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# **The Sales Impact of Storytelling in Live Streaming E-Commerce**

*Short Paper*

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## **Abstract**

*Live streaming e-commerce (LSE) has emerged as a popular third-party service for improving product sales. It persuades consumers through streamers' storytelling or narratives, which encompass descriptions and depictions of their own product experiences. However, the sales impact of a story or narrative in LSEs has been overlooked in the literature. Extending the narrative transportation theory to the LSE context, we posit that the dual landscapes of narrative—the landscapes of action and the landscape of consciousness—can improve product sales through their influence on consumers' imagination of story plotline and empathy for streamers' product experiences. We also propose that the efficacy of the dual landscapes is contingent on streamers' interaction response to consumer queries. By collecting LSE data from the Taobao Live platform, we manually and algorithmically measured these variables and proposed to empirically examine their effects.*

**Keywords:** Live streaming, e-commerce, narrative transportation theory

## **Introduction**

Live streaming, an emerging real video-based narration function, has been successfully leveraged by the e-marketplace to boost sales in recent years. Amazon Live and Taobao Live are prominent cases. In 2021, Taobao Live, China's dominant live streaming e-commerce (LSE) platform, achieved a gross merchandise value of more than 72 billion USD. LSE is believed to have revolutionized the e-commerce industry and reshaped people's consumption habits. Streamers often broadcast products from multiple sellers to multiple consumers in a live format. Sellers commonly compete by cooperating with these streamers to offer third-party live streaming services.

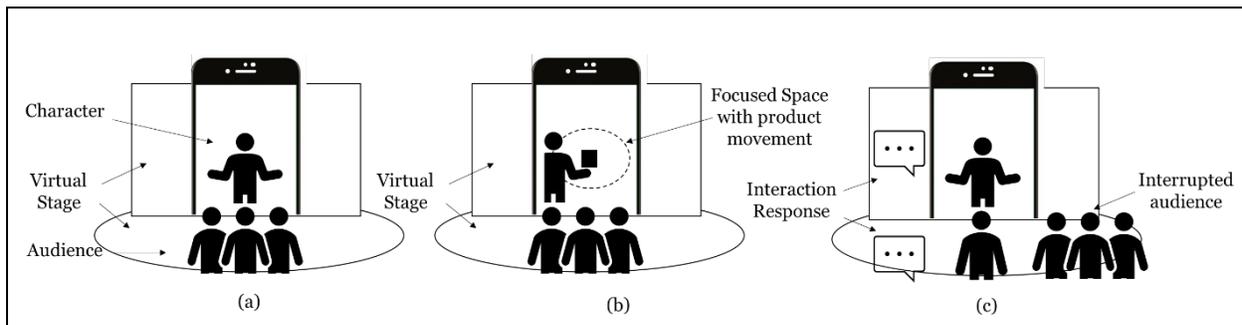
LSE has the potential to combat the lack of product experiences in traditional e-commerce. E-commerce literature identifies a set of web-based functions—including zoom, alternative pictures, and live chat—that can deliver product attributes to consumers and enable transactions (Li et al. 2019; Tan et al. 2019). However, the static and impersonal display of product information leads to the absence of pleasurable experiences of trialing or fitting products. When consumers purchase in traditional e-commerce, they cannot experience face-to-face interactions with sellers, and they can only have curiosities clarified through one-to-one interaction with digital assistants in live chat. This results in less pleasure and lower purchase intentions. In comparison, LSE is more likely to create a pleasurable shopping experience to encourage

purchasing. This is because streamers often disclose their faces, frame what they know and feel, show the various physical angles of products, tactilely interact with the products (e.g., using touch, smell, or taste), answer any queries potential consumers may have, and induce them to buy (Chen et al. 2019; Xue et al. 2020). Consumers can thus predict or envision their experience of consuming the same products while viewing the live stream (Chen et al. 2017). Thus, building on the functions of e-commerce, LSE can take advantage of real-time video narration to deliver the streamers' product experiences.

