International Journal of Instruction *October 2024 ● Vol.17, No.4*
e-ISSN: 1308-1470 ● www.e-iji.net *p-ISSN: 1694-609X*
pp. 421-440

Article submission code: 20240124171203
Received: 24/01/2024 Revision: 21/05/2024
Accepted: 29/05/2024 OnlineFirst: 01/07/2024

Enhancing Social-Communication and Behavior Skills in Adolescents with Intellectual Disabilities through Computerized Cognitive Training

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Although it is not disputed that cognitive training can affect similar domains (near transfer) such as similar working memory tasks, it is still hotly debated whether they advance seemingly different domains (far transfer), such as social skills improvement. This study aimed to investigate the possibility of far transfer in enhancing social-communication and adaptive behavior skills using a computerized cognitive training program (CCTP) in adolescents with intellectual disabilities (ID). The two research participants aged 14 & 16 conducted a 16-week home-based CCTP using CogniFit for 2-4 days a week, at 20 minutes a day. After the 16-week CCTP, an adjusted 4-week CCTP based on CogniFit activities and on added social cues was followed. The participants underwent pre and post assessments for examining far transfer skills using a) the Test of Pragmatic Language-2, b) the Social Skills Improvement System Rating Scale, and c) the Vineland Adaptive Behavior Scales II. The results showed that this intervention program can benefit adolescents with ID in social-communication and adaptive skills, which can function as an important driver of cognitive development and academic outcomes.

Keywords: cognitive training, intellectual disability, social-communication skills, adaptive behavior

INTRODUCTION

In today's world, individuals require training to acquire increasingly sophisticated knowledge and skills, as well as to stay abreast of rapid information changes (Tarigan et al., 2023). This necessity is underscored by the goal of 21st-century education, which aims to educate students by ensuring they possess creative and entrepreneurial potential to effectively navigate evolving global circumstances (Yaşar et al., 2023). For individuals with intellectual disabilities (ID), this presents a unique challenge, as these individuals experience difficulties in social-communication skills (Djordjevic et al., 2023; Drossinou-Korea & Panopoulos, 2017; García et al., 2020; Hofmann & Müller, 2021) and thus, addressing social-communication deficits is of paramount importance in this population. Social interactions and communication are fundamental aspects of

Citation: Georgoula, E., & Koustriava, E. (2024). Enhancing social-communication and behavior skills in adolescents with intellectual disabilities through computerized cognitive training. *International Journal of Instruction*, *17*(4), 421-440. https://doi.org/10.29333/iji.2024.17424a

human interaction (Czeszumski et al., 2020), contributing to social relationships (Hoppler et al., 2022), successful functioning in life such as guiding communication and facilitating understanding and adaptation in social settings (Isawumi & Oyundoyin, 2016), health (Umberson & Montez, 2010) and overall well-being (Lee et al., 2023). Furthermore, social-communication skills are closely linked to adaptive functioning (Del Hoyo Soriano et al., 2022) and school life (Leifler et al., 2022) such as academic success (Gustavsen, 2017).

For individuals with ID, social-communication difficulties present substantial barriers that impede their ability to engage in education, employment and to be involved in activities that provide interactions with others (e.g., form meaningful connections, engage in reciprocal conversations) (Smith et al., 2020). These deficits can lead to feelings of loneliness and depression (Spithoven et al., 2017), emotional and behavioral problems (Weber et al., 2021), mental and physical health problems (Palmer et al., 2016) and limited social participation (Garrote, 2017). Poor social skills can be significant and have a profound impact during the period of adolescence (Orben et al., 2020) as adolescence represents a critical neurobiological period for the development of higher-order cognitive functions (Larsen & Luna, 2018). Therefore, addressing social-communication deficits in adolescents with ID is not only a matter of enhancing their interpersonal relationships, but also a means to promote their overall development, social inclusion, and long-term success in multiple domains of life.

