leisure talks, welcoming

⁵ Due to privacy concerns, we are not allowed to display the interface of human streamers. However, aside from the streamer themselves, the live streaming background and all components are consistent with what is currently being shown.

new viewers and call for actions)⁶. Additionally, Treatment 6 (T6) featured a single female human streamer introducing products using the same streaming script as in T2. The streamer conducted real-time Q&A sessions and lotteries, responding to viewer questions in real time, as in T5, with the lottery frequency matching that of T4.

Our experiment ran continuously for seven weeks, starting from July 10, 2023, until August 27, 2023. To control the time-of-day effect, we ran only one live streaming session from 8 to 10 PM each day, a typical peak live streaming time (Huang et al. 2014), with only one experiment condition presented. The retailer had a total of 18 products for sale, all of which were included in the experiment⁷. Prior to each live streaming session every day, all products were randomly arranged and then sequentially broadcasted based on this random order. The duration of each product introduction was approximately 1-2 minutes. Thus, to cover this 2-hour session, all products were demonstrated for four rounds based on the randomized order decided at the beginning of each session. To control the day of the week effect, each experiment condition was randomly assigned to only one day in each week. We also make sure that each condition was tested on every weekday. Thus, our randomized field experiment lasted for 49 days. The live streaming viewership and the duration of product introduction did not exhibit significant differences across the seven conditions (details are reported in Online Appendix J), which suggest that there were no other factors related to viewership and the duration of products introduction that could influence product sales.

4.2 Analyses and Results

We obtained the daily online transaction data of each product from the online retailer, including

⁶ We employed a plausible, future-oriented “Wizard of Oz” approach (Seymour et al. 2024), a method commonly utilized to explore user perceptions of emerging technologies still under development (Rietz et al. 2021). This approach allows us to assess whether a generative AI-powered chatbot, once capable of interacting at the level of a human assistant, can enable digital streamers to achieve strong sales outcomes entirely independent of human involvement. Thus, Treatment 5 was utilized as a substitute in the absence of more capable AI chatbots.

⁷ In Study 2, all products included in the analysis recorded sales during the experimental period; therefore, no product had zero total sales.

product name, live streaming sales quantity and revenue, tag price, and discount level from the retailer if there was any. Table 6 presents the variable definitions and descriptive statistics of the main variables used in Study 2.

--- Insert Table 6 ---

4.2.1. Model-Free Evidence

We first report the model-free evidence regarding the mean comparisons across the seven conditions. An ANOVA model was estimated on two dependent variables, *sales quantity* and *sales revenue*, respectively. The results demonstrate a significant difference across the experiment conditions (*sales quantity*: $F(6, 875) = 6.740, p < 0.001$; *sales revenue*: $F(6, 875) = 7.850, p < 0.001$).