The sales impact of streamers' product experiences remains unexplored in live streaming literature, which has mainly focused on the influence of consumer motivations (Guo et al. 2021; Zhang et al. 2020a) and streamer characteristics (Lu and Chen 2021; Xu et al. 2020) on purchase intention. Some studies have realized the importance of video content features (e.g., discrete emotional displays) in persuading consumers (Bharadwaj et al. 2022; Lin et al. 2021), but they direct no attention to the screen-mediated product presentation. As LSE engages consumers in a shopping environment and showcases sellers' real products, streamers often communicate with consumers via their product-centered experiences (Chen et al. 2019; Lu and Chen 2021). These experiences might involve consumers through more subtle psychological mechanisms related to experiential engagement, described as absorption (e.g., Xu et al. 2020) and a sense of immersion (e.g., Sun et al. 2019). Despite this, live streaming studies do not consider how streamers' storytelling about product experiences affects product sales.

This study proposes that streamers' product experiences follow a storyline and persuade consumers by involving them in a performative narrative world. Indeed, the entire sales encounter can be seen as a theatrical performance designed to impress consumers (Fisk and Grove 1996). It traditionally includes (1) the role played by the characters, (2) the stages or spaces, and (3) the role-playing activities of the characters within the changing narrative (Goffman 1956). Adding the role of the audience to this relationship, we thus consider LSE as live theatre, where streamers are both storytellers and characters, live streaming rooms are virtual stages mediated by mobile phones, and streamers' performances of experiencing products are narratives directed to consumers (Figure 1a). For example, a streamer's performance of a type of lipstick includes their set of actions and subjective thoughts and feelings, such as displaying a product at an initial state ("This is a lipstick I really like"), trying on the lipstick at a later state ("Wow, it's convenient to use"), and showing the usage outcome at the final state ("I haven't seen such beautiful color for a long time"). In this case, the streamer's performance is inherently a narrative or story, as it captures a sequence of action events about a streamer-as-character who uses products, leading to a transition of the streamer's state in engaging the product (van Laer et al. 2014). A few live streaming studies have acknowledged that technical features (e.g., microphone and camera shots) may help streamers narrate their actions, thoughts, and feelings to consumers (Li et al. 2020; Sjöblom et al. 2019). Yet the arc of narration, or the way a story is told, remains a neglected perspective of LSE. We thus propose the first research question:

**RQ1: To what extent is narrative related to product sales in LSE?**



**Figure 1. Live Streaming E-Commerce as a Live Theatre**

We examine this research question by extending the narrative transportation theory from the marketing field. The theory posits that a story, constructed by the dual landscapes of action and consciousness, persuades people by activating their imagination of the story plot and encouraging them to empathize with the story characters (Bruner 1986; van Laer et al. 2014). The *landscape of action* refers to the causal sequence of action events that are visible to the audience, including the landscapes of *temporal action* and

*spatial action* (Bruner 1986; Escalas and Bettman 2000). The theory demonstrates action events that happen in a particular space and at a particular time, and thus make the audience imagine the described setting in a compelling manner (van Laer et al. 2019). In parallel, the landscape of consciousness—including the landscapes of *cognitive and affective consciousness*—refers to the ways in which a story describes the psychological state of a character's thoughts and feelings (Bruner 1986; Feldman et al. 1990). It offers insights into the character's state of mind and allows the audience to empathize with the character (van Laer et al. 2019). The transformation narrative that such transportation achieves is referred to as *narrative persuasion*. By extending the narrative transportation theory to LSE, we posit that the landscapes of action and consciousness will heighten the level of narrative persuasion and increase product sales.

While the narrative transportation theory is appropriate for understanding the sales impact of streamers' performances of experiencing products, the theory was developed in the unidirectional text and image narratives (Grigsby et al. 2022; van Laer et al. 2019). Existing studies of video narratives mainly focus on the impact of the general narrative structure (Cao et al. 2021; Gilliam and Zablah 2013), but offer little insight into how to design the specific components of video narratives. LSE is a context of real-time video narration, which has a unique effect on consumers' imagination of the product experience plot and empathy with the streamers. Thus, to better understand the sales impact of streamers' performances as the dual landscapes of narrative in the unique context of LSE, it is desired to offer a context-specific understanding of the effectiveness of narrative design on product sales.