Individuals with ID are an under-studied population (Traina, 2018) and hence, research on social-skills training for individuals with ID is limited compared to other populations or areas of study. The interventions that have been conducted on individuals with ID and focused on enhancing the social skills of individuals with ID include the use of video modeling (Park et al., 2020), tablet assisted social stories (Kim et al., 2014), emotional intelligence training (Adibsereshki et al., 2016), classroom-based interventions (Adeniyi & Omigbodun, 2016), school-based social skills training (Plavnick et al., 2015), equine assisted intervention (Jeon & Son, 2021), cognitive therapy (Kulnazarova et al., 2023), puppets play therapy (Khodabakhshi-koolaee et al., 2018), combined use of video modeling and social stories (Gül, 2016), video modeling and behavioral skills training (O'Handley et al., 2016), and peer tutoring and storytelling (Jacob et al., 2021).

Despite promising effects of such interventions as strategies for improving social skills, limited studies (Kirk et al., 2017; Kirk et al., 2016) have evaluated the efficacy of cognitive training to promote social or behavior functioning of individuals with ID. Cognitive training interventions have demonstrated potential in enhancing specific cognitive functions in individuals with intellectual and developmental disabilities, yet the broader impact on social and behavioral domains, particularly social-communication and adaptive behavior skills, remains less established. Kirk et al. (2016; 2017) reported improvements in areas like attention and numeracy but highlighted a significant gap in translating these gains into broader developmental outcomes. This underscores the critical need for intervention designs that address the interconnected nature of cognitive functions with social-communication skills.

Social communication deficits are linked to underlying cognitive processes such as executive functions skills (Christ et al., 2017), which are also associated with adaptive behaviors (Kim et al., 2023). Despite evgidence (e.g., Orsolini et al., 2018; Pulina et al., 2015) supporting the near transfer effects of cognitive training on similar cognitive domains, the debate on the potential for far transfer effects (such as enhanced social skills), continues (Smid et al., 2020).

Bennett et al. (2013) and García-Alba et al. (2022) contribute to this discussion by showing that targeted computerized cognitive training can yield significant cognitive improvements in children with Down syndrome and adults with mild and moderate ID, respectively. However, these positive cognitive outcomes prompt further inquiry into how such gains can translate into improvements in social-communication and adaptive behaviors.

Addressing these gaps, the current study seeks to investigate the potential of a computerized cognitive training program (CCTP) to not only improve foundational cognitive processes but also to significantly enhance social-communication and adaptive behaviors in adolescents with ID. Integrating previous research findings, it is aimed to develop innovative interventions that support cognitive development for individuals with ID.

Theoretical support and Research framework

The current research explores the efficacy of the CCTP, drawing upon cognitive development theories and behavioral change models. Central to this study is the concept of brain plasticity, which underpins our theoretical framework. Brain plasticity, the brain's capacity to adapt to experiences (Laube et al., 2020), enables CCTPs to potentially enhance specific cognitive skills through structured exercises (D'Antonio et al., 2019), leading to neural changes (Salminen et al., 2020) and potentially improved cognitive performance.

This enhanced performance, facilitated by brain plasticity, is hypothesized to positively influence outcomes measured by the Test of Pragmatic Language-Second Edition (TOPL-2), the Social Skills Improvement System (SSiS), and the Vineland Adaptive Behavior Scales II (VABS-II). Thus, CCTPs may indirectly enhance social-communication skills and adaptive behavior. A graphical illustration of the proposed study model is shown in Figure 1.

Building on this, the study employs a multi-component cognitive training approach, supported by recent research which highlights its effectiveness (e.g., Kim et al., 2022; Santos Lopes da Silva et al., 2023; Wu et al., 2023).

A. Attention and Inhibitory control

Attention and Inhibitory Control (AIC) refer to the ability to focus on relevant stimuli and suppress irrelevant or distracting information (van Moorselaar & Slagter, 2020). This cognitive domain is crucial for learning and behavioral regulation, particularly in educational settings. The CCTP's emphasis on improving AIC is hypothesized to directly impact participants' adaptive behaviors and social-communication skills, based

on previous literature indicating that executive functions (such as attention, inhibitory control) are essential for adaptive social behavior (Grinspun et al., 2020).

Cognitive Flexibility (CF) pertains to the ability of individuals to swiftly transition to alternative thoughts when facing challenges (Toraman et al., 2020). The construct of CF is pivotal in educational psychology, particularly concerning interventions designed to enhance learning and behavioral outcomes. Previous studies underscore the importance of CF both in the academic performance (Sousa et al., 2023) and in the social life (Schwenke et al., 2020). Notably, CF training can reduce cognitive problems in adolescents with ID (Rostambegyi et al., 2021). Therefore, the following hypothesis is formulated:

Hypothesis 1: The AIC and CF components of the CCTP improve adaptive behaviors and social-communication skills.

