Trust in Humanoid Robots in Footwear Stores: A Crisp-Set QCA Model

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Background: Robotic innovation has provided a new opportunity for fashion retailers to address consumers' physical and emotional needs for receiving efficient customer service (Huang & Rust, 2020). A humanoid robot is an artificially intelligent (AI) robot with a human-like face and body shape that interacts, recognizes, analyzes, and adaptively responds to consumers' emotions and expressions (De Graaf & Allouch, 2013). This humanoid robot can offer more personalized services and delightful shopping experiences, ultimately influencing their intention to visit the store (Murphy, Gretzel, & Pesonen, 2019). Based on Social Exchange Theory, sharing beneficial functions (i.e., performance) and interpersonal communication (i.e., social intelligence) between humans are fundamental aspects of building relationships, requiring mutual trust (Fox & Gambino, 2021). According to Computers Are Social Actors (CASA) theory (Nass, Steuer, and Tauber (1994), such social exchanges with humanoid intelligent machines can occur in a similar manner as in human-to-human interaction, because social cues exhibited by the robots can prompt people to perform an action that is beneficial to themselves and engaging in collaboration (i.e., operation) with the computer. Synthesizing two theoretical backgrounds, we propose that one's intent to visit the store is determined by the interplay among the three dimensions—users' trust in robots, the robots' social intelligence and performance. Such causal relationships in the use of technology can be explained by membership relations among sets of cases, which are then described in terms of "sufficiency" (i.e., the outcome that "always" occurs whenever a "sufficient" causal condition is present; sufficient condition $\supset$ outcome) and "necessity" (i.e., a condition is necessary to elicit the outcome and is always present when the outcome occurs; necessary condition $\subset$ outcome), which is referred to as "set-theoretic methods"(Schneider & Wagemann, 2012). Using a Crist-Set Qualitative Comparative Analysis (csQCA), a set-theoretic comparative technique comparing observations/cases with binary-coded data, we explore the causality of intention to visit or non-visit a robot-operated footwear store.

Methods and analytic strategies: The study used the following methodological approach: (1) a video stimulus, (2) a pretest, and (3) csQCA using empirical data. We obtained a data set (n = 455) consisting of consumer panelists of a commercial online survey company. Gender was evenly distributed (47.3% were female), with a median age of 39. The participants were widely distributed along the income spectrum with the median of $60,000-$79,999. All scale items were modified from existing scales (7-point Likert-type scale). For data calibration, 2 x 4 x 4 case matrix was created by categorizing based on gender, four education levels, and four generations (generation Z, millennials, generation X, and Baby Boomers). To make the binary conditions, we used a "thresholdsetter" function of TOSMANA which provides split-thresholds (trust = 5.24;

social intelligence = 5.73; performance = 5.26; visit intent = 50% split) by each variable's system auto-clustering for dichotomization (Vink & Van Vliet, 2009). If the value of each case is lower than its given threshold, the variable of the case is recorded as 0, and if it is greater than the threshold, it is recorded as 1. To identify sufficient and necessary conditions, we performed the following analyses of csQCA using TOSMANA 1.6.1.0: a truth table of all combinations of conditions and analysis of necessary and sufficient conditions along with TOSMANA diagram (Figure 1). As suggested by Ragin (2006), we also performed these analyses by fs/QCA 2.5 software to reconfirm TOSMANA "solution" along with consistency and coverage (i.e., relevance) scores of the csQCA model.

<u>Results</u>: A one-factor confirmatory factor analysis showed that all factor loadings were greater than 0.50. TOSMANA software generated a truth table and yielded its "solution" for the visit intent as *Trust (1) * Performance (1) + Social intelligence (1) * Trust (1)*. This solution implies that either the "presences" of trust and performance or social intelligence and trust "must occur" for generating the visit intent. On the other hand, a solution for the non-visit intent was configured as *Social intelligence (0) * Trust (0)*, explaining that the "absences" of social intelligence and trust "must occur" for yielding the non-visit intent. Figure 1 presents TOSMANA diagram model showing these relationships. The fs/QCA software yielded the intermediate solution (i.e., with an intermediate level of complexity), which provided the identical solutions as TOSMANA's with total coverage of 1.00 and consistency of 1.00, indicating the substantial strength, relevance, and empirical support for the results (Ragin, 2008). The presence of trust was a "necessary condition" (consistency = 1.00; coverage = 1.00), whereas the absences of social intelligence (consistency = 1.00; coverage = 0.96) and trust (consistency = 1.00; coverage = 1.00) were "necessary conditions" of the non-visit intent. Yet, no sufficient condition was identified in csQCA solutions. Figure 2 illustrates a Venn diagram that depicts the results along with case ID assignment sequences, using R statistical software.

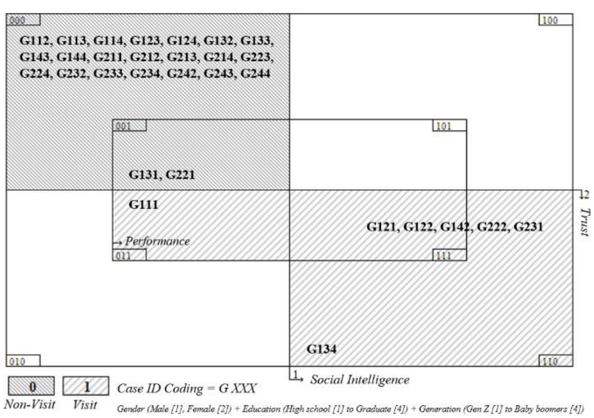

Figure 1. TOSMANA Diagram Model

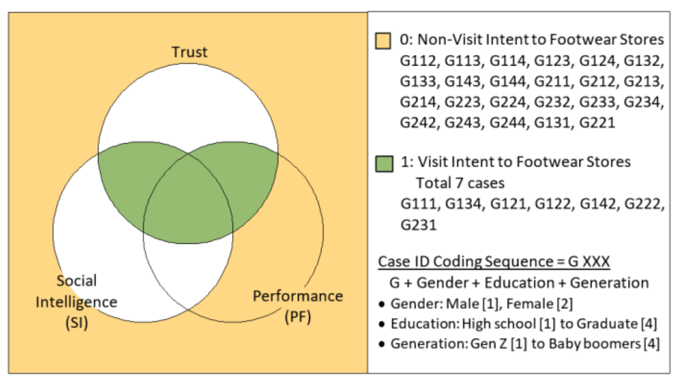

Figure 2. Venn Diagram Display of csQCA

Conclusion/Implication: The csQCA analysis yielded three key findings. First, users' trust in humanoid robots was a "necessary condition" of visit intent to a humanoid robot-operated store with 100% absolute consistency but is insufficient to produce the outcome as a single causal configuration. Second, when high levels of trust and performance or social intelligence and trust are combined as a causal condition, positive visit intent will occur. In comparison, non-visit intent will take place when low levels of social intelligence and trust are combined as a condition. Trust in humanoid robots is a fundamental baseline and a "prerequisite" of bringing consumers to the footwear retail stores; simultaneously, consumers require a satisfying level of robots' social skills "and/or" functional performance to make their in-store trip. For footwear retailers working toward adopting humanoid robots, we suggest modifying AI algorithms to (1) increase human trust, (2) enhance coding to be able to make autonomous trustworthy decisions with moral reasoning capabilities throughout service interaction, and (3) avoid inconsistency in autonomous communication undermining trust-based relationships with consumers.

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