Does a Computerized Social Cognitive Intervention Improve Implicit or Explicit Theory of Mind?

BY

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SUMMARY

Individuals with schizophrenia spectrum disorders experience social functioning impairments in relation to the general population. Social cognition has been identified as a primary contributor of social functioning deficits, and individuals with schizophrenia spectrum disorders have been found to have difficulties in all domains of social cognition. Most therapeutic interventions have been found to have limited effect on the improvement of social cognition. The current study focuses on the implementation of a computerized social cognitive intervention designed to improve several domains of social cognition in individuals with schizophrenia spectrum disorders, including theory of mind. This intervention was found to lead to change in implicit theory of mind but not explicit theory of mind or social functioning. Possible reasons for this pattern of changes and the implications of these findings are discussed.

Introduction

Schizophrenia Spectrum Disorders and Functioning Impairments

Individuals with schizophrenia spectrum disorders experience widespread challenges, including social cognitive difficulties, general cognitive difficulties, and severe psychiatric symptoms, often including hallucinations and/or delusions (American Psychiatric Association, 2013; Nuechterlein et al., 2004; Penn et al., 2008). These challenges are believed to contribute to severe functioning difficulties within this population, and the unemployment of individuals with schizophrenia (one metric of functioning) contributes to an annual cost of over 50 billion dollars to the US economy, which is the single largest factor in the economic burden of schizophrenia in the US (Couture et al., 2006; Cloutier et al., 2016). Social cognitive difficulties have been identified as stronger predictors of social functioning than positive symptoms of schizophrenia or general cognitive difficulties (Hoe et al., 2012). As such, any attempts to improve the lives of individuals with this diagnosis must include an understanding of their social cognitive abilities and difficulties.

Social cognition has been defined as "the perception, interpretation, and processing of socially-relevant information," and this set of processes allows us to understand and navigate the social world (Rose et al., 2015, p. 1). Some researchers have indicated that there are at least 4 core domains of social cognition in which individuals with schizophrenia spectrum disorders are impaired: emotion perception (identification of facial affect and vocal prosody), social cue perception (awareness and understanding of social cues), attributional style (explaining the causes of social events), and theory of mind (determining the mental states of others) (Rose et al., 2015). Individuals with schizophrenia have demonstrated difficulties in each of these domains, and each of these domains has been linked to difficulties in social functioning (Rose et al., 2015).

Theory of Mind

Theory of mind (ToM), also known as mentalizing, mental state attribution, and/or mindreading, is a critical component of social interaction used to understand the behavior of others and plan one's own behavior accordingly (Premack & Woodruf, 1978). ToM can be broadly explained as the ability to identify the mental states of others and the awareness that the mental states of others may differ from one's own (Premack & Woodruf, 1978; Corcoran & Frith, 1995). There is evidence that ToM abilities can be observed early in the human life cycle and in some non-human primates (Baron-Cohen et al., 1999; Krupenye et al., 2016; Kovács, Téglás & Endress 2010), and there is a range of ToM abilities present in the general, neurotypical population (Onishi & Baillargeon, 2005).

Individuals with schizophrenia have repeatedly been found to exhibit ToM difficulties when compared to healthy controls, (Savla et al., 2013, Bora et al., 2009, Sprong et al., 2007; Brune, 2005) and ToM difficulties are persistent and pervasive in the lives of individuals with schizophrenia (Addington et al., 2006). Studies have revealed that ToM difficulties in individuals with schizophrenia spectrum disorders (including both chronic and first episode psychosis) are associated with social functioning impairments (Roncone et al., 2002; Brune et al., 2005; Bora et al., 2006; Bell, 2008; Sullivan et al., 2013).

Measurement of Facets of Theory of Mind

Many different measures of ToM exist for use with individuals with schizophrenia. The Social Cognition Psychometric Evaluation (SCOPE) Study attempted to identify the best measures of social cognition, including measures of ToM, for use with a schizophrenia population (Pinkham et al., 2013). The SCOPE Study examined over 40 measures of ToM, ultimately selecting the three measures with the highest expert ratings over the course of their evaluation process. These three ToM measures were the Reading the Mind in the Eyes (Baron-Cohen et al., 2001), the Hinting Task (Corcoran et al., 1995), and The Awareness of Social Inferences Test – Part III (McDonald et al., 2003). Each of these measures were found to be more psychometrically reliable than the other measures of ToM examined, and each of these measures examined a specific facet of ToM termed explicit ToM (Pinkham et al., 2013).

Explicit (or deliberative) ToM abilities involve interpreting the internal, mental states of others when cued to do so, and measures of explicit ToM often involve presenting participants with written vignettes or videos and asking the participants directly about the mental states of the characters in these scenes [i.e. "Is Tanya genuinely trying to make Kath feel better about her party?" from The Awareness of Social Inference Test (TASIT; McDonald et al., 2002)]. Most studies of ToM utilize explicit ToM measures, and these studies, as previously discussed, typically find that, on average, individuals with schizophrenia have more inaccurate interpretations of others' mental states than do healthy controls (Savla et al 2013, Bora et al 2009, Sprong et al 2007). Similarly, the studies that found associations between poorer ToM performance and difficulties in social functioning predominantly utilized explicit ToM measures (Brune et al., 2005; Bora et al., 2006; Piovan et al., 2016).

Relatively fewer studies have examined implicit (or spontaneous) ToM, which has been described as an individual's ability to understand and attend to the internal, mental states of others without being prompted to do so (Rice & Redcay, 2015). Measures of implicit ToM tend to involve presenting an individual with a visual vignette and then asking the individual to describe the scene without specifically asking the individual to describe the thoughts, emotions, or intentions of the participants featured in the scene [i.e. the prompt "Describe this scene" from the Spontaneous Theory of Mind Protocol (STOMP; Rice & Redcay, 2015)]. The most well-known implicit ToM measure is the Silent Animations task in which participants describe the interactions between animated triangles and later have their responses coded for aspects related to the participant's descriptions of intentionality, appropriateness, and other characteristics associated with mental states (Castelli et al., 2000). Studies that have utilized the Silent Animations task tend to find that individuals with schizophrenia spectrum disorders use less appropriate mentalizing language compared to healthy controls (Russell et al., 2006; Horan et al., 2009).

Limited studies have published findings regarding the link between implicit ToM performance and social functioning for individuals with schizophrenia spectrum disorders. The studies that have examined these factors have found moderate correlations between implicit ToM and social and role functioning, such that lower scores on the Silent Animations task (lower intentionality and less appropriate descriptions) were associated with poorer functioning (Stewart et al., 2009; Ventura et al., 2015). The moderate strength of this relationship between implicit ToM and functioning is interesting and worth further study, as it could be proposed that one's unprompted use of ToM would be a better indicator of real-world functioning than one's cued ability to utilize ToM, considering that outside of research studies, people are rarely explicitly asked about the mental states of others and instead rely on spontaneous reflections.

Another measure of implicit ToM was recently developed to include videos of human interactions. The Spontaneous Theory of Mind Protocol (STOMP) was designed to assess an individual's unprompted description of video clips involving characters undergoing mental state change (Rice & Redcay, 2015). The participant's verbal explanations of the video clips are coded for their descriptions of the mental states of the characters in the different clips. As this is a recently created measure, there are few studies that have utilized this task, and psychometric data is currently unavailable.

Explicit and implicit ToM measures assess different facets of overall ToM performance. While explicit ToM performance is comparable to how individuals understand ToM when they are cued to do so, implicit ToM performance is indicative of how an individual thinks about and verbally describes ToM without being prompted to do so. Researchers that have examined both implicit and explicit ToM in the same study revealed that when compared to healthy controls individuals with schizophrenia exhibit impairments/differences in both aspects of ToM (Langdon et al., 2017). Interestingly, this study concluded that explicit and implicit ToM dysfunction was not due to a single underlying ability, as explicit and implicit ToM performance were weakly correlated with one another and each made significant, independent contributions to analyses designed to predict diagnostic group membership (Langdon et al., 2017). Additionally, this study suggested that improving explicit ToM performance would not be sufficient to improve the ToM difficulties observed by individuals with schizophrenia spectrum disorders in the real-world, as they found explicit and implicit ToM to be separate constructs (Langdon et al., 2017). Overall, it appears that explicit and implicit ToM are distinct, and each is important to the understanding of difficulties in social cognition and functioning in individuals with schizophrenia.

Interventions Impact on ToM

Medication and Psychotherapy

Attempts to improve ToM and other domains of social cognition through standard treatment approaches for schizophrenia spectrum disorders have revealed little success. Few to no studies have examined the effect that traditional psychotherapies have on ToM performance, and pharmacological approaches have had little effect on social cognitive difficulties, despite reducing the severity of hallucinations and delusions (Mueser et al., 1996). A review of the literature on the effect of antipsychotic medications on social cognitive performance indicated that they do not reliably affect social cognition, and further, research investigating this effect show inconsistencies in design and problems with methodology (Kucharska-Pietura & Mortimer, 2013). Specifically, difficulties in explicit ToM do not appear to show significant, consistent improvement during the course of pharmacological interventions, and explicit ToM difficulties are present in individuals with schizophrenia spectrum disorders even when psychotic symptoms are effectively treated (Kucharska-Pietura & Mortimer, 2013). No research was identified that studied the impact of pharmacological interventions on implicit ToM in this population.

Recently, oxytocin used as an intranasal medication has been identified as a possible tool for improving aspects of social cognition. A meta-analysis investigating the effect of oxytocin on social cognition concluded that while intranasal oxytocin may not have a positive impact on all social cognitive domains, it appears to be beneficial for explicit ToM and other higher order social cognitive domains in particular (Burkner et al., 2017). However, the same study also suggested that these results must be interpreted cautiously, as the effect on explicit ToM was small and inconsistent (Burkner et al., 2017). Overall, there is consistent, reliable evidence to suggest that medications, including oxytocin, or traditional psychotherapies do not improve explicit ToM reliably or with great effect. Little evidence is available regarding the effect of these interventions on implicit ToM for individuals with schizophrenia spectrum disorders.