B. Working Memory

Working memory (WM) plays a crucial role in goal-directed behaviors, requiring the maintenance and manipulation of information to achieve successful task performance (Chai et al., 2018). WM is associated with adaptive behavior, particularly daily living skills (Udhnani et al., 2020; Will et al., 2021) and in communication (Udhnani et al., 2020), as well as social play (Shimizu, 2023). Interestingly, recent research (Zhao & Zhang, 2024) also underscores the beneficial influence of memory training on attention and cognitive emotion regulation in children with ADHD, further highlighting WM's pivotal role in diverse contexts. Thus, the following hypothesis is proposed:

Hypothesis 2: The WM training component of the CCTP enhances social-communication and adaptive behaviors skills.

C. Integration of Social Cues

The integration of Social Cues (SC) in the CCTP aims to contextualize cognitive training within social cues, thereby improving its transferability to real-world interactions. The addition of social cues is hypothesized to enrich the training's impact, especially on social-communication skills. This approach aligns with theories on cue-specific interventions which focus on strengthening associations by pairing specific cues, relevant to the desired behavior outcome, with cognitive responses (Jones et al., 2016). The concept of cue-specific interventions, where specific cues relevant to the desired outcome behavior are paired with cognitive responses, aligns closely with the approach taken in the current study involving the incorporation of cognitive skills activities along with additional social cues to enhance participants' social and adaptive behavior skills. Accordingly, it is hypothesized:

Hypothesis 3: The inclusion of SC in the CCTP enhances the program's effectiveness in improving social-communication skills.

However, a recent study showed that individuals with ASD showed no distinction in their utilization of social or non-social cues during dynamic interactive situations (Liu et al., 2022). This finding suggests the need to reassess the specific benefits of social cues in the population with ID within training contexts.

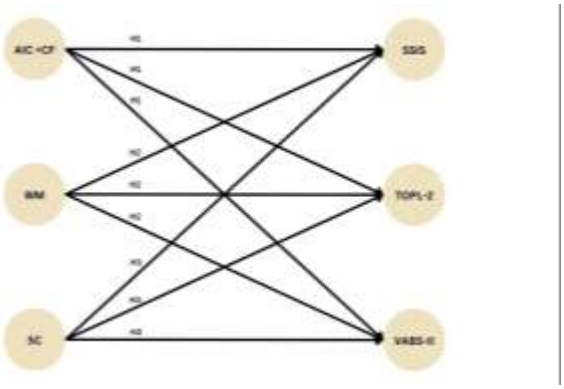

Figure 1
Conceptual framework for current study on cognitive training in individuals with ID. It shows hypothesized pathways from latent variables – Attention and Inhibitory Control plus Cognitive Flexibility (AIC+CF), Working Memory (WM), and Social Cues (SC) – to observed outcomes in social skills (SSiS), pragmatic language skills (TOPL-2) and adaptive behaviors (VABS). Each pathway is labelled with a corresponding hypothesis number (H1, H2, H3) to indicate the proposed effect of each CCTP component on the observed variables.

METHOD

Compliance with ethical standards

The current study adhered to the ethical standards set by the World Medical Association (Declaration of Helsinki). Approval for the study was obtained from the Committee for Research Ethics of the University of Macedonia. Prior to their involvement in the research, consent was obtained from both the parents and the participants, who were school students.

Participants

The study involved two participants. Participant 1 (P1) was a 14-year-old boy diagnosed with mild ID (intelligence quotient range 50–69). P1 had siblings, underwent speech therapy and occupational therapy, and he was familiar with using computers. Participant 2 (P2) was a 16-year-old boy also diagnosed with mild ID. P2 had siblings, participated in extracurricular sports activities, and he was familiar with computer usage. P1 attended a special high school, while P2 attended a mainstream high school with parallel support (that is, a collaborative teaching program tailored to provide educational services in inclusive settings). Both participants resided in Thessaloniki, an urban city. Valid diagnoses had been received for both participants.