To address this need, we first highlight the design of video narratives in LSE by extending the landscape of action. By contrast with static texts or images, streamers often present a coherent plot about experiencing products, which are directly observable in the form of videos in LSE. Temporal and spatial action in this context refers to how a story is structured by action events that unfold through time and space (Escalas and Bettman 2000; Thompson 1997). Yet, existing conceptualizations of temporal and spatial action have largely focused on text and image narratives (Grigsby et al. 2022; van Laer et al. 2019), providing a limited understanding of the LSE video narratives where streamers perform a coherent sequence of visual actions with a connection to physical products. We reconceptualize temporal action in LSE as a sequence of action events portraying product usage occasions with a beginning, middle, and end. This construct can convey a sense of time change and a causal relationship between characters and their visual actions, evoking imagery and thereby transporting consumers into the consumption setting (Glaser and Reisinger 2021). In addition, we propose a reconceptualization of spatial action comprised of two dimensions that tap into *maximum size*—the largest percentage of product display in relation to screen size in a product-level video, as well as *movement*—the extent to which a product is moving on the screen. These new dimensions, which are rooted in the product placement prominence literature, reflect the high visibility of size and position on a screen (Gupta and Lord 1998). For example, placing a product close to the camera shot or in motion can structure streamers' action events in a spatial trajectory that makes consumers form similar narratives and imagine themselves in product usage situations.

Second, we incorporate interaction response as a streamer-specific factor that moderates the sales impact of storytelling. We select interaction response because it is another unique characteristic of LSE. Narratives studies are dominated by unidirectional narratives, whether online reviews (van Laer et al. 2019), print ads (Grigsby et al. 2022), or live theatre (Rathje et al. 2021). By contrast, LSE delivers narratives in a real-time interactive manner. Streamers can respond to an individual consumer's text comments, which are shown publicly in a scrolling dialog box (Chen et al. 2019). *Interaction response*—which refers to whether the streamer responds to consumers' live comments in the showcase of a product—is important for an individual consumer who asks questions via live comments, because the streamer can offer more information for product evaluation. But the overall effect of interaction response to the product-level video is not clear. For example, interrupting the flow of storytelling to answer an individual's questions may negatively impact other consumers' imagination of the plot and empathy with the streamer. Understanding interaction response is thus important in determining the narrative transportation effect in LSE. Further, although the positive effect of interaction response on purchase intention has been widely examined (e.g., Xu et al. 2020; Xue et al. 2020), we know far less about the combined effect of interaction response with narratives on live streaming performance. As such, we propose the second research question:

**RQ2:** *How does interaction response moderate the effect of narrative on product sales in LSE?*

## **Theoretical Background and Hypothesis Development**

### ***Live Streaming E-Commerce***

How LSE persuades consumers has received increasing attention in academia. Prior studies have been undertaken on factors that drive consumers to purchase in LSE, primarily (1) consumer motivations, such as trust and perceived product uncertainty (Guo et al. 2021; Zhang et al. 2020a), and (2) streamers' characteristics, such as physical traits and values (Lu and Chen 2021; Xu et al. 2020). Recently, an emerging line of live streaming work has begun to explore the role of video content features, especially streamers' emotional displays, in engaging or persuading consumers (Bharadwaj et al. 2022; Lin et al. 2021). Yet we suggest that this perspective does not fully capture the potential of streamers' narrative performance of experiencing products, which is a novel phenomenon of LSE in comparison with traditional e-commerce. To showcase and promote the products assigned by sellers, streamers are required to communicate with consumers by depicting their product usage experiences (Chen et al. 2019; Lu and Chen 2021). In this paper, we suggest that consumers' level of involvement in streamers' narratives has a major impact on persuasion. As recent studies have confirmed that live streaming technology has the potential to involve consumers via the mechanisms of absorption (e.g., Xu et al. 2020) and related immersion (e.g., Sun et al. 2019), LSE storylines that describe the specific experiences streamers are sharing with consumers (Li et al. 2020; Sjöblom et al. 2019) promote a distinctive type of involvement characterized by getting transported to the story world and relating closely with its characters. The specific narrative messages depicting the streamers' performances of experiencing products may therefore play an important role in boosting product sales, largely because they enable consumers to make sense of the story in mind and interpret it with the streamers' product bias. Yet the ways in which narration works to increase product sales in LSE remain unexplored.

