# Understanding Epistemic Networks in Virtual Reality-based Collaborative Gameplay for Social-Skills Training With Children With Autism

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**Abstract:** This study explored how collaborative gameplay of children with autism in VR-based social-skills training yielded different social-skill connections in comparison to those of individual gameplay. We collected a total of 42 one-hour VR-based social-skills training sessions performed by two children with high-functioning autism (HFA). Based on systematic behavior-analysis records, we conducted the epistemic network analysis (ENA) to examine how HFA children's social skills were interconnected by investigating the co-occurrences of multiple social skills. The result of this study revealed that collaborative gameplay yielded stronger connections among multiple social skills than those of individual gameplay.

## Introductions

Approximately 1 of 59 children is diagnosed with an autism spectrum disorder (ASD) in the United States. Children with ASD experience certain social impairments, such as failures in understanding others' minds and deficits of interpersonal communication skills. In the past decade, increasing research has examined virtual reality (VR)-based social-skills training, which facilitates ASD children's social-skills improvement in a 3D-simulated social world. VR-based social-skills training can engage ASD children in various social problem-solving simulations reflecting different social contexts to facilitate their social-skills practice and development.

According to social learning theory, the occurrence of social skills is dynamic and situational (Winner & Crooke, 2011). Social skills are not single-dimensional, but synergistic implementations of multiple social actions. In other words, performing social skills involves the adaptive uses of multiple social skills in different social contexts.

Collaborative gameplay can present learners with opportunities to implement and practice diverse social skills (Ben-Sasson, Lamash, & Gal, 2013). Collaborative gameplay in this study refers to the training setting that facilitates multiple ASD children's social play. However, questions remain about whether and how collaborative gameplay in VR-based social-skills training will promote adaptive and concurrent practices of multiple social-skills by children with ASD. Hence, it is important to examine how collaborative gameplay supports ASD children's learning and practice of multiple social skills in VR-based training contexts, compared to individual gameplay. To understand ASD children's concurrent practice of multiple social skills, we used epistemic network analysis (ENA: Shaffer, Collier, & Ruis, 2016), which better portrays how co-occurrences of meaningful data features emerge. In this study, ENA was aimed to describe how the concurrent practice of social skills appears in a network. This research question will guide this study: *How do ASD children's concurrent practice of multiple social skills in collaborative gameplay differ from that in individual gameplay during VR-based social-skills training?*

## Method

### Samples and intervention design

This study used 42 one-hour videos (Collaborative = 22, Individual = 20) of social-skills-training sessions for two 10-14-year-old children with HFA. We screen- and video-recorded all participants' training sessions in VR. Each participant joined the social-skills training over 16-26 intervention sessions. The number of training sessions varied based on each participant's learning progress.

Via *Opensimulator*, we built a 3D environment that offers multiple types of social simulations depicting different socials scenarios. Simulations for collaborative gameplay sessions include: (a) storytelling games, (b) math games, (c) scavenge hunting, (d) roleplaying, (e) design quests, and (f) social problem-solving games. The study participants experienced collaborative gameplay together with two to three peers in their 3D environment. We used multiple non-player characters (NPCs) to provide ASD children with in-time prompts to foster their social skills. The intervention targeted five core social skills: (1) responding, (2) initiating social interactions, (3) interpersonal negotiation, (4) self-identity, and (5) cognitive flexibility.

## Data collection and analysis

We used two analytics: (1) systematic behavior analysis and (2) ENA. First, we conducted a systematic behavior analysis with the participants' video-recorded training sessions. Based on a structured behavior coding scheme (Ke & Moon, 2018), we coded the participants' social-interaction behaviors via time sampling (per 30 seconds). Using a behavior-annotation tool (Boris), we recorded all participants' co-occurrences of social-interaction behaviors in both collaborative and individual gameplay sessions. Multiple coders did independent coding with a randomly-sampled set of training session data and discussed and refined their coding until they reached 100% agreement among each other. Second, we used ENA to analyze how co-occurrences of the social skills emerged overall. We aimed at investigating how collaborative gameplay facilitated the concurrent practice (or co-occurrences) of multiple social skills. In ENA, we set both stanza (the sequence of intervention sessions) and unit (gameplay type) to convert behavior-analysis results to corresponding epistemic networks.
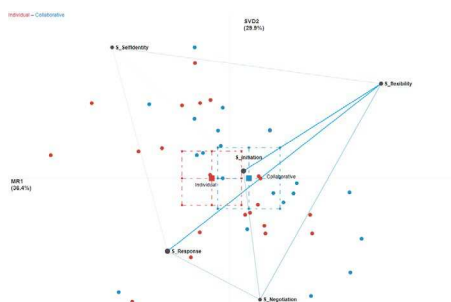


Figure 1. ASD children's social-skills network in collaborative and individual gameplay conditions
(blue= collaborative, red=individual).

## Findings and discussion

Findings indicated different epistemic networks of social-skills connections between collaborative and individual gameplay sessions in VR-based social-skills training. Overall, collaborative gameplay yielded more social-skills connections (or co-occurrences) than individual gameplay, whereas individual gameplay had a slightly stronger connection between responses and self-identity. The comparison plot in Figure 1 shows that collaborative gameplay fostered stronger connections among multiple social skills—such as response, initiation, negotiation, and cognitive flexibility. This result indicated that collaborative gameplay better fostered ASD children's concurrent practice of multiple social skills. Specifically, the epistemic network of collaborative gameplay demonstrates stronger connections between response, initiation, and cognitive flexibility. The qualitative observation records of collaborative gameplay sessions suggested that collaborative gameplay encouraged ASD children to dynamically test and refine their social perspectives when performing interpersonal interactions and social problem-solving during collaborative gaming or simulation tasks. Further research will examine how their trajectory of social-skills connections changes across multiple training sessions.

## References

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