Study design

The participants underwent pre-assessments to evaluate their social-communication skills through a) the Test of Pragmatic Language-Second Edition (TOPL-2), b) the Social Skills Improvement System (SSiS), and c) the Vineland Adaptive Behavior Scales II (VABS-II). For the assessment of TOPL-2 and SSiS, two assessments were

needed and took place either at university or at the participant's home. These assessments were conducted by the researcher. Additionally, the VABS-II assessment was completed by parents through guidance provided by the researcher.

Following this, a home-based Computerized Cognitive Training Program (CCTP) was initiated, with a parent present to provide guidance as needed. The parents were initially trained by the researcher to guide the participant during the intervention. The CCTP used was Cognifit (https://www.cognifit.com/). The researcher ensured the correct implementation of the intervention by observing the process through the online platform of CogniFit, where the researcher could monitor when the participant was using the program.

The CCTP focused on three areas: a) attention and inhibitory control, b) cognitive flexibility, and c) (working) memory. Each program lasted for two months and occurred twice a week, with sessions lasting approximately 20 minutes. The attention and inhibitory control and cognitive flexibility programs were conducted simultaneously. The participant alternated between the two programs, using the attention and inhibitory control program on one day and the cognitive flexibility program on the next. This schedule was implemented four times a week, with two sessions dedicated to each program. After completing the two-month period, a reassessment of social-communication skills was conducted using the same measures. Following the reassessment, the participant continued with the memory program, which was used three times a week.

Following the 16-week CCTP, an adjusted 4-week CCTP was implemented, incorporating CogniFit activities along with additional social cues. The adjusted CCTP was created using ReactJS (React, n.d.), an open-source JavaScript framework and library developed by Facebook. ReactJS offers several advantages, including the ability for developers to build web applications quickly and efficiently with reduced code compared to vanilla JavaScript. The applications developed using ReactJS are single-page apps, where the question text and answers are rendered dynamically based on the user's actions.

One of the participants (P1) participated in the adjusted 4-week CCTP along with additional social cues, while the other participant (P2) used the same program but without additional social cues. This allowed for a comparison of the effectiveness of the added social cues in achieving the study's objectives. Post assessment (final assessment) was conducted to examine the development of far transfer skills.

The assessments after each phase were conducted by the same researcher. The pre-assessments [Rating point 1 (R1)] occurred before the participants started using the attention, inhibitory and cognitive flexibility program. The mid-assessment (R2) occurred two months after using the attention, inhibitory and cognitive flexibility program. The second mid-assessment (R3) took place after completing the memory program, and the post-assessment (R4) occurred after completing the adjusted CCTP program. A one-week interval was observed between each assessment phase and before the next phase commenced.

Instruments

The intervention program selected was CogniFit (https://www.cognifit.com/), an online training program featuring various games incorporating auditory, visual, and cross-modality stimuli. This program has undergone scientific validation across diverse populations, including adults with intellectual and developmental disabilities (Siberski et al., 2015). Nevertheless, empirical research on computer-based interventions like CogniFit involving child populations remains scarce (Rossignoli-Palomeque, Perez-Hernandez, & González-Marqués, 2018).

The measures utilized to assess the impact of CCTP on social-communication and adaptive behavior skills in adolescents with mild ID include: The Test of Pragmatic Language-Second Edition (TOPL-2; Phelps-Terasaki & Phelps-Gunn, 2007), consists of 43 items designed for individuals between the ages of 8 and 18 years. This test is specifically designed to evaluate pragmatic language skills in students using standardized, norm-referenced measures (Valdespino, 2013). The TOPL-2 has been used in populations with Williams Syndrome (Hoffmann et al., 2013), ASD (Malaia et al., 2019; Malaia et al., 2020; Volden & Phillips, 2010) and in other populations.

The Social Skills Improvement System (SSiS; Gresham & Elliott, 2008) is a standardized, norm-referenced assessment that focuses on evaluating social skills in children and youth aged 3 to 18 years (Ratcliffe et al., 2015). In the present study, the parent and student form from the SSiS was used, which is common in the research field (De Los Reyes et al., 2013). The SSiS has been used in population with ASD with or without ID (Idris et al., 2022; Mendelson et al., 2016; Ratcliffe et al., 2015; Yuen et al., 2023), ADHD (Cheung et al., 2017) and in other populations.