### ***Narrative Transportation Theory***

The narrative transportation theory suggests that when people are engrossed in a story, they are more likely to change their attitudes and behaviors in accordance with its message (Green and Brock 2000). A story or narrative refers to a sequence of action events leading to the characters' transition from an initial state to a later state or outcome (van Laer et al. 2014). It consists of two key components of plot and character (Escalas 1998; Escalas 2004), where the plot frames the temporal sequence and causality of action events, whereas the character is the protagonist who acts within the events (van Laer et al. 2014). The extended transportation-imagery model has argued that a story persuades the audience through narrative transportation, which refers to "the extent to which (1) an individual empathizes with the story characters and (2) the story plot activates his or her imagination, which leads them to experience suspended reality during story reception" (van Laer et al. 2014, pp. 799–800). Narrative transportation thus leads to narrative persuasion (Green and Brock 2000).

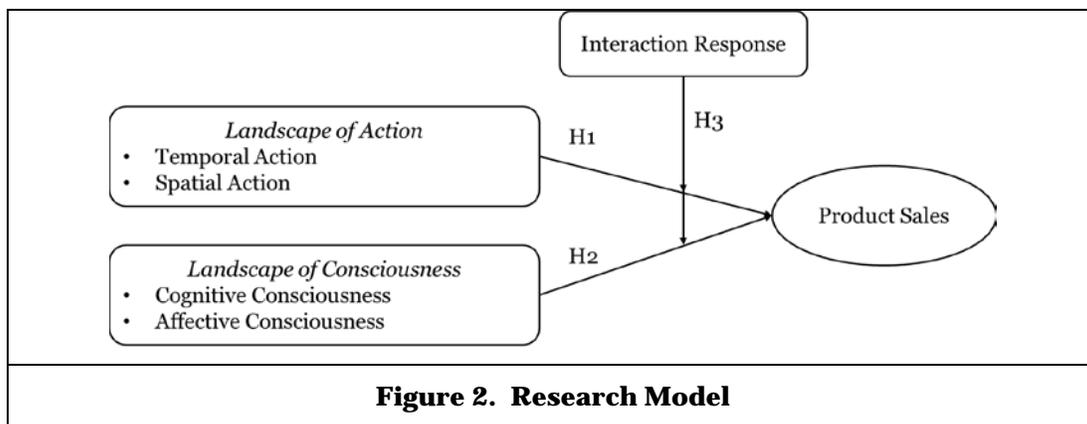
A story by definition must include the dual landscapes of action and consciousness (Bruner 1986). One is the landscape of action, which refers to a sequence of action events patterned in a temporal or spatial trajectory (Feldman et al. 1990; Thompson 1997). Action establishes the relationships between characters and action events and allows for causal inferencing. In such a landscape, action events are observable to the audience and are not overly concerned with the psychological states of the characters (Feldman et al. 1990). Indeed, the purpose of this landscape is to report events encountered and capture the imaginability of the story plot in terms of time and space (Escalas and Bettman 2000; Thompson 1997). The other is the landscape of consciousness, which denotes the ways in which the characters perceive, feel, or respond to the narrative world (Feldman et al. 1990). It aims to explore the mental states of characters in a story, including their thoughts and feelings (Escalas and Bettman 2000). The landscape of consciousness makes a narrative more compelling because it helps the audience enter into the mind of characters and empathize with them (Bruner 1986). In summary, the dual landscapes of action and consciousness are conceptually distinct from each other and collectively offer a holistic picture of a story.