Cognitive Remediation

Some treatments designed to improve cognitive functioning have been found to also improve social cognition. Cognitive remediation is a well-researched behavioral training intervention designed to improve cognitive processes, such as attention, memory, and even social cognition, by correcting cognitive difficulties and helping the client to successfully navigate their environment and overcome environmental obstacles (Barlati et al., 2013). Typically, studies of cognitive remediation find that this intervention leads to functional improvement (Kurtz et al. 2001; Krabbendam & Aleman, 2003; Twamley et al. 2003; McGurk et al. 2007; Grynszpan et al. 2011; Roder et al. 2011; Wykes et al. 2011; Kurtz, 2012). Several possibilities have been proposed regarding the mechanism of social functioning improvement associated with cognitive remediation for individuals with schizophrenia, including the idea that 1) improvement in cognitive skills leads to improvement in social functioning, as cognition and social functioning have been found to be linked; 2) changes in cognition leads to improved self-efficacy and a willingness to persist in challenging tasks, which may lead to enhanced social functioning, and/or 3) that cognitive remediation interventions include non-specific effects that influence social functioning (Fiszdon et al., 2016). Further research is needed to fully understand the mechanisms of change underlying functional improvement for individuals with schizophrenia involved in a cognitive remediation intervention.

In a meta-analysis conducted in 2015, cognitive remediation was found to lead to trend level improvement in emotional intelligence, but these studies did not examine ToM specifically (Revell et al., 2015). Interestingly, a meta-analysis published in 2011 that reviewed computerized cognitive remediation found that these interventions had a large impact on the social cognitive performance of the participants (Grynszpan et al. 2010). However, this meta-analysis combined performance on a number of different social cognitive tasks into a single social cognition variable, clouding our understanding of the effect of computerized cognitive interventions on specific social cognitive domains. Furthermore, several of the studies reporting this positive relationship between computerized cognitive remediation use and social cognitive improvement utilized social group therapies in combination with the computerized cognitive remediation, suggesting a need for further research to disentangle the effects of these interventions on social cognition (Grynszpan et al. 2010). A meta-analysis of the combination of cognitive remediation and aerobic exercise interventions revealed improvements in emotional intelligence, in addition to enhanced global cognition, but again this meta-analysis did not examine ToM specifically (Firth et al., 2017). Overall, the effects of both cognitive remediation and computerized cognitive remediation on ToM performance is unclear.

Social Cognitive Interventions

Due to a lack of documented progress in enhancing ToM, and ultimately social functioning, using standard treatment methods, researchers have begun targeting ToM and other social cognitive domains more directly using social cognitive interventions (Bartholomeusz & Allott, 2012; Kurtz & Richardson, 2012). A 2012 meta-analysis revealed that social cognitive interventions for individuals with schizophrenia had a medium effect size on social functioning (d = .78; Kurtz & Richardson, 2012). Many of the treatments differed in duration, size of group, and the number and type of social cognitive domains trained. In a meta-analysis published in 2016, Kurtz et al. examined the effects of 7 different social cognitive interventions reported in 16 different studies and found that the most common duration of training was 6 months (ranged from 2.5 to 6 months), the number of members in the training groups varied from 3 to 12 members, and the most common number of social cognitive domains trained was 3 (ranged from

2 to 4). This meta-analysis revealed that each of these interventions showed improvements in at least one domain of social cognition, including showing improvements in explicit ToM measures for 10 of the 13 studies that assessed for ToM (Kurtz et al., 2016).

This meta-analysis also revealed limitations of the studies of these social cognitive interventions, including that not all the studies used blinded raters of social cognitive performance, uncertain treatment fidelity, a lack of understanding of the mechanisms of change, and problems with measurement (Kurtz et al., 2016). Taken together, these meta-analyses suggest promising findings for the possibility of improving social functioning via improvement in social cognition, despite limitations in treatment consistency and study quality.

Some researchers have specifically identified ToM as a target of treatment for interventions that intend to increase social functioning (Marsh et al., 2013; Marsh et al., 2016; Roberts & Penn, 2009). A review of randomized controlled trials (RCT's) of social cognitive interventions that targeted explicit ToM or measured effects on explicit ToM described characteristics of these interventions, as well as the effects that these interventions had upon explicit ToM performance (Vass et al., 2018). This review distinguished between 3 different categories of interventions: 1) Targeted ToM interventions, in which the intervention was specifically designed to improve the mentalizing abilities of participants, 2) broad-based non-ToM interventions that focused on the overall improvement of social cognition without emphasizing a specific domain, and 3) targeted non-ToM interventions, in which the intervention focused on a social cognitive domain aside from ToM but still assessed change in ToM (Vass et al., 2018). Importantly, while these interventions intended to improve ToM as a whole, they assessed change in ToM via explicit ToM measures only.

Common characteristics of targeted ToM interventions included directly focusing on the improvement of ToM using vignettes, animations, and/or videos as training tools to exhibit social situations, and then asking participants to interpret the mental states of the characters in these situations. There were several such interventions identified, including Theory of Mind Intervention (TOMI; Bechi et al., 2012), Emotion and ToM Imitation Training (ETIT; Mazza et al., 2010), and Social Cognitive Training (SCT; Bechi et al., 2013). Some of these interventions also trained participants to observe the facial expressions of other individuals with schizophrenia in a group-based format as a way of improving ToM performance (Veltro, 2011). The duration of the targeted ToM interventions examined in this systematic review ranged from two weekly sessions to six months of weekly sessions, and each of these treatments led to improvements in explicit ToM performance (Vass et al., 2018).

Broad-based non-ToM interventions focused on improving general social cognition, without explicitly targeting specific domains of social cognition in particular. Social Cognition Interaction Training (SCIT) is one of the most commonly used interventions of this type (Roberts and Penn, 2009). SCIT typically takes place over 5 months and involves weekly hour-long sessions and has been used with forensic patients and outpatients with schizophrenia spectrum disorders (Vass et al., 2018). This intervention is designed to help individuals with schizophrenia improve their ability to manage their emotions, increase their understanding of attributional style and ToM, and to integrate these learned skills into their daily functioning (Vass et al., 2018). When comparing SCIT to TAU, the results were mixed, with SCIT improving explicit ToM in one of the studies listed but showing no significant advantage of SCIT over treatment as usual (TAU) for the other three RCT's of SCIT reviewed in this study (Vass et al., 2018). Similarly, other broad-based non-ToM interventions reviewed in this article (Social Cognitive Skills Training; Horan et al., 2011, 2009) did not show improvement in explicit ToM performance.

Another category of social cognitive interventions reviewed by Vass and colleagues (2018) were targeted non-ToM interventions. These interventions focused on the improvement of other domains of social cognition, such as affect recognition, but assessed for explicit ToM improvement in addition to the targeted domain. The two targeted non-TOM interventions reviewed in this study targeted affect recognition and both showed enhanced explicit ToM performance in the experimental treatment condition compared to the control group's explicit ToM performance (Wölwer and Frommann, 2011; Gaudelus et al., 2016). However, in the experimental treatments, performance did not improve on all explicit ToM measures and changes in performance on social functioning measures were inconsistent (Wölwer and Frommann, 2011; Gaudelus et al., 2016).

Overall, Vass and colleagues (2018) found that targeted ToM interventions improved explicit ToM more than either of the non-ToM interventions (broad-based or targeted), and that the non-ToM interventions produced mixed results in regards to the improvement of explicit ToM, such that some studies revealed improvements in explicit ToM and others showed decreased performance on explicit ToM measures (Vass et al., 2018). However, Vass and colleagues (2018) were not able to conclude which of these forms of social cognitive interventions produced the greatest change in social functioning. An important distinction noted between ToM and non-ToM interventions included a more frequent use of training materials relevant to mentalizing in ToM targeted interventions, such as viewing recorded social interactions or analyzing comic strips and asking participants to explain the mental states of the characters, which may enhance the transfer of ToM skills by providing more opportunities and varied contexts in which to practice ToM abilities. In the non-ToM interventions, the training relevant to ToM appeared closer to psychoeducation of social strategies or the use of training materials that were less specific to ToM difficulties (Vass et al., 2018). This review suggested that the contradictory findings regarding change in ToM for non-ToM interventions (finding enhanced performance on some ToM measures and decreased performance on others) within the same study was likely due to the heterogeneity of explicit ToM assessments and the possibility that there are multiple domains of ToM and not that these interventions are likely to increase difficulties in ToM (Vass et al., 2018).

While many treatments designed to improve social cognitive difficulties in schizophrenia have been shown to improve performance on measures associated with the social cognitive domains in this population, some of these interventions have had little effect on functioning outcomes (Sacks et al., 2013). In a study of a computerized social cognitive intervention, researchers found that individuals with schizophrenia exhibited improved performance on an emotional intelligence measure after training, but they did not show social functioning improvement at the end of the intervention (Sacks et al., 2013). As the ultimate desired outcome for social cognitive interventions is to improve social functioning, there is a need to improve social cognitive interventions so that social functioning is improved.

Computerized Interventions

Upon closer inspection of the training paradigms discussed above other problematic aspects reveal themselves. Some of these interventions require the use of skills impaired in schizophrenia, including high level information processing abilities, such as executive control and strategic thinking abilities, which may limit the use and feasibility of these types of interventions with this population (Bell, 2008). Many of these interventions may inhibit the generalizability of the improvement of social cognitive abilities by presenting limited social stimuli or scenarios, which may lead to improvement on assessment measures but not generalize to real-world functioning (Kurtz & Richardson, 2012; Vass et al., 2018). These approaches also tend to be unable to tailor the intervention to the client, ignoring individual differences in functioning and social cognitive skills (Kurtz & Richardson 2012). Additionally, there have been concerns regarding treatment fidelity for clinician-administered social cognitive interventions (Kurtz et al., 2016). More recently, attention has begun to shift towards computerized interventions for individuals with schizophrenia that have the potential to ameliorate the deficiencies described above.