The Vineland Adaptive Behavior Scales II (VABS-II; Sparrow et al., 2006) is a behavior rating scale that assesses the adaptive functioning of individuals, both children and adults. The VABS-II has been used in populations with ASD or ID (Baker et al., 2021; Yerys et al., 2019), ASD with or without attention-deficit/hyperactivity disorder symptoms (Leader et al., 2022) and in other populations.

Analysis

Pre- and post-assessment differences in cognitive skills were evaluated a) to display the pre-, mid- and post-assessment scores for each participant and identify any changes over time, and b) to identify any patterns or trends in the data, such as whether there is a consistent increase or decrease in scores before and after intervention.

FINDINGS

The findings presented elucidate the assessment outcomes derived from Tables 1-6, offering insightful analyses of two distinct case studies. These assessments encompass a diverse array of outcome measures (SSIS Social Skills Scale and Problem Behaviors Scale, TOPL-2, and VABS-II), evaluated across multiple rating points (R1-R4). Hence, the data not only describe the participants' social skills and problem behaviors but also their pragmatic language proficiency and adaptive behavior skills, highlighting their developmental trajectories over time.

Table 1 shows the results of the SSIS (Social Skills Scale) assessment, specifically the Parent form. For participant P1, the raw scores and standard scores remained relatively consistent across the assessment points (R1-R4). The percentile ranks indicate that P1's social skills are relatively lower compared to the norm group. For participant P2, the raw and standard scores showed improvement across the assessment points. These scores indicate a high level of social skills. The percentile ranks indicate that P2's social skills are relatively higher compared to the norm group. Overall, P2 demonstrated consistently higher social skills compared to participant P1, as indicated by the raw scores, standard scores, and percentile ranks.

Table 1
SSIS - social skills scale - parent form

Rating number	Participant	Raw score	Standard score	Confidence Interval	%ile Rank
R1	P1	66	75	72-78	8
R2	P1	66	75	72-78	8
R3	P1	82	87	84-90	18
R4	P1	82	87	84-90	18
R1	P2	113	110	107-113	74
R2	P2	113	110	107-113	74
R3	P2	122	117	114-120	88
R4	P2	124	119	116-122	90

Table 2 presents the results of the SSIS (Problem Behaviors Scale) assessment, specifically the Parent form. For participant P1, the raw scores for problem behaviors remained consistent across all assessment points (R1-R4). The percentile ranks suggest that P1's problem behaviors are relatively higher compared to the norm group. For participant P2, the raw scores for problem behaviors also remained consistent across all assessment points. The percentile ranks indicate that P2's problem behaviors are relatively higher compared to the norm group. Overall, both participants (P1 and P2), on average, exhibit fewer problem behaviors compared to the first two ratings.

Table 2
SSIS - problem behaviors scale - parent form

Rating number	Participant	Raw score	Standard score	Confidence Interval	%ile Rank
R1	P1	35	123	120-126	93
R2	P1	35	123	120-126	93
R3	P1	31	119	116-122	90
R4	P1	31	119	116-122	90
R1	P2	26	114	111-117	85
R2	P2	26	114	111-117	85
R3	P2	22	109	106-112	78
R4	P2	21	108	106-112	77

Table 3 shows the results of the Social Skills Scale assessment, specifically the Student form. For both participants (P1 and P2), there is a consistent improvement in social skills across the assessment points (R1-R4). The raw scores gradually increased,

indicating an improvement in social skills. The percentile ranks indicate that social skills are relatively high compared to the norm group.

Table 3
SSIS - social skills scale - student form

Rating number	Participant	Raw score	Standard score	Confidence Interval	%ile Rank
R1	P1	106	110	107-113	73
R2	P1	121	121	119-124	91
R3	P1	125	124	121-127	94
R4	P1	129	127	124-130	96
R1	P2	124	123	120-126	93
R2	P2	130	128	125-131	97
R3	P2	134	131	128-134	99
R4	P2	135	131	128-134	>99

Table 4 illustrates the results of the Problem Behaviors Scale assessment, specifically the Student form. Both participants (P1 and P2) exhibit relatively low problem behaviors based on the raw scores and standard scores. However, participant P2 shows slightly higher problem behaviors compared to P1. The percentile ranks indicate that both participants' problem behaviors are relatively low compared to the norm group.