### ***Extending the Narrative Transportation Theory to Live Streaming E-Commerce***

In looking at LSE from the performative perspective, we conceptualize a streamer's product experience as a narrative. This conceptualization is appropriate because the performance of streamers in LSE bears the key characteristics of a transporting story. As noted earlier, streamers' performances of experiencing

products often take the form of a story where streamers showcase the products in a setting, following a classic storyline of a coherent sequence of actions with an initial state, a later state, and a final state. Moreover, these action events are all performed by the streamers in the live streaming video, who act as the story characters to express personal thoughts and feelings in the context of specific experiences. A streamer's performance is thus made up of narrative structures.

Compared with unidirectional text and image narratives (e.g., online reviews and print ads) (Grigsby et al. 2022; van Laer et al. 2019), streamers' product experiences in LSE are real-time video narratives. Previous video narrative studies mainly explore the impact of general narrative structure (Cao et al. 2021; Gilliam and Zablah 2013), verbal narrative outcomes (i.e., narrative topics and sentiments) (Hwang et al. 2021), and the moment-to-moment synchronicity between movie plots and viewer engagement (Zhang et al. 2020b). However, they direct no attention to the design of specific narrative components, especially the dual landscapes. We believe that the unique features of LSE in which consumers watch real-time narrative videos can generate a context-specific of the sales impact of narrative design. Thus, we extend the narrative transportation theory to the LSE context by (1) reconceptualizing the landscape of action to highlight the design of video narratives in LSE and (2) incorporating interaction response as streamer-specific factor moderating the sales impact of the dual landscapes of narrative. Figure 2 shows the proposed research model featuring the dual landscapes of narrative and interaction response in relation to product sales:



### The Dual Landscapes of Narrative and Product Sales

The landscape of action consists of the action events that convey a sense of time and space, referring to both temporal and spatial action. Temporal action denotes the extent to which action events are structured over time with a beginning, middle, and ending, indicating the direction of a story (Thompson 1997). It is mainly operationalized as the texts organizing events in time order (van Laer et al. 2019) and the images with depicted movement (Grigsby et al. 2022). In comparison, streamers' narrative performances in LSE follow a coherent sequence of the real-life interaction between streamers and physical products. Since the connection between the product and the storyline influences narrative transportation (Russell 2002), we suggest the context-specific temporal action as a temporal sequence of actions portraying the product usage process, from a mere mention of a product, a brief display of the product on the screen, to the usage of the product. The narrative transportation theory proposes that a series of temporally sequenced action events form a base for an imaginable plot (van Laer et al. 2014). By extending this logic to the LSE context, we argue that streamers' higher degree of temporal action could generate more vivid images of product usage experiences. This is because when the streamers assemble their actions into a temporal sequence, consumers are more likely to perceive a coherent plot and a causal relationship between streamers and their visual actions. In this way, streamers depict the (positive) change in their situation and their interaction with products. Prior research also supports that consumers can generate vivid images of characters' product usage experiences that form the basis of their self-imagined use of the product (Glaser and Reisinger 2021). Thus, we expect a positive relationship between temporal action and product sales.

Spatial action, on the other hand, refers to the extent to which action events are patterned in a spatial trajectory, explaining the changing scene of the narrative world (Escalas and Bettman 2000; Thompson 1997). It is mainly operationalized as the text indicating a sequence of action events that move from one

space to another (van Laer et al. 2019). However, LSE narrows down the spatial scope due to the fixed performance stage. In other words, streamers' action events unfold in a focused space, where streamers move products from one position to another on the screen (Figure 1b). Drawing on the product placement prominence literature, we reconceptualize spatial action as two dimensions: maximum size (e.g., the largest percentage of space used for product display in relation to screen size) and movement (e.g., the extent to which a product is moving on the screen) (Gupta and Lord 1998). The narrative transportation theory suggests that spatially patterned action events are capable of enhancing the imagination of storyline plots (van Laer et al. 2019). By extending this theory, we argue that both largest-size and moving product placement could help consumers generate vivid images of the product experience in the focused space. In LSE, streamers often move a product near the camera shot or take a close-up shot to show the visual details. Streamers also interact with a product by moving, rotating, opening, or folding it rather than merely placing it on the table. These actions can achieve the spatial transition from the whole virtual stage to a focused moving space of the product. LSE studies also confirm that when a product is prominently placed on the screen, consumers can construct the real-life experience in their minds and feel as though they are trying the product themselves (Chen et al. 2019). Therefore, spatial action can convince consumers to purchase through their immersion in mentally imagined plots, thus positively impacting product sales:

**H1:** (a) Temporal action and (b) spatial action are positively related to product sales.

Characters' cognitive and affective consciousness refers to how the story reflects the psychological state of their thoughts and feelings, respectively (van Laer et al. 2019). It is generally manifested as insight (e.g., consider, know, and think) and affect words (e.g., abandon, cry, and happy) in the text to reflect the internal world of the characters. Building on the narrative transportation theory, the landscape of consciousness improves the audience's empathy with the story characters (Bruner 1986; Feldman et al. 1990). To interpret a story, consumers need to understand or relate to the mental perspectives of characters rather than only observe a sequence of action events reported (Feldman et al. 1990). In this way, they can vicariously experience the characters' beliefs and emotions, which further enhances their sense of inclusiveness and empathy. By extending this logic to the LSE context, we argue that streamers that focus on the use of the landscape of consciousness rather than only the landscape of action, are able to make consumers empathize with their product experiences. In other words, if streamers frequently express their psychological world—what they are thinking and feeling about using a product, consumers are more likely to substitute the streamers' experiences as their own. We thus hypothesize that cognitive and affective consciousness can achieve better product sales in LSE:

**H2:** (a) Cognitive consciousness and (b) affective consciousness are positively related to product sales.

### **The Moderating Role of Interaction Response**

Interaction response is another unique characteristic of LSE. Compared with traditional contexts like online reviews (van Laer et al. 2019), print ads (Grigsby et al. 2022), or live theatre (Rathje et al. 2021), where the audience passively receives stories, the narratives in LSE are delivered in an interactive mode. Streamers could respond to the live comments embedded in videos and have one-to-many synchronous conversations with consumers (Chen et al. 2019). LSE literature has highlighted the benefits of interaction response (e.g., Xu et al. 2020; Xue et al. 2020), but little scholarly attention has been paid to its possible moderating role. This offers us an opportunity to extend the LSE literature by examining how streamers' storytelling behaviors and response to consumers work together to affect product sales.

We argue that interaction response may weaken the narrative transportation effect. The logic for this moderation effect is that interaction response serves as a verbal message capable of interrupting a transportation experience. Attentional focus is of particular importance to narrative transportation because the audience often devotes high levels of cognitive and affective engagement to image the plot and empathize with the characters (Gordon et al. 2018; Green and Clark 2013). When the narrative flow of a story is disrupted, the audience's transportation experience will be weakened. For example, the audience will react negatively to an antismoking ad placed in a narrative program (Durkin and Wakefield 2008). Thus, narrative transportation requires a high level of attention.

As elaborated earlier, the one-to-one Q&A may benefit the individual consumer who asks questions via live comments, because the consumers can obtain more information for product evaluation and thus increase purchase intention (Xue et al. 2020). Yet LSE—as a one-to-many stage where a streamer showcases

products—needs to ensure the coherence of its narrative structure. In comparison with active interactions (e.g., greetings) induced by a streamer to engage consumers (Lu et al. 2021), a streamer's passive response to an individual consumer (e.g., answering questions) can force him or her to suspend the narrative performance. This is because these responses are not his or her intention and will distract the attention of other consumers. Streamers' responding to comments of an individual consumer may therefore disrupt the transportation experience of other consumers (Figure 1c). This in turn interrupts other consumers' imagination of the plotline and empathy with the streamer. Interaction response thus decreases the likelihood that these consumers would be transported into the story. We therefore hypothesize:

**H3:** Interaction response weakens the positive effects of (a) temporal action, (b) spatial action, (c) cognitive consciousness, and (d) affective consciousness on product sales in LSE.

## **Proposed Research Methodology and Future Work**

Given that a streamer's narrative performance centers on a single product, the unit of analysis of our study is at the product level. To validate the proposed research objectives, data were gathered from Taobao Live between 1 October 2020 and 31 January 2021. The data offer four distinct sources: (1) streaming videos, (2) streamer profiles (e.g., number of followers and live streams), (3) video profiles (e.g., number of views, comments, likes, and products), and (4) product profile (e.g., duration, price, discounts, and category).