A meta-analysis published in 2010 revealed that computerized cognitive remediation had positive effects on improving both domains of general cognition and social cognition (Grynszpan et al., 2010). There have also been several studies finding success in improving different domains of social cognition using social cognitive computerized interventions, including facial recognition and empathy (Byrne et al., 2015; Kurtz et al., 2015; Roberts et al., 2015), but none of these interventions assessed ToM directly. Furthermore, there is no standard computerized (or otherwise) intervention for individuals with schizophrenia spectrum disorders and reviews of computerized interventions have found serious problems in methodology (Naeem et al., 2017). As such, there is a need for a highly controlled study of computerized interventions.

The Current Study

While many of the previously discussed social cognitive interventions could potentially be of use in the treatment of some social cognitive difficulties in individuals with schizophrenia, none of these interventions have been adopted for widespread use in the general schizophrenia population, nor is there any standardized treatment for the social cognitive difficulties of individuals with schizophrenia (Rose et al., 2015). Many of the interventions or the studies investigating the social cognitive interventions described above also involved one or more of the following methodological or intervention-level problems: 1) studies examining efficacy of social cognitive interventions lacked blinded raters when measuring change in social cognitive domains and/or social functioning (Kurtz et al., 2016), 2) the interventions are offered in a limited number of clinics around the country providing limited accessibility (Rose et al., 2015), 3) social cognitive interventions requiring the use of skills that individuals with schizophrenia have difficulties with may limit their feasibility for this population, (Bell, 2008), 4) studies presenting limited social stimuli or scenarios may prevent generalizability of social cognitive improvement (Kurtz & Richardson, 2012), and 5) interventions often adopt a "one size fits all" approach and are unable to tailor the intervention to the client, ignoring individual differences in functioning and social cognitive skills (Kurtz & Richardson 2012). As such, the current study intends to address these issues by examining a computerized social cognitive intervention (named SocialVille) designed to address each of these limitations and its impact on implicit and explicit ToM and social functioning in individuals with a schizophrenia spectrum disorder in a randomized control trial.

Specifically, SocialVille improves upon previous social cognitive interventions by 1) utilizing a double-blinded procedure to limit researcher bias and the placebo effect, 2) allowing for the possibility of future use of the intervention by individuals around the country by providing training through a web-based interface, 3) implementing a training strategy to social cognitive improvement that does not rely on explicitly strengthening social cognitive skills through methods utilizing abilities with which individuals with schizophrenia exhibit inherent difficulties, 4) exposing participants to numerous, varied, and relevant social stimuli, giving participants the opportunity to generalize their skills, and 5) tailoring the intervention to the specific social cognitive difficulties of the participants by adjusting the difficulty of the tasks presented based on participant performance.

While some social cognitive interventions have utilized a “top-down” approach focused on teaching participants to overcome their difficulties through direct instruction and coaching (Bell et al., 2008; Pilling et al., 2002), the recently developed SocialVille instead strengthens the social information processing and stimulus representations of each of the core domains of social cognition, which has been described as a neuroplasticity-based strategy or “bottom-up” approach (Mahncke et al., 2006). This bottom-up strategy targets lower level social cognitive processes, such as emotion perception, prior to targeting higher level social cognitive domains, such as theory of mind. The bottom-up method of training may provide a substantial advantage over top-down training methods, as top-down training methods require the use of skills impaired in schizophrenia, such as executive control and declarative memory (Kern et al., 2010). Alternatively, bottom-up training strategies, such as what SocialVille utilizes, have been found to improve neural representations and functioning associated with perception and cognition (Fisher et al., 2009; Wexler et al., 1997; Smith et al., 2009).

A problematic aspect of many clinician-led interventions is limited use of social stimuli and information (Kurtz & Richardson, 2012). This problem is one in which having a computer-based training program to increase social skills has an advantage over traditional in-person interventions. SocialVille requires its participants to make hundreds to thousands of challenging decisions and discriminations per training session of socially relevant stimuli, such as faces, voices, and social situations. These tasks require the user to increase their decision speed and accuracy of increasingly challenging social stimuli in a way that is only possible using computerized technology. While attempting to improve functioning and social cognition in the absence of a clinician may seem paradoxical, this is at least one way in which a computerized approach may be more beneficial. This approach to training increases the generalizability of skills by giving participants more opportunities and contexts to practice these skills. A recent meta-analysis found that "drill and practice" computerized interventions, in which participants learn skills implicitly through repeating tasks that gradually increase in difficulty, led to improvements in cognition in individuals with schizophrenia when compared to participants in control groups (Prikken et al., 2019). As SocialVille's training method is similar to this category of training, it is important to determine whether a "drill and practice" computerized training intervention for social cognition will yield similar improvements as seen in the previously mentioned meta-analysis for general cognition.

In group-based social cognitive interventions, it is challenging to address the specific needs of each individual. In SocialVille, however, each individual is allowed to move through training at their own pace, as sessions can be completed at any time, and progress in training is adapted to the skills of the individual. The difficulty level of each task is designed and adapted so that participants maintain a correct performance rate between 70-80%. This level of completion ensures that tasks are not perceived as too challenging, while also leading the client to make gains in social cognitive domains. A systematic review of "drill and practice" computerized interventions (of which SocialVille is comparable) concluded that tailoring the training to the needs of the specific difficulties of the participant is a benefit of this form of intervention compared to other forms of computerized interventions (Paquin et al., 2014).

While there are no research studies that have compared in-person treatment to computerized treatment for social cognitive difficulties in individuals with schizophrenia, outcomes of computerized interventions did not differ from outcomes of in-person interventions for anxiety and depressive disorders, and computerized interventions have been found to be potentially more cost-effective (Carlbring et al 2018; Adelman et al 2013). As such, the use of computerized interventions could be a promising option for the treatment of difficult to engage individuals and populations.

In order to confirm that changes in implicit and explicit ToM and social functioning are associated with the intervention, participants will be tested prior to beginning the intervention (baseline), half-way through the intervention (mid-point), and after the intervention has concluded (post-test). Participants will be randomly assigned to either the active, experimental intervention group (SocialVille) or to a control group where participants will play computer games that are not known to affect social cognition.

Study Hypotheses

The following hypotheses are based on the ToM and social cognition intervention literature reviewed above and will be tested during this project:

Hypothesis 1a: Participants in the experimental intervention group will exhibit a greater increase in implicit ToM performance across treatment visits compared to the control group's change in implicit ToM performance.

Hypothesis 1b: Participants in the experimental intervention group will exhibit a greater increase in explicit ToM performance across treatment visits compared to the control group's change in explicit ToM performance.

Hypothesis 1c: Participants in the experimental intervention group will exhibit a greater increase in social functioning across treatment visits compared to the control group's change in social functioning.

Hypothesis 2a: Average implicit ToM performance and change in implicit ToM performance will be positive predictors of social functioning, such that higher average implicit ToM performance and change in implicit ToM performance across visits will be associated with increased social functioning for both treatment arms.

Hypothesis 2b: Average explicit ToM performance and change in explicit ToM performance will be positive predictors of social functioning, such that higher average explicit ToM performance and change in explicit ToM performance across visits will be associated with increased social functioning for both treatment arms.

Hypothesis 3a: Average implicit ToM performance will be more closely associated with social functioning when compared to the relationship between explicit ToM performance and social functioning across treatment arms.

Hypothesis 3b: Change in implicit ToM performance will be more closely associated with social functioning when compared to the relationship between change in explicit ToM performance and social functioning across treatment arms.

Hypothesis 4a: The number of ToM training exercises a participant completed will be a significant, positive predictor of implicit ToM performance.

Hypothesis 4b: The number of ToM training exercises a participant completed will be a significant, positive predictor of explicit ToM performance.

Methods

Data Collection

The data collection for this project was funded in part by a Phase II SBIR Grant (R44MH091793) from the National Institute of Mental Health as a part of the Treatment of Social Cognition in Schizophrenia Trial (TRuSST; ORA# 15103005). The TRuSST study is being monitored by the FDA for possible FDA approval, and as such, not all data is currently available to the author of this project.

Participants

Based on past treatment protocols involving individuals with schizophrenia, all participants recruited for this project met the following criteria: 1) at least 18 years of age, 2) met criteria for schizophrenia as defined by the DSM-5 criteria and assessed by the Structured Clinical Interview for DSM-IV Patient Edition, with psychotic screen (SCID-I/P), 3) clinically stable (not acutely psychotic or hospitalized) for 8 weeks, 4) no medication changes for 6 weeks prior to consent, 5) native English speaker or have learned English prior to age 12, 6) visual and auditory sensory capacities to participate in a computer based intervention, 7) rated at a 4 or below on the hallucinations and unusual thought content sections of the Positive and Negative Symptoms Scale (PANSS), and 8) adequate decision-making capacity to choose to be part of a treatment study.

Participants were excluded from eligibility for the study if they: 1) were hospitalized in the 8 weeks prior to consent, 2) appeared under the influence of any substance during testing, 3) received an IQ score below 70 based on performance on the Wechsler Test of Adult Reading (WTAR) or had a diagnosis of pervasive developmental disorder, traumatic brain injury, epilepsy, or Parkinson’s disease, 4) had received computerized cognitive training created by Posit Science (developers of SocialVille) in the 5 years prior to consent, 5) had participated in another research study that could affect the outcome of this study, 6) were taking more than two anti-psychotic medications, and/or 7) reported Active Suicidal Ideation with Specific Plan and Intent, or reported having an actual attempt, an interrupted attempt, an aborted attempt, or any preparatory acts or behaviors on Columbia-Suicide Severity Rating Scale (C-SSRS) in the month preceding consent.

After data collection concluded, the STOMP was administered to 40 participants at baseline testing, 38 participants at the mid-point testing, and 36 participants at post-test, while the TASIT and SFS were administered to 45 participants at baseline testing, 41 participants at mid-point testing, and 41 at post-test. 31 participants completed all study visits and have data at all time points.