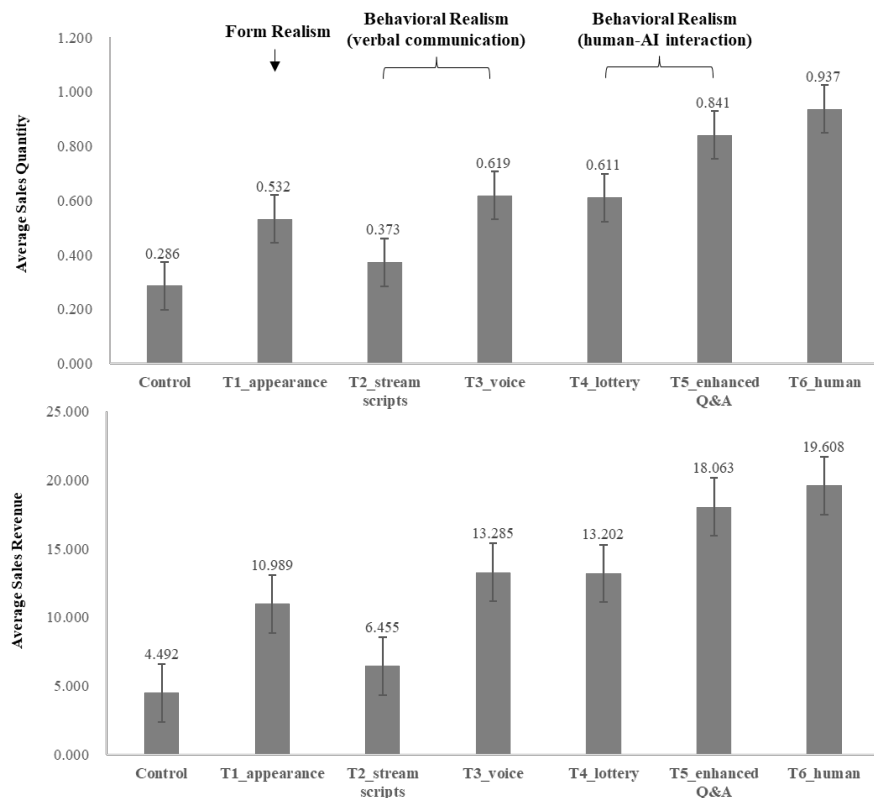


Figure 3. Sales Quantity and Revenue Comparison Across the Conditions in Study 2⁸

To further explore which condition yields superior sales performance, we present the mean

⁸ The error bars in the figures are based on 95% confidence intervals of the respective means.

comparisons across seven groups in Figure 3. Results show that, on average, the human streamer group (T6) yielded the highest daily sales quantity and revenue, followed by the digital streamer group with enhanced real-time Q&A (T5). In contrast, the lowest sales quantity and revenue were observed in the control group with the current low-realism design. This suggests that the digital streamer incorporating enhanced real-time Q&A yielded a comparable good performance as the human streamer, and it is significantly better than the currently prevalent design of digital streamers. We also conducted a post-hoc pairwise multiple comparison using Fisher's least significant difference (LSD) test, the results remain the same and details are presented in Online Appendix K.

4.2.2. Main Effects

We proceed to conduct regression analyses to quantify the impacts of different design features of digital streamers on product sales. Employing ordinary least squares (OLS) estimation with product fixed effects, our regression specification is shown as Equation (2), with the current design of digital streamer (control) as the baseline.

$$Y_{it} = \beta_0 + \beta_1 Treatment1_appearance_{it} + \beta_2 Treatment2_stream\ scripts_{it} + \beta_3 Treatment3_voice_{it} + \beta_4 Treatment4_lottery_{it} + \beta_5 Treatment5_enhanced\ Q\&A_{it} + \beta_6 Treatment6_human_{it} + X_{it} + \mu_i + w_t + \varepsilon_{it} \quad (2)$$

where Y_{it} represents our two log-transformed dependent variables: sales quantity and sales revenue of product i on day t ⁹. $Treatment1_appearance_{it}$ involves modifications to appearance, $Treatment2_stream\ scripts_{it}$ represents changes to the stream scripts, $Treatment3_voice_{it}$ denotes alterations in voice, $Treatment4_lottery_{it}$ and $Treatment5_enhanced\ Q\&A_{it}$ represents changes in two interactive features, namely the integrating of lottery and real-time Q&A. $Treatment6_human_{it}$ represents the adoption of a human streamer. X_{it} includes a series of

⁹ We added a small number to log-transformed variables to handle zero values.

covariates, including the number of live-streaming viewers, the number of product exposures, and the duration of the product introduction. μ_i captures the product-level fixed effects to control for unobservable time-invariant characteristics of the products. w_t captures day of the week fixed effects to control the average time trends that are common for all products. ε_{it} is the mean-zero random error term.

Table 7 summarizes the results of our regression analysis. The inclusion of enhanced real-time Q&A in digital streamers yielded the biggest improvement in sales performance (25% increase in product sales quantity and 86% increase in sales revenue) compared to improvements in other design features. Furthermore, the Treatment 6 group, featuring human streamers, continued to show the most favorable sales performance. To examine whether there are significant differences between T1-T5 and the human streamer (T6), we used the Wald test (Kim and Krishnan 2015, Yang and Xiong 2019) to assess the difference between estimated coefficients. The results suggest that only the T5 (digital streamers with enhanced real-time Q&A) remained comparable with human streamers (T6) in live streaming sales, as suggested by the p -value of (T6-T5) in the last row of Table 7. This result indicates that incorporating the real-time Q&A capabilities to the current low-realism designed digital streamer can enable it to achieve performance on par with a human streamer.