We conducted a video cleaning process using two criteria. First, we restricted our sample to third-party streamers who sell products for sellers. Second, we restricted our sample to videos broadcasted between 6 p.m. and 1 a.m. UTC +8. These cutoffs were necessary because they ensure that live streaming activities can be observed around specific phases, and thus minimize the influence of other potentially confounding phases. Third, we eliminated videos with extreme values because they need to be minimal conservative numbers to have any meaningful result. Our full sample contains 462,862 products in 10,951 videos broadcasted by 394 streamers. In this study, we propose to restrict the sample to a subcategory (e.g., cosmetics) to prevent cross-category confounds on product sales. Another reason why we decide to restrict the sample is that the measures of some key variables rely on manual coding, which is costly and labor intensive. We randomly selected 1,337 products in 561 videos broadcasted by 182 streamers as the final sample. We believe that the variance and size of the sample is sufficient to examine our research questions. In subsequent work, we will extract the variables according to the following operationalization, where we plan to propose and estimate a fixed-effects model to quantify the hypotheses.

We manually code temporal action as a categorical variable coded as 0 (event 1), 1 (firstly event 1 and then event 2), or 2 (firstly event 1, then event 2, and finally event 3). Specifically, streamers merely mention the product at event 1, briefly display the product on the screen at event 2, and react to or try the product at event 3. Spatial action is indicated by two variables: the maximum size and movement of the product displays. Maximum size is measured with the largest percentage of the product display size of screen size in a product-level video. We choose the screenshot with the share of the largest area of the displayed product relative to the screen and manually code the largest area of a displayed product. Movement is also manually coded by recording the time length of a product moving in a product-level video. To quantify cognitive and affective consciousness, we rely on a speech-to-text algorithm and the simplified Chinese version of the Linguistic Inquiry and Word Count (LIWC) dictionary. We measure these two variables through the proportions of insight and affect words of total words conveyed by streamers during each product-level video. We adopt one built-in category of LIWC, insight (e.g., consider, know, and think) to count the insight words. We use another category of LIWC, affect (e.g., abandon, cry, and happy) to identify affect words. Interaction response is measured by manual coding with a dummy variable indicating whether streamers responded to consumers' comments during a product-level video, such as answering questions and reading the comments. We measure product sales with the number of pieces of a single focal product in a live streaming video hosted by a streamer. Control variables at the level of streamers (e.g., number of followers), videos (e.g., live duration), and products (e.g., price) are also incorporated in the model.

## **Intended Contributions**

This study makes three important contributions. First, it contributes to the e-commerce literature by extending the narrative transportation theory to examine the sales impact of the dual landscapes of narrative. While e-commerce literature has primarily focused on how platform-based functions improve

product sales, product experience remains largely unexplored due to the static and impersonal display of product information. Relying on the unique LSE context, we complement the existing work by highlighting the storytelling role of streamers' product experiences, which transport consumers into the performative story world and then persuade them to purchase. This perspective also sheds light on the studies of designing video content in live streaming. Second, the study provides a context-specific understanding of the sales impact of the dual landscapes of narrative by reconceptualizing the landscape of action and incorporating interaction response as a moderator, thereby contributing to the narrative transportation theory. We go beyond text and image narratives to specify the video narrative components in LSE. Additionally, we highlight the moderating role of interaction response that is crucial to consumers' transportation experiences. In doing so, we contribute to the narrative transportation theory by enriching the condition under which the theory operates in the LSE context. Third, we contribute to the understanding of interaction response by going beyond its positive impact on purchase intention in the LSE literature and revealing its moderating role in weakening the sales impact of the dual landscapes of narrative. This research also provides practical implications for both streamers and LSE platform owners in terms of detailing how to describe and depict streamers' product performances aiming to persuade consumers to purchase and thus improve product sales. This ongoing study is not without limitations. In particular, we acknowledge the potential endogeneity issues (e.g., selection issues) are not fully addressed in the current version, which needs relevant robustness checks in future work.

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