Participants were randomized into the active experimental treatment group or the control treatment group (both of these treatment arms are discussed in detail below). Demographic information and analyses to test for differences between these groups are included in table 1. After statistically comparing differences in demographics using chi-square analyses and one-way analyses of variance (ANOVAs), the groups were not found to differ on any of the following variables: age, IQ, gender, ethnicity, race, symptom ratings at baseline, symptom ratings at post-test, or education.

Table 1

Demographic descriptives by treatment group

	Group		
	Control (*n* = 24)	Treatment (*n* = 21)	Difference Testing
Age	44.08 (12.07)	42.71 (13.11)	***p* = .72**
Gender			***p* = 1**
Male	17 (70.8%)	15 (71.4%)	
Female	7 (29.2%)	6 (28.6%)	
Hispanic (ethnicity)			***p* = .87**
Hispanic	2 (8.3%)	3 (14.3%)	
Not Hispanic	22 (91.7%)	18 (85.7%)	
Race			***p* = .28**
White	8 (33.3%)	7 (33.3%)	
African American	16 (66.7%)	11 (52.4%)	
Hispanic	0 (0.0%)	2 (9.5%)	
Other	0 (0.0%)	1 (4.8%)	
Highest Education			***p* = .38**
Less Than High School	2 (8.3%)	4 (19.0%)	
High School Only	8 (33.3%)	4 (19.0%)	
Some College	13 (54.2%)	10 (47.6%)	
Bachelor's Degree	1 (4.2%)	1 (4.8%)	
More than Bachelor's Degree	0 (0.0%)	2 (9.5%)	
WTAR Full Scale IQ Estimate	94.96 (12.35)	95.24 (11.77)	***p* = .94**
Clinical Symptoms			
PANSS Positive Symptoms (Baseline)	19.12 (5.61)	17.71 (5.50)	***p* = .40**
PANSS Negative Symptoms (Baseline)	15.67 (5.42)	18.05 (6.32)	***p* = .18**
PANSS Positive Symptoms (Posttest)	15.13 (4.54)	15.61 (6.38)	***p* = .78**
PANSS Negative Symptoms (Posttest)	14.17 (5.33)	15.72 (6.36)	***p* = .40**

Recruitment and Compensation

Participants for this study were recruited from the Chicago area. Efforts were made to recruit not only individuals familiar to the clinic where this project is taking place, but also individuals from the community who participate in research less frequently. Investigators for this project employed established methods for participant recruitment, including posting recruitment flyers and ads on public transportation, speaking with mental health practitioners about the project and identifying possible participants, advertising in local newspapers, and contacting individuals who have consented to be contacted about future research studies. Interested individuals were requested to contact study staff who then conducted a brief-phone screen to assess for relevant eligibility criteria prior to scheduling a clinic visit. The purpose of the phone screen is to describe the study, answer any questions about the study, and briefly determine the client's eligibility based on the inclusion/exclusion criteria. If the client appeared to meet criteria for the study, the study staff scheduled a clinic visit to provide informed consent to the client and a more thorough assessment of the client's diagnostic and cognitive status.

During the initial visit to the clinic, study staff described the study process in detail, including the purpose of the project, all trial procedures, the risks and benefits of taking part in the project, treatment randomization, confidentiality, compensation, and the voluntary nature of research (the right to withdraw consent for services at any time). Participants were informed that the purpose of the project was to compare the effectiveness of two forms of computerized cognitive remediation. The purpose of this language was to encourage the participants to avoid thinking of the trial as including a placebo treatment group and to help maintain the double-blind procedures of the study. Participants were told not to discuss their training with anyone at the study site except for the unblinded staff member who would be available to assist them with training. Additionally, individuals in the control group were offered the option of taking part in the experimental intervention after they completed the control treatment.

Participants were asked to attend up to 7 visits to the clinic (screening visit, 2 baseline assessments, 2 mid-training assessments, and 2 post-training assessments). Participants received $25 for each of these visits and were compensated $10 for transportation costs for each visit, bringing the total for attending all visits to $245 ($175 for visits, and $70 for transportation). Additionally, all participants were paid $5 for each session completed in both (control and experimental) computerized training interventions (up to 40 training sessions) for a total training compensation of $200. The total amount of money a participant could receive if they completed all assessment visits and training sessions was $445. Participants were informed that they would only be paid for the visits they attended and training sessions they completed.

Interventions

Experimental Intervention: SocialVille: Social cognitive computerized intervention

The training exercises included in the social cognitive computerized intervention used on this project were designed to collectively target difficulties in the core domains of social cognition through a drill and practice training paradigm. Participants logged into the training program using a standard web browser and the login information given to them by study staff. Each exercise took an average of 5-10 minutes to complete, and participants were scheduled to complete roughly 6 exercises per training session. Training exercises were repeated throughout the full training protocol, with varying levels of difficulty based on the participant's responses. Each session consisted of hundreds of trials of social stimuli of varying complexity. Auditory and visual feedback were used to display whether the client's responses were correct or incorrect, utilizing operant conditioning procedures. The participant's performance during the session was used to update the difficulty of subsequent administrations of the same task, such that a participant performing very well would be given more challenging stimuli in later task administration, and participants who were performing poorly would be given less challenging material. Participants were shown their progress and success rates on different exercises throughout their use of SocialVille. An unblinded member of the study staff with access to the participant's progress and training performance was available to discuss the training program with the participant should any problems arise.

Training was designed to progress in a defined order, starting with less challenging exercises that included fewer response options and stimuli that were easier to discriminate, and progressing towards more complex exercises that were characterized by stimuli that were more challenging to discriminate and included more complex rules. Forty training sessions would be considered a "full dose" of the treatment, and all sessions were designed to be completed over the course of 8-12 weeks. Below are brief descriptions of the 5 exercises that target ToM difficulties most directly. As the treatment is in the process of FDA testing for widespread use, the descriptions of the tasks were intentionally limited by the creators of the treatment to prevent replication.

Social Scenes. Participants were shown a clip of an individual expressing an emotion and then given a list of possible situations. The participants were asked to select what was the most likely situation to have preceded the individual's emotional expression. Successful performance of the task led to faster presentations of the emotional expression, whereas incorrect responses led to slower presentations.

What Happened. Participants were shown different descriptions of events and were asked to select which was the most likely situation to have occurred given the fewest amount of hints. The difficulty of this task was adjusted via the number of hints given.

Say What. Participant were read a short script about a social situation and asked how a character in the script would respond and given three options differing in prosody. The participant's goal was to select the appropriate prosody for the situation. The difficulty of the task was adapted via the complexity of the script, the number of options of prosodies presented to the participant, and the length of the statements read presented to the participant.

What Joe's Thinking. Participants were presented with a video of a face looking in a specific direction. After the face was removed from the screen, an array of objects was presented, and the participants were asked to identify which object the face was looking at.

Person Description. Participants were given facts about a character and asked to infer the character's beliefs.

Control Intervention

An important component of any intervention study is including an appropriate control group that leaves out the proposed mechanism of change. As the current treatment paradigm is still being actively investigated, it is unclear exactly what sort of control group is most appropriate for use with this intervention. In order to maintain some similarity between the control and experimental groups, conventional computer games were chosen to be used as the control group for this project. Using computer games also assisted in maintaining the double-blind procedure for study staff and participants, in addition to controlling for the placebo effects that could be associated with being involved in a computerized intervention, meetings with study staff, and screen time/multi-media exposure.

The control treatment was delivered identically to the experimental treatment, utilizing the same internet-based interface as used for the experimental intervention. Participants logged on to complete 6 games for 5-10 minutes each during every session. Similar to the experimental intervention, the games were repeated throughout the full protocol. Each of the games were selected to exhibit the face-valid appearance of cognitive stimulation. These games included: Chinese checkers, Sudoku, Reverse, Double Klondike Solitaire, Tri Peaks Solitaire, Brick Breaking Hex, Brick Squasher II, Gem swap, War ship, A Maze Race, Lineup 4, Word Search II, and Crossword Puzzle. The unblinded study staff member had access to the control group's performance on each task and was available to check in with the participant to offer guidance and support for completing the tasks, further supporting the similarity in procedures between the groups.

Study Procedure

Participants took part in the trial in the following order:

1. Consent Visit: clinicians provided informed consent, discussed study procedures, and performed inclusion/exclusion assessments (1 visit, approximately 2 hours in clinic).
2. Pre-training Assessment: clinician(s) conducted all assessment measures. (1-2 visits, approximately 4 hours in clinic)
3. Randomization: the participants were randomized after pre-training assessment measures were scored and client eligibility was verified. Participants were assigned to treatment or control groups and efforts were made to ensure that experimental and control groups were demographically matched. (No visit)
4. Set-Up Visit: participant performed first computerized training session in clinic under observation by the unblinded staff member who instructed the client regarding how to use the program. Participants were allowed to use their own computer, or one provided by the clinic. (1 visit, approximately 2 hours in clinic)
5. Program Use: participants logged on to the training portal and took part in up to 20 training sessions in total (3-5 sessions per week for approximately 45 minutes to an hour per session) over the course of 4-8 weeks prior to the mid-training assessment. The unblinded staff member contacted participants to discuss any difficulties with training. Participants were requested to complete no more than two training sessions per day (up to approximately 15-20 hours of program use outside of clinic prior to the mid-training

assessment visit). Participants were asked to attend the mid-training assessment visit after completing 20 sessions, or 8 weeks after starting the training protocol, whichever happened first. (No visit necessary)

6. Mid-Training Assessment Visit: clinicians administered assessment measures from the pre-training assessment visit. Participants received alternate versions of measures, if available. After completing this visit, participants were requested to complete another 20 sessions prior to the post-training assessment visit (1-2 visits, approximately 4 hours in clinic). Participants were requested to complete no more than two training sessions per day (up to approximately 15-20 hours of program use outside of clinic prior to the post-training assessment visit). Participants were requested to attend the post-training assessment visit after completing an additional 20 sessions after the mid-training assessment (up to 40 in total), or 8 weeks after the mid-training assessment visit, whichever happened first. (1-2 visits, approximately 4 hours in clinic)
7. Post-Training Assessment Visit: clinicians administered assessment battery and participants received alternate versions of measures, where available. (1-2 visits, approximately 4 hours in clinic)

Blinding

Several social cognitive interventions published in recent years neglected to adequately control for the expectations of researchers and participants by conducting an unblinded study or a single-blind study. The researchers involved in this project conducted a double-blind study to prevent participants and researchers from knowing exactly to which treatment group the participant was enrolled. In order to maintain adequate blinding, the following procedures took place:

1. The clinic had an unblinded staff member who was responsible for training the participants how to use the SocialVille program (experimental intervention and control) and monitoring their progress. This individual answered any questions the participants had regarding the program and was prevented from conducting any assessments of study participants.