Furthermore, compared to the control group, altering the appearance (T1) and voice features (T3) of digital streamers, as well as incorporating lottery (T4), all significantly augmented the product sales and revenue generated from the live streaming. Incorporating enhanced real-time Q&A was the most effective design strategy and the introduction of the lottery ranked second, contributing to a 17% increase in sales quantity and a nearly 70% increase in sales revenue. These findings suggest that the behavioral realism strategy achieved through human-AI interaction delivers the best performance. Furthermore, altering the voice feature yielded a 17% increase in sales quantity and a 65% increase in sales revenue. Modifying

the appearance features of digital streamers led to an 11% increase in product sales quantity, accompanied by a 39% rise in sales revenue. Overall, both the form realism and behavioral realism strategies significantly enhance digital streamers' sales performance, and the behavioral realism has a stronger positive effect than the form realism, supporting our hypotheses 1 and 3. However, modifying the stream scripts does not improve the sales effectiveness of digital streamers. Hence, our hypothesis 2 is only partially supported.

--- Insert Table 7 ---

4.2.3. Mechanism Exploration

To further investigate the underlying mechanisms behind the impact of form and behavioral realism on product sales, we conducted a detailed analysis of recorded live streaming videos to better understand the behavioral processes driving consumer purchases. As discussed in Section 2.2, increasing the form and behavioral realism of digital streamers enhances consumers' social responses by fostering greater sociability, which, in turn, leads to higher viewer engagement with the streamers. To validate this hypothesis, we used the number of real-time comments in the chat box as an indicator of the degree to which consumers perceive the streamer as a social entity and their willingness to engage with the streamer during the live session, thus serving as a proxy for consumers' social responses.

We collected live streaming videos from the 49 days of our field experiment and extracted real-time comments from the chat boxes for each session. The total number of real-time comments per live streaming was calculated and used as a dependent variable to re-estimate Equation (2). The results, presented in Table 8, are consistent with the findings from the main analysis. Specifically, both form realism ($\beta_1 = 0.565$, $p < 0.001$) and behavioral realism features, such as voice ($\beta_3 = 0.881$, $p < 0.001$), lottery ($\beta_4 = 1.072$, $p < 0.001$), enhanced Q&A ($\beta_5 = 1.969$, $p < 0.001$), significantly increased the number of real-time comments. Moreover, the effects of behavioral realism were stronger than those of form realism. These findings

indicate that both design strategies substantially enhance consumers' likelihood of engaging in real-time interactions with the streamer. This heightened engagement reflects the elevated social response achieved through these design strategies (Tsai et al. 2021). Additionally, the increase in real-time comments was found to directly contribute to higher product sales, as shown in Table 9 ($\beta = 0.001, p < 0.001$).

Overall, the results of the video analysis provide robust evidence of how form and behavioral realism design strategies positively influence product sales. In the dynamic environment of live streaming, enhancing the form and behavioral realism of digital streamers significantly boosts consumer engagement, which, in turn, increases the likelihood of purchases and drives product sales. Furthermore, behavioral realism cues, such as voice tone, conversational style, and interactive capabilities, prove to be more effective than static visual features in engaging consumers. These behavioral cues evoke stronger consumer responses by creating dynamic, human-like interactions, making them particularly influential in shaping purchasing decisions.

--- Insert Tables 8 and 9---

5. Conclusions

The rapid growth in the utilization of digital streamers in live streaming commerce can be attributed to two primary factors: the advancement of technology such as AI, VR, and LLMs, as well as the increasing reliance on online experiences among consumers and brands. The digital streamer market has expanded tremendously with an average annual growth rate of 127.89% (Leadleo 2022). However, little is known about the effectiveness of digital streamers in live streaming commerce. Through Study 1, we first provide a comprehensive empirical examination on the economic value of digital streamers and benchmark it with the non-streaming case. Using the GSC method with the transactional data provided by an online retailer, we find that digital streamers did not significantly boost sales compared to non-

streaming control. This finding reveals that digital streamers with the current design fall short of driving significant sales growth in live streaming.