Table 4
SSIS - problem behaviors scale - student form

Rating number	Participant	Raw score	Standard score	Confidence Interval	%ile Rank
R1	P1	8	89	86-92	20
R2	P1	5	86	83-89	12
R3	P1	5	86	83-89	12
R4	P1	4	85	82-88	9
R1	P2	25	106	103-109	63
R2	P2	21	102	99-105	54
R3	P2	16	97	94-100	42
R4	P2	17	98	95-101	44

Table 5 shows the results of the TOPL-2 assessment. The table indicates the raw scores, standard scores, percentile ranks, T-scores, and Z-scores for each participant at different assessment points, providing insights into their performance on the TOPL-2. P1 and P2 demonstrate improvement in pragmatic language skills over time, as indicated by the increasing raw scores and standard scores across the assessment points. P1 shows a relatively lower performance compared to the norm group, while participant P2 shows an average to above-average performance. The percentile ranks indicate that P1's performance in pragmatic language skills is relatively low compared to the norm group, while P2's performance is relatively average to above average compared to the norm group. The T-scores and z-scores suggest that P1's performance is below the mean, while P2's performance is around the mean or slightly above.

Table 5
TOPL-2

Rating number	Participant	Raw score	Standard score	%ile Rank	T-score	z-score
R1	P1	16	76	5	34	-1.6
R2	P1	18	79	8	36	-1.4
R3	P1	20	83	13	39	-1.1
R4	P1	24	89	23	43	-0.7
R1	P2	21	79	8	36	-1.4
R2	P2	27	90	25	43	-0.7
R3	P2	32	99	47	49	-0.1
R4	P2	35	104	61	53	0.3

Table 6 represents the VABS-II standard scores of participants across different rating times (R1-R4) in three domains: Communication, Daily Living Skills, and Socialization. P1 and P2 showed a gradual improvement across all domains. Complementary, Figure 2 displays the Adaptive Behavior Composite standard scores. Both participants exhibited an upward trend, with P2 showing a higher overall increase compared to P1.

Table 6
VABS-II standard scores

Domain	P1-R1 Standard score	P1-R2 Standard score	P1-R3 Standard score	P1-R4 Standard score	P2-R1 Standard score	P2-R2 Standard score	P2-R3 Standard score	P2-R4 Standard score
Communication Domain	67	71	78	78	63	77	77	85
Daily Living Skills Domain	83	98	100	100	71	77	76	79
Socialization Domain	64	68	68	68	76	91	93	93

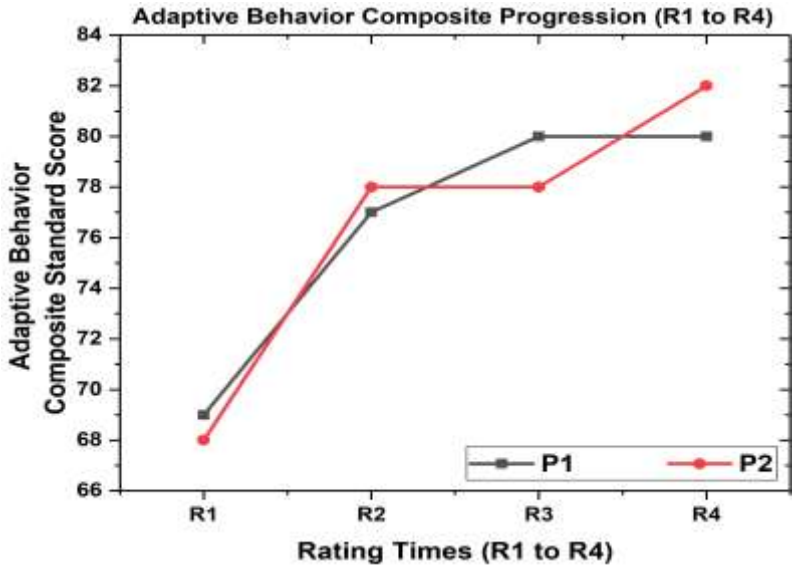

Figure 2
The change in Adaptive Behavior Composite standard scores (vertical axis) for two participants, P1 and P2, over four rating times: R1, R2, R3, and R4 (horizontal axis).