2. All other study staff were blinded to treatment condition. These staff members were available to conduct assessments and evaluations. If a staff member became unblinded to the treatment status of a specific participant, they were no longer allowed to conduct assessments for that participant.

3. Participants were instructed not to discuss the details of treatment with a blinded staff member and to only discuss the treatment with the unblinded staff member.

Measures

The complete assessment battery conducted as a part of the TRuSST protocol will not be analyzed, as the author was only given permission to discuss and report upon the following assessment measures. This battery was intended to be administered at the pre-training assessment, the mid-training assessment, and the post-training assessment, although not all participants received all assessments. The battery was administered to individuals in both arms of the trial and alternate versions of assessment measures were administered when available. The assessment measures were administered using several different modalities, including paper and pencil questionnaires, clinician-administered interviews, and computerized assessments. Below are descriptions of the primary measures involved in analyses for this project.

The Awareness of Social Inferences Task (TASIT)

Part 3 of the TASIT (McDonald et al., 2003) is a measure of explicit theory of mind, during which participants watch 16 short videos that involve lying and deception and are then asked a series of yes/no questions about the mental states and intentions of the individuals shown in the clips. The responses of the participants are scored for correctness, and the overall score of the TASIT (total scores range from 0-64) has been used as a reliable measure of explicit ToM. There are 2 versions of the test that were given at different time points, such that participants who received version A of the TASIT at baseline, received version B at mid-point testing, and received version A at post-test. The TASIT has been found to have acceptable to good test-retest reliability, an association with performance on measures of social functioning, and performance on the TASIT can be used to distinguish between healthy controls and individuals with schizophrenia (McDonald et al., 2006; Sparks et al., 2010).

Spontaneous Theory of Mind Protocol (STOMP)

The STOMP is a measure of implicit ToM that assess an individual's description of movie clips. Each of the movie clips in the task involve multiple characters, and at least one character in each clip experiences a change in mental state. The STOMP stimuli include 3 videos (each available on movieclips.com), averaging 2 minutes in length, from feature length films. Participants are asked to describe each movie clip verbally without being instructed to discuss the characters' mental states. The participants' responses are audio recorded and later transcribed by laboratory research assistants. These transcriptions are then divided into clauses by the author of this paper and coded by research assistants who were trained to a reliability kappa coefficient of .85. These research assistants coded the responses into internal (emotion, intention, mental state) or external (physical description, physical inference) categories, which were used to calculate the STOMP index. The STOMP index is the primary dependent variable for this task and is computed by summing the total number of clauses in the internal category across all videos and then dividing by the total number of clauses across all videos. STOMP scores can range from .00 to 1.00. The STOMP is a relatively new measure of implicit ToM and reliability psychometrics are not currently available. Similar to the past studies using the STOMP, only two of the three videos were used in the calculation of the STOMP index due to variability in responses for the first video presented and the other two presented videos.

Social Functioning Scale (SFS)

The SFS is a clinician-administered, self-report measure of social functioning designed for use with an individual with schizophrenia (Birchwood et al., 1990). This measure has been adapted for use in multiple languages, and it has been found to be reliable over time and sensitive to change (Torres & Olivares, 2005; Hellvin et al., 2010; Birchwood et al. 1990). The SFS assesses 7 different domains of social functioning, including social engagement, interpersonal behavior, pro-social activities, recreation, independence-competence, independence-performance, and employment/occupation. SFS scores are standardized, such that average performance on a scale is equal to 100.

Positive and Negative Syndrome Scale (PANSS)

The Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987) is a clinician-administered, semi-structured interview designed to determine the presence and severity of symptoms associated with psychotic spectrum disorders, including positive, negative, and general clinical symptoms. This measure has been found to have excellent interrater reliability and is used extensively in research studies (Bell et al., 1992). The PANSS was administered and scored by experienced researchers trained to a kappa value of .85. The PANSS total score was used as a covariate in some analyses.

Wechsler Test of Adult Reading (WTAR)

The Wechsler Test of Adult Reading (WTAR; Wechsler 2001) is designed to estimate an individual's full-scale intelligence quotient (FSIQ) through a measurement of their ability to accurately pronounce words of varying difficulty. FSIQ scores were used as covariates in some analyses.

Analytic Approach

After the dataset was compiled and cleaned, each of the specific hypotheses of this project were tested using a series of hierarchical longitudinal mixed-effects models, where study visit was treated as a random effect relative to the participants. Mixed-effect models conducted in R (Version 3.6.3) using the lme4 package (Bates et al., 2015) used maximum likelihood fitting. Model fits between successive hierarchical model fits were tested using deviance testing. Degrees of freedom for individual predictors were estimated via Satterthwaite's method using the lmerTest package (Kuznetsova et al., 2017). The tableone package (Kazuki, 2020) was utilized to create Table 1 for this project, which consists of baseline demographic information. All hypotheses were considered as *a* priori and did not require statistical corrections for conducting multiple analyses.

We used mixed-effects models to examine the effects of computerized social cognitive training on measures of implicit ToM (STOMP), explicit ToM (TASIT), and social functioning (SFS), as well as the relationship between implicit and explicit ToM performance and social functioning. In the analyses, treatment group status was dummy coded, such that the control group was coded as 0 and the experimental group was coded as 1, unless otherwise specified.

The baseline study visit was coded as 0, the midpoint study visit was coded as 1, and the posttest study visit was coded as 2. As such, unless otherwise specified, the intercept for the analyses was the performance of the control group at baseline. Additionally, continuous variables utilized as predictor variables in analyses, except for study visit and treatment group, were z-scored. Longitudinal mixed-effects effects models used to test the following hypotheses were able to create a slope for participants with one missing data point (of three), thus allowing for more participants to be retained.

As general cognition has been found to be related to both social cognition and functioning (Hoe et al., 2012), FSIQ scores as estimated by the WTAR were used as covariates in analyses. Additionally, studies have found that the severity of positive symptoms (Konstantakopoulos et al., 2014) and the severity of negative symptoms (Andrzejewska et al., 2017) as measured by the PANSS have been associated with performance on ToM tasks. As such, both positive and negative symptom severity were also included as covariates in analyses.

Hypothesis 1

Hypothesis 1 was tested via three separate analyses looking at each of three outcome variables (STOMP index score, total TASIT score, SFS scaled scores averaged across all domains). Hypothesis 1a examined implicit ToM performance (STOMP Index Score), hypothesis 1b examined explicit ToM performance (total TASIT score), and hypothesis 1c examined ratings of social functioning (SFS scaled scores averaged across all domains). For hypothesis 1 overall, I predicted that individuals in the experimental treatment group would exhibit a greater increase in each of the three outcome variables when compared to the control group. This hypothesis was tested using hierarchical mixed-effects models and followed a four-step forward fitted model order. Model 0 for each outcome variable tested the intercept only to determine if subsequent models provided any significant explanation of the variance above and beyond this step. Model 1 for each outcome variable included the main effects of treatment group and visit as predictor terms. Model 2 for each outcome variable included the simple effects of treatment group and visit on the control group, unless otherwise specified, and the interaction of these variables as predictor terms. The third model for each outcome variable included full-scale IQ estimates from performance on the WTAR as a measure of general cognition and the positive and negative symptom severity scores from the PANSS, as well as all of the terms from model 2 to determine if any significant relationships found between variables continued to exist when accounting for cognition and symptom severity covariates. As significance in model 0 does not represent meaningful statistical information apart from revealing that the average score on the measure is greater than 0, only models 1, 2, and 3 will be discussed in the results section.

Hypothesis 2

Hypothesis 2 was divided into two separate analyses. Hypothesis 2a examined the effects of average implicit ToM performance and change in implicit ToM performance on social functioning, and hypothesis 2b examined the effects of average explicit ToM performance and change in explicit ToM performance on social functioning. I predicted that higher average performance and change in both implicit and explicit ToM performance would predict improved social functioning. The testing of hypothesis two followed a similar process to hypothesis 1 and hierarchical testing for effects on social functioning followed a 4-step forward fitted model order to determine the best fit of the data for performance on each ToM measure. Model 0 for each analysis tested the intercept only. Model 1 included the main effects of average performance on the implicit or explicit ToM measure and visit. Model 2 tested the predictors from model 1, in addition to the change in implicit or explicit ToM performance across treatment visit. Model 3 included the predictor terms from model 2 and the covariates of full-scale IQ estimates from performance on the WTAR and the positive and negative symptom severity scores from the PANSS.

Hypothesis 3

Hypothesis 3 was divided into two separate analyses. Hypothesis 3a examined the relationship between average implicit ToM performance, average explicit ToM performance, and social functioning performance, whereas hypothesis 3b examined the relationship between change in implicit ToM performance, change in explicit ToM performance, and social functioning performance. I predicted that average implicit ToM performance would be a better predictor of social functioning performance compared to average explicit ToM performance and that change in implicit ToM performance would be a better predictor of social functioning performance compared to change in explicit ToM performance. Hypothesis 3 was tested using a hierarchical analysis following a 4-step forward fitted model designed to determine if implicit ToM was a better predictor of social functioning performance than explicit ToM performance and if change in implicit ToM or change in performance on the explicit ToM measure was a better predictor of performance on the measure of social functioning. Model 0 tested the intercept of overall social functioning performance. Model 1 included the main effects of visit and performance on the explicit ToM measure or change in performance on the explicit ToM measure. Model 2 included the predictor terms from model 1 and the main effects of average implicit ToM performance or change in implicit ToM. Hypothesis 3 would only be tested if implicit ToM or explicit ToM performance were found to be significant predictors of social functioning performance.