Building on the insights from Study 1, the next step is to explore how digital streamers might be optimized to achieve similar effectiveness as human streamers. Leveraging a randomized field experiment, Study 2 is adopted to quantify the impact of various design strategies (i.e., form realism and behavioral realism) that can be employed to improve the sale performance of digital streamers. We have assessed five design features along the three dimensions (i.e., visual appearance, verbal communication, and human-AI interaction) and found that incorporating enhanced real-time Q&A (one type of human-AI interaction) led to a 25% increase in sales quantity and an 86% boost in sales revenue compared to the current design of digital streamers. In addition, integrating enhanced real-time Q&A in digital streamers showed no significant difference in boosting sales as compared to human streamers, indicating that this design strategy can make digital streamers rival with human streamers.

Additionally, incorporating a lottery feature (the other type of human-AI interaction) contributes to a 17% increase in sales quantity and a nearly 70% increase in sales revenue. Similarly, modifying voice features (verbal communication) yields a 17% increase in sales quantity and a 65% increase in sales revenue. Altering the appearance feature (visual appearance) results in a 11% increase in sales quantity and a 39% increase in sales revenue. Surprisingly, adopting stream scripts from proficient human streamers (verbal communication) does not significantly boost live streaming sales. These findings highlight various design strategies that could be employed for digital streamers to boost their sales performance. Overall, enhancing behavioral realism rather than focusing solely on form realism of digital streamers can significantly increase sales quantity and revenue in live streaming commerce.

Theoretical Contributions. Our contributions to the extant literature are two-fold. First, we contribute to the live streaming commerce literature by examining the economic value of

digital streamers. While a burgeoning stream of research has examined the effectiveness of human streamers (Bharadwaj et al. 2022, Zhang et al. 2022), little is known about the emerging AI-powered digital streamers. To the best of our knowledge, this study is among the first to examine the economic benefits of digital streamers in live streaming domain. Additionally, we enrich the existing literature on how the characteristics of digital streamers influence consumer purchase behavior. Previous research has mainly focused on consumer-perceived streamer characteristics (such as likeability and sociability) and their effects on consumer experience and purchase intention (e.g., Gao et al. 2023, Wu et al. 2023). This study provides direct empirical evidence on how various design strategies impact digital streamers' sales effectiveness.

Second, our research contributes to the current literature on the anthropomorphic features of digital agents. This study has examined a complete set of anthropomorphic design strategies that could enhance the effectiveness of digital streamers on product sales. Prior studies have investigated how the anthropomorphic design of digital agents affects consumer psychological perceptions (Wu et al. 2023, Xu and Liu 2022, Yim et al. 2023), and less attention has been paid to the direct impact of design features on product sales. Moreover, prior research mainly focused on individual aspects or specific features of the digital agent without a holistic view (e.g., appearance in Chen et al. (2024), communication style in Yao et al. (2024), language in Hu and Ma (2023), interaction in Wu et al. (2023)). Our study advances this research stream by evaluating and comparing the influence of various design strategies, including both form realism and behavioral realism ones, on promoting products sales outcomes in live streaming commerce.

Practical Implications. From a managerial perspective, the results of this study present potential insights for online retailers and the designers of digital streamers. First, our findings on digital streamers provide timely and actionable suggestions to online retailers, who have

either adopted digital streamers or are debating whether to adopt them, in terms of the economic value digital streamers may bring and how to use it properly. Although the current design of digital streamers cannot improve product sales, we have identified the optimal design strategy that can improve the sales effectiveness of digital streamers and make them as comparable as human counterparts. Therefore, not all the advancements of AI technology on digital agents may bring benefits right after its adoption, and our research serves as a reminder for retailers that they need to be cautious when adopting new technologies like digital streamers.