DISCUSSION

The study's purpose was to investigate the potential for far transfer effects, meaning the ability of the CCTP to improve skills beyond those directly targeted by the training. The CCTP aimed to enhance attentional control, working memory capacity, and cognitive flexibility, with the expectation that these cognitive improvements would lead to enhanced social-communication skills.

Studies investigating the effects of CCTPs on individuals with ID have reported mixed findings. Some studies have shown positive outcomes in terms of cognitive improvements (Orsolini et al., 2018; Pulina et al., 2015), while others (Kirk et al., 2017) have not observed significant transfer effects to social-communication or adaptive behavior skills.

The simultaneous application of the AIC and CF components between R1 and R2 led to slight improvements in both social-communication skills, as observed in the SSIS and TOPL-2 scores, and adaptive behaviors, as indicated by the VABS-II scores. This incremental progress supports the hypothesis 1 of AIC and CF's role in enhancing these skills to some degree, resonating with the broader literature that underscores the positive impact of targeted interventions or educational programs on improving social skills in individuals with ID (Adeniyi & Omigbodun, 2016) and highlights the benefits of interventions targeting adaptive behavior skills (Kim et al., 2023).

The period following the introduction of WM training (from R2 to R3) represents a pivotal moment in the CCTP's impact, with both participants showing notable

improvements, especially in SSIS, TOPL-2, and in VABS-II assessments. The consistent improvement across these assessments provides strong support for hypothesis 2, highlighting the WM training component's effectiveness in enhancing both social-communication and adaptive behavior skills. This finding aligns with previous research that demonstrated that WM interventions positively influence cognitive emotion regulation strategies, indicating an increase in adaptive strategies and a decrease in maladaptive strategies (Zhao & Zhang, 2024).

The introduction of SC training in the final CCTP phase (from R3 to R4) brought to light the distinctions in program delivery for P1 and P2, with P2 engaging in the CCTP training without the inclusion of additional social cues. Despite these differences in approach, both participants demonstrated significant improvements in their social-communication skills, as evidenced by their SSIS and TOPL-2 scores. The VABS-II scores during this phase continued to show improvement or maintained the enhanced levels of adaptive behaviors for both participants. A recent study revealed that individuals with Autism Spectrum Disorder showed no distinction in their utilization of social or non-social cues in dynamic interactive scenarios (Liu et al., 2022), which complements the observation that P2, who experienced CCTP training without additional social cues, showed marked enhancement in P2's TOPL-2, SSIS and VABS scores. This suggests that the CCTP training, even in the absence of explicit social cues, can profoundly enhance social-communication skills. This nuanced outcome challenges the necessity of additional social cues in the CCTP training context. The additional social cues do not appear to affect the outcomes, but they need to be tested in a larger sample.

The detailed examination of the specific components of the CCTP (Attention and Inhibitory Control, Cognitive Flexibility, Working Memory training, and additional Social Cues) to the observed outcomes provides a detailed understanding of the program's multifaceted impact. Complementing this, current research supports that such multicomponent interventions not only enhance cognitive function (Santos Lopes da Silva et al., 2023; Wu et al., 2023) but also may be beneficial in improving activities of daily living (Kim et al., 2022).

CONCLUSION

This study significantly advances the understanding of cognitive training's impact on individuals with ID, underscoring the CCTP's effectiveness in bolstering social-communication and adaptive behaviors. Through a detailed examination of the CCTP's components— AIC, CF, WM, and SC—the existing research outlines a clear pathway through which these interventions can lead to meaningful improvements. The study underscores the importance of creating adaptive cognitive training programs that are finely tuned to the diverse needs and capabilities of individuals with ID, reinforcing the CCTP's role as an instrumental resource in promoting cognitive and behavioral development.

The findings indicate that the CCTP, irrespective of the inclusion of additional social cues, may positively impact social-communication and adaptive behavior skills among adolescents with ID. This suggests the CCTP's capacity to facilitate broader far transfer

effects, potentially improving social-communication and adaptive behaviors. Despite these promising outcomes, it becomes evident that further investigation is essential to ascertain the CCTP's generalizability and durability of impact on social-communication abilities and adaptive behavior in the ID population.

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