Hypothesis 4

Hypothesis 4 was divided into two separate analyses. Hypothesis 4a examined the relationship between the number of ToM training exercises and implicit ToM performance, and hypothesis 4b examined the relationship between the number of ToM training exercises and performance on the explicit ToM measure. I predicted that a greater number of ToM training sessions would lead to increased scores on the implicit and explicit ToM measures. Hypothesis 4 was tested using a hierarchical analysis following a 4-step forward fitted model. Model 0 for hypothesis 4a included the intercept of performance for the implicit ToM measure, while model 0 for hypothesis 4b included the intercept of performance for the explicit ToM measure. Model 1 for hypothesis 4a and 4b tested the main effects of ToM training and visit. Model 2 included the predictor terms for model 1 and the interaction of training and visit. Model 3 included the predictor terms from model 2 and the covariates of positive and negative symptom severity scores from the PANSS and the estimate of full-scale IQ from the WTAR.

The models for all analyses were compared to one another using deviance testing. Model 1 was always compared to model 0, and if model 1 was found to be a significantly better fit of the data than model 0, model 2 was compared to model 1. If model 1 was not found to be a better fit of the data than model 0, then model 2 was compared to model 0. If model 2 was found to be a significantly better fit of the data than a previous model, then model 3 was compared to model 2. If model 2 was not found to be a better fit of the data than a previous model, then model 3 was compared to the best previous fit of the data. In the results section, the author of the paper described whichever model was found to be the most parsimonious fit of the data.

Results

Hypothesis 1 Overview

Hypothesis 1 predicted that individuals in the experimental group would exhibit a significantly more positive rate of change on performance of the measures of implicit ToM (STOMP), explicit ToM (TASIT), and social functioning (SFS) over the course of the study protocol when compared to the control group (see Tables 2, 3, and 4 for detailed results, respectively). This hypothesis was tested by determining whether performance on each of these outcome variables changed as a function of treatment group over time by using a series of longitudinal mixed-effects models. Each of the outcome variables were tested in independent analyses.

Hypothesis 1a

In hypothesis 1a, Implicit ToM model 0 tested the intercept of implicit ToM performance across all participants, treatment group status, and study visits. Implicit ToM model 1 tested the main effects of study visit and treatment group status. Implicit ToM model 2 tested the simple effects of study visit and treatment group status, as well as the interaction of study visit and treatment group. Implicit ToM model 3 included previous terms from Implicit ToM model 2 and the covariates of full-scale IQ from the WTAR and positive and negative symptom severity scores from the PANSS, in order to determine if the inclusion of these covariates affected the statistical relationship between variables in the previous models. Implicit ToM model 1 did not explain significantly more variance than Implicit ToM model 0, $\chi^2(2) = 2.01$, $p = .37$. Implicit ToM model 2 explained significantly more variance than Implicit ToM model 0, $\chi^2(3) = 13.94$, $p = .003$. Implicit ToM model 3 did not explain significantly more variance than Implicit ToM Model 2, $\chi^2(3) = 2.60$, $p = .46$. These results indicated that Implicit ToM model 2 is the best fit for the data and the results of Implicit ToM model 2, as well as the implications of Implicit ToM model 3, are explained below.

As seen in Table 2 and Figure 1, Implicit ToM model 2 revealed a significant simple effect of treatment group, a trend level simple effect of visit, and a significant interaction of treatment group and study visit. As such, Model 2 indicated that individuals in the control group had a significantly higher implicit ToM score (as measured by the STOMP index) at baseline than the experimental group, individuals in the control group scored lower on the implicit ToM measure at subsequent visits at the trend level, and the experimental group had a significantly more positive rate of change on the implicit ToM measure when compared to the control group's rate of change on the implicit ToM measure.

When testing the simple slope of study visit for individuals in the experimental group in a rotated version of Implicit ToM model 2 that made the experimental group's performance the intercept instead of the control group's performance, the experimental group's change in implicit ToM performance was found to be significantly greater than zero ($b = .05$, $t(64.86) = 6.2$, $p < .001$). This result indicated that the experimental group increase in implicit ToM scores was not only significantly greater than the controls but also significantly greater than zero. The statistical relationships found in Implicit ToM model 2 between treatment group and implicit ToM performance and between the interaction of visit and treatment group and implicit ToM performance remained significant when controlling for potential covariates in Implicit ToM model 3. Additionally, the simple effect of visit for the control group on implicit ToM performance was significant in Implicit ToM model 3, such that individuals in the control group exhibited decreased scores over time.

Table 2

Results of Hypothesis 1a

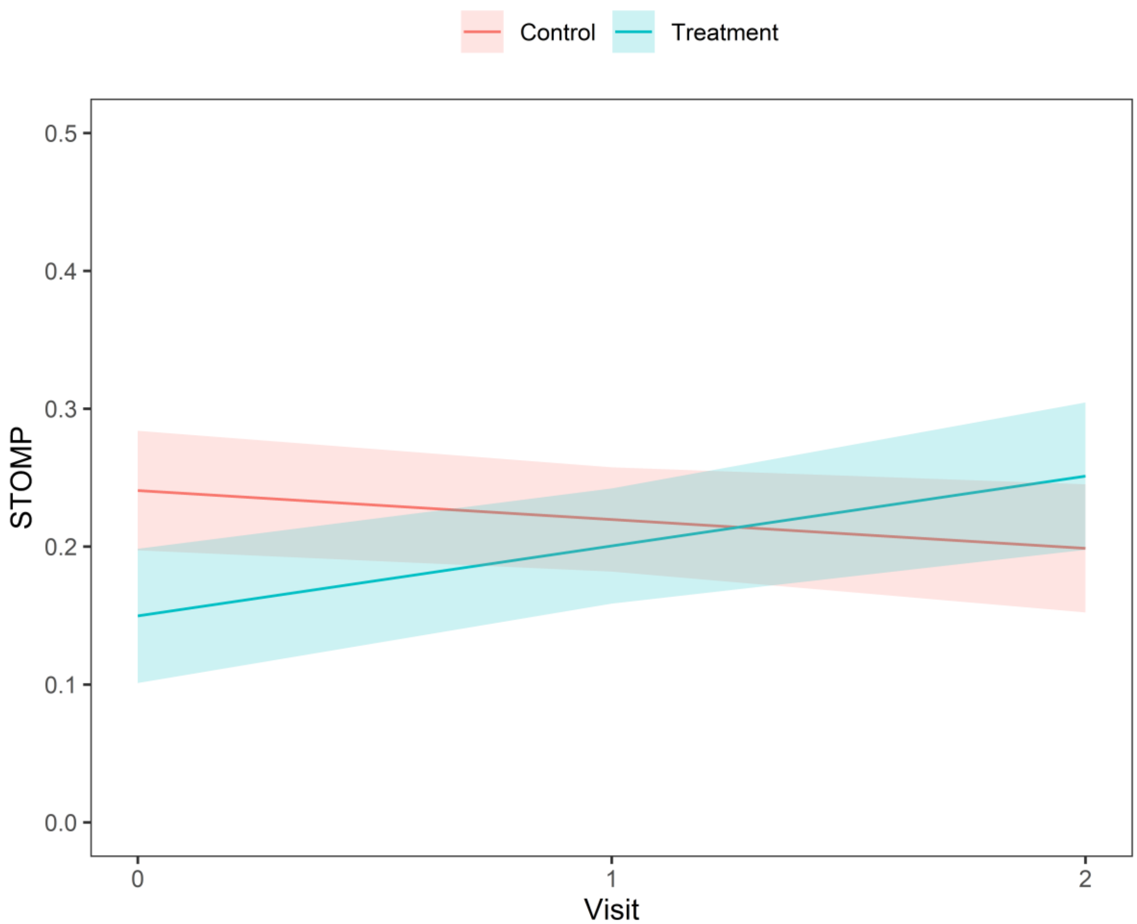
Fixed Effects	**Implicit ToM Model 1**	**Implicit ToM Model 2**	**Implicit ToM Model 3**
(Intercept)	0.218^{***}	0.241^{***}	0.244^{***}
	(0.021)	(0.022)	(0.022)
Visit	0.008	$-0.021^{\cdot}$	-0.025^{*}
	(0.011)	(0.012)	(0.013)
Treatment Group	-0.037	-0.091^{**}	-0.090^{**}
	(0.028)	(0.033)	(0.033)
Visit * Treatment Group		0.072^{***}	0.071^{***}
		(0.019)	(0.019)
Full-scale IQ Estimate of WTAR			-0.013
			(0.014)
Positive Symptom Severity (PANSS)			-0.011
			(0.012)
Negative Symptom Severity (PANSS)			-0.008
			(0.013)
Random Effects (Variance)			
Intercept | Subject	0.005	0.006	0.006
Visit | Subject	0.001	0.0003	0.0002
Residual	0.006	0.006	0.006
Model Fit			
AIC	-177.868	-187.799	-184.402
BIC	-161.451	-168.645	-157.040
Log Likelihood	94.934	100.899	102.201

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$

Note. Mixed-effects models assessing the effects of visit, treatment group, and covariates on change in implicit ToM (i.e. STOMP index scores) with slope (standard error) estimates reported.

Figure 1

Change in implicit ToM Performance



Note. Average implicit ToM performance (i.e. STOMP Index Score) across each of the three visits for individuals in the control group and computerized treatment group.