Second, this study highlights the importance of the design strategies regarding form realism and behavioral realism of digital streamers. We find that human-like visual appearance contributes positively to enhancing consumer purchases. In addition, imitating human streamers' verbal communication does not always lead to increased sales. Specifically, adopting stream scripts from proficient humans has no impact on product sales. In contrast, improvements on human-AI interactions significantly stimulate consumer purchases, surpassing the positive effects brought by changes in visual design. Given the substantial financial and time investments required for designing digital streamers, designers and online retailers should carefully make decisions on the design of digital streamers (China Daily 2022). For instance, they may choose to enhance the humanoid appearance or voice design and make them more human-like.

Moreover, beyond single-feature improvements, managers should consider integrating multiple realism features to further optimize digital streamers' performance. For example, advanced Q&A capabilities allow for dynamic, personalized audience interaction, increasing perceived social presence and fostering trust. Similarly, interactive features such as lottery or giveaways amplify audience engagement by creating a sense of community and excitement during live streams. When combined, these elements have the potential to produce synergistic effects, making digital streamers not only comparable to human streamers but potentially more

efficient given their scalability and cost-effectiveness.

Limitations and Future Directions. The present research offers some opportunities for future research. First, a key limitation of our study is the current difficulty in accurately estimating the costs associated with integrating advanced digital streamer features. Despite these technologies show promise, some remain in early developmental stage and cannot yet fully emulate the nuances of human interaction, such as the enhanced real-time Q&A. Consequently, reliable data on their long-term operational costs are limited. Preliminary evidence suggests that incorporating AI into live streaming may reshape cost structures. McKinsey & Company (2024) reports that using AI reduces human streamer wages by about 20%, signaling shifts in labor-related expenses. As GenAI continues to advance, they may become even more cost-effective, potentially stabilizing operational costs and enhancing overall sales performance. However, our current analysis does not provide a comprehensive cost-benefit evaluation of these emerging design features. Future research should focus on systematically examining both the direct and indirect expenses of AI integration once the technology reaches a more stable and advanced stage.

Second, other behavioral realism features, such as personalized nudging or deeper socially engaging behaviors, could provide further insights into the effectiveness of digital streamers. Future research could investigate how more advanced interactive capabilities impact downstream outcomes, such as user satisfaction and long-term loyalty. Moreover, while our results demonstrate the independent positive effects of these features on sales, the interaction between them (e.g., the design which combines high-realism appearance and lottery interaction) was not explicitly tested in our current design. Future research could investigate whether a cohesive integration of realistic visual and interactive features could produce compounded benefits, potentially bringing digital streamer efficacy closer to human levels or even surpassing them in certain contexts.

Third, AIGC technologies like ChatGPT have started being utilized for text generation (Wang et al. 2023). Because of the stochastic nature of generated content by ChatGPT, which could lead to randomness in the product scripts and affect the generalizability of the results, we decided to not include a condition for product scripts generated by GenAI tools like ChatGPT. Future research could explore how GenAI tools could be integrated to live streaming and improve its operational efficiency.

Lastly, in addition to the positive benefits that digital streamers may bring, research has also identified some limitations of digital streamers. For instance, they may be appealing to young consumers, making it challenging to capture the attention of older ones (Hu and Ma 2023). Therefore, future research could investigate the impact of digital streamers on different consumer groups' psychological feelings and attitudes, thereby helping companies in customer segmentation.

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Tables:

Table 1. Selected Studies on Anthropomorphic Features of Digital Agent

Reference	Context	Design features		Research design		Dependent variables
		Form realism	Behavioral realism	Method	Sample	
This study	Digital streamer	√	√	Quasi experiment & Randomized field experiment	Live streaming platform users	Sales quantity and revenue
Liu et al. (2024)	Healthcare chatbot	√	√	Questionnaire	Not specified	Use intention
Youn and Cho (2023)	Chatbot	√		Online experiment	Amazon MTurk	Use intention
Lee and Lee (2023)	Psychotherapy chatbots	√		Online experiment	College students	Engagement
Schillaci et al. (2024)	Healthcare chatbot		√	Online experiment	Not specified	Use intention
Xu et al. (2024)	Freight chatbot		√	Field experiment	Truck drivers in a truck-sharing platform	Response rate, conversation length, and order acceptance intention
Schanke et al. (2021)	Shopping chatbot		√	Field experiment	Shoppers in a targeted retailer	Conversion rate
Luo et al. (2019)	Financial chatbot		√	Field experiment	Customers in a loan company	Purchase rate
Hu and Ma (2023)	Virtual streamer		√	Online experiment	Wenjuanxing.com	Purchase intention
Li et al. (2023)	E-commerce chatbot		√	Online experiment	Wenjuanxing.com	Purchase intention
Zhou et al. (2024)	Virtual influencer		√	Online experiment	Credamo & Prolific	Purchase intention
Yao et al. (2024)	Virtual streamer		√	Online experiment	Credamo	Purchase intention

Table 2. The Taxonomy for Anthropomorphic Design of Digital Streamers

	Design Features	Realism level	
		Low	High
Form realism (Low vs. High)	Visual appearance	Digital streamers with humanoid appearance, akin to cartoon-like visual representations. 	Digital streamers with a highly realistic, fully humanlike appearance that is indistinguishable from a real person. 
Behavioral realism (Low vs. High)	Verbal communication	• Voice • Stream script Machine-synthesized voice Scripted product presentation	Human voice Imitates the text of a professional human streamer, including pauses, filler words, and other speech nuances.
	Human-AI interactions	• Lottery • Real-time interaction Without lottery Limited interaction restricted to predefined questions	With real-time lottery Interaction as if with a real human

Table 3. Variable Definitions and Descriptive Statistics

Variables	Definitions	Mean	SD	Min	Max	Obs
$Sales_{it}$	The sales quantity of product i on day t	7.338	25.411	0	1,052	41,097
$Price_{it}$	The tag price of product i on day t	715.593	283.899	40	1,880	41,097
$Discount_{it}$	The discount percentage of product i on day t	0.201	0.136	0	0.501	41,097

Table 4. Average Treatment Effect of Digital and Human Streamers

	Digital Streamers	Human Streamers
D (treatment effect)	-1.571 (2.088)	10.350*** (0.584)
Price	-0.022*** (0.005)	-0.022*** (0.006)
Discount	12.085*** (1.851)	12.085*** (2.250)
Product-level fixed effects	Yes	Yes
Day-level fixed effects	Yes	Yes
Number of treated products	72	74
Number of control products	182	182

Note: *** $p < 0.001$. Standard errors are produced by 1,000¹⁰ parametric bootstraps blocked at the product level and are presented in parentheses.

¹⁰ Results are consistent when we increase the number of bootstrap times to 5,000 or more for all analyses.

Table 5. The Experimental Design of Study 2

Condition	Design	Improved avatar design features		
		Form realism	Behavioral realism	
			Verbal communication	Human-AI interactions
Control 1	Current digital streamer design: low-realism digital streamer	/		
Treatment 1	Current digital streamer design with a human-like face	Appearance		
Treatment 2	Current digital streamer design with streaming scripts from human streamer		Stream scripts	
Treatment 3	Current digital streamer design with voice features from human streamer		Voice	
Treatment 4	Current digital streamer design with real-time lottery			Lottery interaction
Treatment 5	Current digital streamer design with enhanced real-time Q&A			Human-AI interaction
Treatment 6	Current human streamer design	/		

Table 6. Variables, Measures, and Descriptive Statistics in Study 2

Variable	Measurement	Mean	SD	Min	Max	Skewness	N
Quantity _{it}	The sales quantity of product <i>i</i> on day <i>t</i>	0.600	1.028	0	7	2.262	882
Revenue _{it}	The sales revenue of product <i>i</i> on day <i>t</i>	12.299	22.778	0	151.600	2.582	882
Price _{it}	The tag price of product <i>i</i> on day <i>t</i>	31.878	18.599	12.900	74.400	0.975	882
Discount _{it}	The discount level of product <i>i</i> on day <i>t</i>	0.223	0.194	0	0.652	0.642	882