Hypothesis 1b

In hypothesis 1b, Explicit ToM model 0 tested the intercept of explicit ToM performance across all participants, treatment group status, and study visits. Explicit ToM model 1 tested the main effects of study visit and treatment group status. Explicit ToM model 2 tested the simple effects of study visit and treatment group status, as well as the interaction of study visit and treatment group. Explicit ToM model 3 included previous terms from model 2, as well as the covariates of full-scale IQ from the WTAR and positive and negative symptom severity scores from the PANSS, in order to determine if the inclusion of these covariates affected the statistical relationship between variables in the previous models. Explicit ToM model 1 did not explain significantly more variance than Explicit ToM model 0, $\chi^2(2) = 3.41$, $p = .18$. Explicit ToM model 2 did not explain significantly more variance than Explicit ToM model 0, $\chi^2(3) = 3.79$, $p = .28$. Explicit ToM model 3 explained significantly more variance than Explicit ToM model 0, $\chi^2(6) = 18.40$, $p = .005$. These results indicate that Explicit ToM model 3 is the best fit for the data and the results of Explicit ToM model 3 are explained below.

As seen in Table 3 and Figure 2, Explicit ToM model 3 revealed no simple effects of visit or treatment group or a significant interaction of visit and treatment group. FSIQ estimates from the WTAR and negative symptom severity scores from the PANSS were significantly associated with explicit ToM performance, such that greater severity of negative symptoms and lower IQ estimates predicted lower scores on the measure of explicit ToM.

Table 3.

Results of Hypothesis 1b

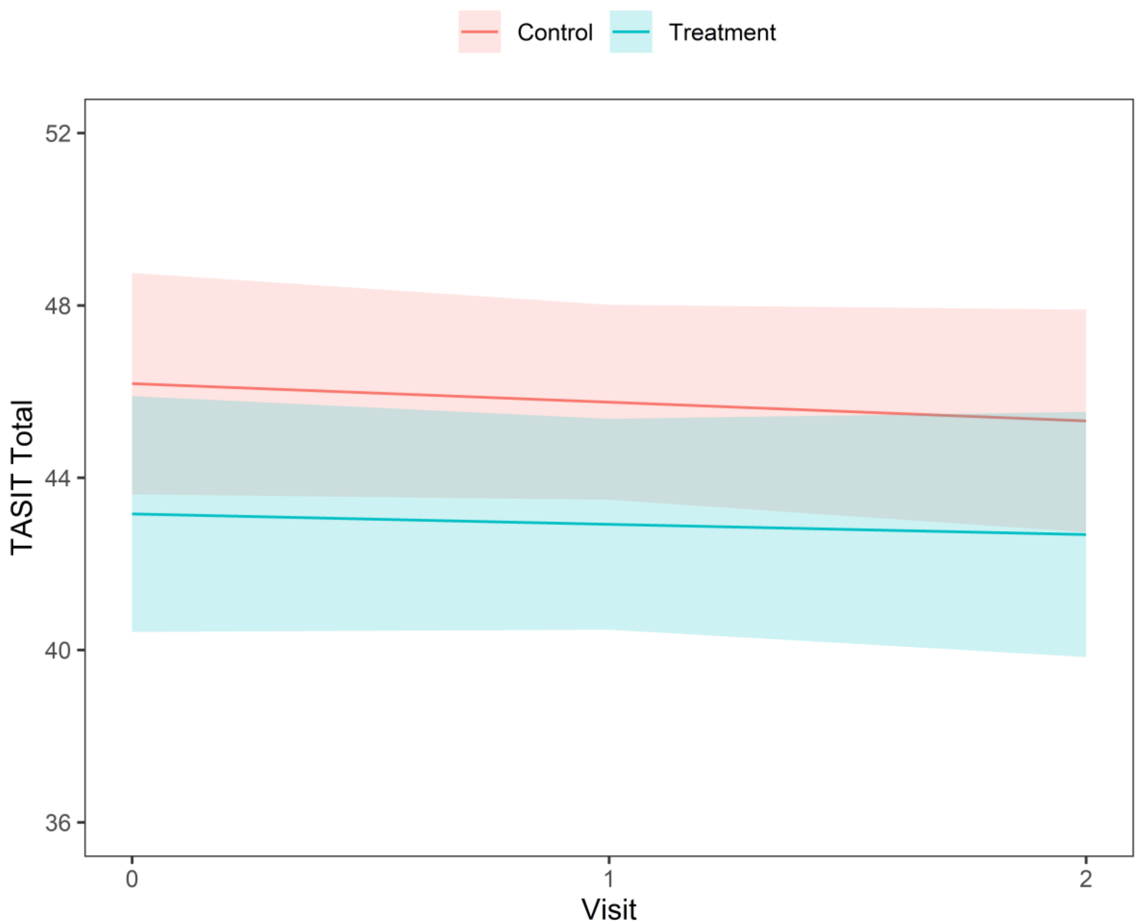
Fixed Effects	**Explicit ToM Model 1**	**Explicit ToM Model 2**	**Explicit ToM Model 3**
(Intercept)	46.301***	46.534***	46.116***
	(1.406)	(1.453)	(1.296)
Visit	-0.218	-0.460	-0.433
	(0.436)	(0.583)	(0.622)
Treatment Group	-3.580˙	-4.081˙	-3.028
	(1.974)	(2.130)	(1.902)
Visit * Treatment Group		0.545	0.194
		(0.876)	(0.888)
Full-scale IQ Estimate of WTAR			2.610**
			(0.832)
Positive Symptom Severity (PANSS)			0.810
			(0.654)
Negative Symptom Severity (PANSS)			-1.957**
			(0.696)
Random Effects (Variance)			
Intercept | Subject	37.542	37.458	25.194
Visit | Subject	0.000	0.000	0.005
Residual	15.795	15.742	15.792
Model Fit			
AIC	813.679	815.293	806.688
BIC	830.744	835.203	835.130
Log Likelihood	-400.839	-400.647	-393.344

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, ˙$p < 0.1$

Note. Mixed-effects models assessing the effects of visit, treatment group, and covariates on change in explicit ToM scores with slope (standard error) estimates reported.

Figure 2

Change in Explicit ToM Performance



Note. Average explicit ToM (total TASIT) scores across each of the three visits for individuals in the control group and computerized treatment group.

Hypothesis 1c

In hypothesis 1c, SF model 0 tested the intercept of social functioning performance across all participants, treatment group status, and study visits. SF model 1 tested the main effects of study visit and treatment group status. SF model 2 tested the simple effects of study visit and treatment group status, as well as the interaction of study visit and treatment group. SF model 3 included previous terms from Model 2 and the covariates of full-scale IQ from the

WTAR and positive and negative symptom severity scores from the PANSS, in order to determine if the inclusion of these covariates affected the statistical relationship between variables in the previous models. SF model 1 did not explain significantly more variance than SF model 0, $\chi^2(2) = 2.84$, $p = .24$. SF model 2 did not explain significantly more variance than SF model 0, $\chi^2(3) = 2.87$, $p = .41$. SF model 3 did not explain significantly more variance than SF model 0, $\chi^2(6) = 6.54$, $p = .37$. These results indicate that these models failed to predict significant variance in social functioning performance. Table 4 and Figure 3 provide greater detail of these analyses.

Table 4.

Results of Hypothesis 1c

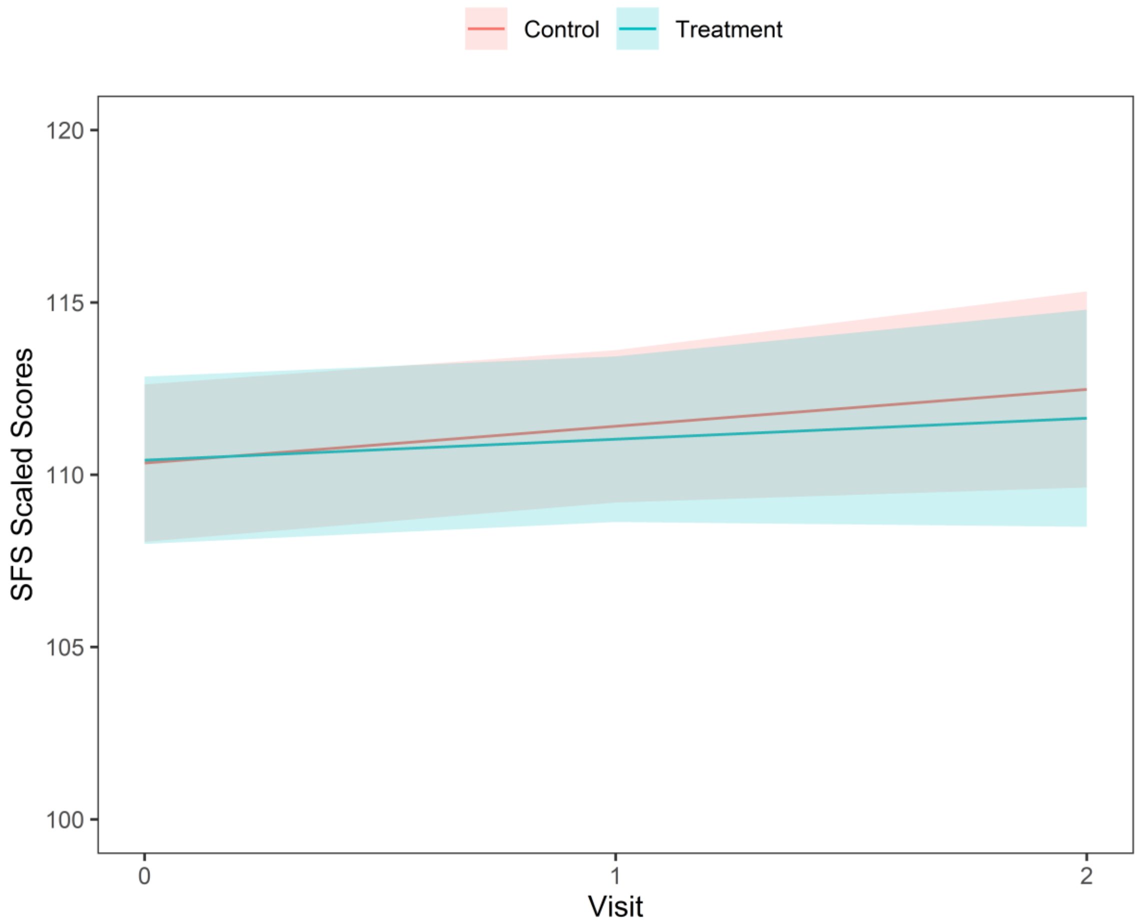
Fixed Effects	**SF Model 1**	**SF Model 2**	**SF Model 3**
(Intercept)	110.807***	110.767***	110.329***
	(1.145)	(1.165)	(1.152)
Visit	0.799	0.881	1.069
	(0.488)	(0.652)	(0.670)
Treatment Group	-0.772	-0.684	0.084
	(1.645)	(1.708)	(1.690)
Visit * Treatment Group		-0.188	-0.460
		(0.982)	(0.973)
Full-scale IQ Estimate of WTAR			0.314
			(0.787)
Positive Symptom Severity (PANSS)			0.932
			(0.617)
Negative Symptom Severity (PANSS)			-1.118$^{\cdot}$
			(0.656)
Random Effects (Variance)			
Intercept | Subject	24.153	24.159	21.319
Visit | Subject	4.810	4.804	4.181
Residual	10.015	10.013	10.546
Model Fit			
AIC	787.494	789.457	791.792
BIC	804.559	809.367	820.233
Log Likelihood	-387.747	-387.729	-385.896