Table 7. Regression Results in Study 2 – Current Design of Digital Streamer as Baseline

Variables	DV=Log (Sales Quantity)		DV=Log (Sales Revenue)	
Treatment 1_appearance	0.122*	0.111*	0.422*	0.388*
	(0.050)	(0.051)	(0.175)	(0.178)
Treatment 2_stream scripts	0.049	0.048	0.205	0.202
	(0.044)	(0.044)	(0.157)	(0.158)
Treatment 3_voice	0.174***	0.168**	0.668***	0.651***
	(0.049)	(0.049)	(0.175)	(0.175)
Treatment 4_lottery	0.174***	0.168**	0.702***	0.686***
	(0.049)	(0.049)	(0.176)	(0.178)
Treatment 5_enhanced Q&A	0.264***	0.253***	0.894***	0.864***
	(0.056)	(0.055)	(0.186)	(0.186)
Treatment 6_human	0.314***	0.301***	1.096***	1.059***
	(0.054)	(0.056)	(0.184)	(0.191)
Number of viewers		0.000		-0.000
		(0.001)		(0.002)
Number of exposures		0.000		0.001
		(0.000)		(0.001)
Duration of the product introduction		-0.006		-0.018
		(0.005)		(0.015)
Constant	0.173***	0.598	0.615***	1.916
	(0.030)	(0.389)	(0.108)	(1.304)
Product-level fixed effects	Yes	Yes	Yes	Yes
Day of the week fixed effects	Yes	Yes	Yes	Yes
Observations	882	882	882	882
R-squared	0.208	0.210	0.188	0.191
<i>p</i> -value (T6-T1)	0.002	0.002	0.001	0.002
<i>p</i> -value (T6-T2)	0.000	0.000	0.000	0.000
<i>p</i> -value (T6-T3)	0.019	0.028	0.036	0.048
<i>p</i> -value (T6-T4)	0.020	0.028	0.054	0.070
<i>p</i> -value (T6-T5)	0.445	0.471	0.343	0.361

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Robust standard errors are in parentheses.

Table 8. Regression Results on Consumer Real-Time Comments in Study 2

Variables	DV=Log (Real-time comments)	
Treatment 1_appearance	0.565*** (0.145)	0.424* (0.163)
Treatment 2_stream scripts	0.060 (0.169)	0.043 (0.176)
Treatment 3_voice	0.881*** (0.219)	0.738*** (0.182)
Treatment 4_lottery	1.072*** (0.185)	0.943*** (0.212)
Treatment 5_enhanced Q&A	1.969*** (0.195)	1.735*** (0.227)
Treatment 6_human	2.069*** (0.217)	1.748*** (0.222)
Number of viewers		0.001 (0.003)
Number of exposures		0.005* (0.002)
Constant	3.099*** (0.077)	2.634** (0.750)
Day of the week fixed effects	Yes	Yes
Observations	49	49
R-squared	0.818	0.845
<i>p</i> -value (T6-T1)	0.000	0.000
<i>p</i> -value (T6-T2)	0.000	0.000
<i>p</i> -value (T6-T3)	0.000	0.000
<i>p</i> -value (T6-T4)	0.001	0.004
<i>p</i> -value (T6-T5)	0.714	0.956

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Robust standard errors are in parentheses.

Table 9. Regression Results on Sales Quantity in Study 2

Variables	DV=Log (Sales Quantity)	
Real-time comments	0.001*** (0.000)	0.001*** (0.000)
Number of viewers		0.001 (0.001)
Number of exposures		0.000 (0.000)
Duration of the product introduction		-0.006 (0.005)
Constant	0.247*** (0.020)	0.501 (0.379)
Product-level fixed effects	Yes	Yes
Day of the week fixed effects	Yes	Yes
Observations	882	882
R-squared	0.191	0.196

Notes: *** $p < 0.001$. Robust standard errors are in parentheses.