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$

Note. Mixed-effects models assessing the effects of visit, treatment group, and covariates on change in social functioning (average SFS domain scaled scores) with slope (standard error) estimates reported.

Figure 3

Change in Social Functioning Performance



Note. Social functioning scores (SFS) across each of the three visits for individuals in the control group and computerized treatment group.

Hypothesis 2 Overview

Hypothesis 2 predicted that implicit and explicit ToM performance would be positive predictors of social functioning, such that higher scores on the measures of implicit and explicit ToM would be associated with greater social functioning for both treatment arms (see Tables 5 and 6 for detailed results, respectively). This hypothesis was tested by determining whether performance on the implicit and explicit ToM measures impacted social functioning over time by using a series of longitudinal mixed-effects models. The impact of implicit ToM and explicit ToM were tested in independent analyses.

Hypothesis 2a

In hypothesis 2a, Implicit – SF model 0 tested the intercept of social functioning performance across all participants, treatment group status, and study visits. Implicit – SF model 1 tested the main effects of study visit and average implicit ToM performance. Implicit – SF model 2 tested the predictors from Implicit – SF model 1, as well as a subject centered implicit ToM score reflecting the subject's change in implicit ToM performance over time. Implicit – SF model 3 included previous terms from Implicit – SF model 2 and the covariates of full-scale IQ from the WTAR and positive and negative symptom severity scores from the PANSS, in order to determine if the inclusion of these covariates affected the statistical relationship between variables in the previous model. Implicit – SF model 1 explained significantly more variance than Implicit – SF model 0, $\chi^2(2) = 10.24$, $p = .006$. Implicit – SF model 2 did not explain significantly more variance than Implicit – SF model 1, $\chi^2(1) = 1.73$, $p = .18$. Implicit – SF model 3 did not explain significantly more variance than Implicit – SF model 1, $\chi^2(4) = 5.12$, $p = .28$ These results indicate that Implicit – SF model 1 is the best fit for the data and the results of Implicit – SF model 1 are explained below.

As seen in Table 5, Implicit – SF model 1 revealed a significant main effect of average implicit ToM performance, such that higher average performance on the implicit ToM measure predicted better performance on the measure of social functioning. This relationship between average implicit ToM scores and higher social functioning scores remained significant even when accounting for change in implicit ToM scores over time and covariates in subsequent analyses and the magnitude of the effect did not change.

Table 5.

Results of Hypothesis 2a

Fixed Effects	Implicit - SF Model 1	Implicit - SF Model 2	Implicit - SF Model 3
(Intercept)	105.366***	105.323***	105.577***
	(1.865)	(1.867)	(1.815)
Visit	0.704	0.739	0.744
	(0.482)	(0.470)	(0.498)
Average STOMP Index	23.729**	23.738**	22.419**
	(7.981)	(7.974)	(7.706)
Subject Centered STOMP Index		-7.032	-7.067
		(5.213)	(5.310)
Full-scale IQ Estimate of WTAR			0.584
			(0.725)
Positive Symptom Severity (PANSS)			0.779
			(0.608)
Negative Symptom Severity (PANSS)			-1.030
			(0.636)
Random Effects (Variance)			
Intercept | Subject	19.343	19.576	16.762
Visit | Subject	2.368	1.792	1.117
Residual	11.758	11.917	12.869
Model Fit			
AIC	703.365	703.634	706.248
BIC	719.783	722.787	733.610
Log Likelihood	-345.683	-344.817	-343.124

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, ·$p < 0.1$

Note. Mixed-effects models assessing the effects of implicit ToM performance (i.e. STOMP Index) on change in social functioning (average SFS domain scaled scores) with slope (standard error) estimates reported.

Hypothesis 2b

In hypothesis 2b, Explicit – SF model 0 tested the intercept of social functioning performance across all participants, treatment group status, and study visits. Explicit – SF model 1 tested the main effects of study visit and average explicit ToM performance. Explicit – SF model 2 tested the predictors from Explicit – SF model 1, as well as a subject centered explicit ToM score reflecting the subject's change in explicit ToM performance over time. Explicit – SF model 3 included the terms from Explicit – SF model 2 and the covariates of full-scale IQ from the WTAR and positive and negative symptom severity scores from the PANSS, in order to determine if the inclusion of these covariates affected the statistical relationship between variables in the previous models. Explicit – SF model 1 did not explain significantly more variance than Explicit – SF model 0, $\chi^2(2) = 3.54$, $p = .17$. Explicit – SF model 2 did not explain significantly more variance than Explicit – SF model 0, $\chi^2(3) = 3.73$, $p = .29$. Explicit – SF model 3 did not explain significantly more variance than Explicit – SF model 0, $\chi^2(6) = 6.92$, $p = .33$. These results indicated that these models failed to predict significant variance in social functioning performance. Table 6 provides more detail from these analyses.

Table 6
Results of Hypothesis 2b

Fixed Effects	**Explicit - SF Model 1**	**Explicit - SF Model 2**	**Explicit - SF Model 3**
(Intercept)	105.318***	105.273***	108.072***
	(5.388)	(5.388)	(5.952)
Visit	0.797	0.786	0.855˙
	(0.488)	(0.488)	(0.508)
Average TASIT total	0.116	0.117	0.052
	(0.120)	(0.120)	(0.132)
Subject Centered TASIT total		-0.043	-0.069
		(0.100)	(0.102)
Full-scale IQ Estimate of WTAR			0.172
			(0.861)
Positive Symptom Severity (PANSS)			0.916
			(0.615)
Negative Symptom Severity (PANSS)			-1.046
			(0.687)
Random Effects (Variance)			
Intercept | Subject	23.666	23.673	21.321
Visit | Subject	4.829	4.793	4.202
Residual	10.007	10.003	10.476
Model Fit			
AIC	786.794	788.608	791.413
BIC	803.859	808.517	819.855
Log Likelihood	-387.397	-387.304	-385.707

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$

Note. Mixed-effects models assessing the effects of explicit ToM performance (TASIT) on change in social functioning (average SFS domain scaled scores) with slope (standard error) estimates reported.

Hypothesis 3 Overview

For hypothesis 3, I predicted that implicit ToM performance would be a significantly better predictor of social functioning performance than explicit ToM performance. As average implicit ToM performance and not change in implicit ToM performance was found to be a significant predictor of social functioning performance, average explicit and implicit ToM performance will be used as predictors of social functioning performance, while changes in implicit and explicit ToM performance will not be used as predictors of social functioning performance (See table 7 for detailed results of this analysis). As such, hypothesis 3a will be tested in this study, and hypothesis 3b will not be tested. Hypothesis 3a was tested by determining if the model that included average implicit ToM and average explicit ToM performance was a significantly better fit of the social functioning performance data than the model that included explicit ToM performance alone and whether implicit ToM performance was found to be a significant predictor of social functioning performance.

Hypothesis 3a

In hypothesis 3a, ToM-SF model 0 tested the intercept of social functioning performance across all participants, treatment group status, and study visits. ToM-SF model 1 tested the main effects of study visit and average explicit ToM performance. ToM-SF model 2 tested the predictors from ToM-SF model 1, as well as average implicit ToM performance. ToM-SF model 3 included the terms from ToM-Social Functioning model 2 and the covariates of full-scale IQ from the WTAR and positive and negative symptom severity scores from the PANSS, in order to determine if the inclusion of these covariates affected the statistical relationship between variables in the previous model. ToM-SF model 1 did not explain significantly more variance than ToM-SF model 0, $\chi^2(2) = 3.54$, $p = .17$. ToM-SF model 2 explained significantly more variance than ToM-SF model 0, $\chi^2(3) = 12.49$, $p = .006$. ToM-SF model 3 did not explain significantly more variance than ToM-SF model 1, $\chi^2(3) = 2.73$, $p = .43$. These results indicate that model 2 is the best fit of the data and will be explained below.

As seen in ToM-SF model 2 in Table 7, average implicit ToM performance was a significant positive predictor of social functioning, such that higher average implicit ToM scores predicted higher social functioning scores. This relationship between average implicit ToM scores and higher social functioning scores remained significant even when accounting for covariates in subsequent analyses. This analysis revealed that average performance on the measure of implicit ToM was a better predictor of social functioning as measured by the SFS than average performance on the measure of explicit ToM.

Table 7
Results of Hypothesis 3a

Fixed Effects	ToM-SF Model 1	ToM-SF Model 2	ToM-SF Model 3
(Intercept)	105.318***	101.668***	105.230***
	(5.388)	(5.007)	(5.535)
Visit	0.797	0.810·	0.874·
	(0.488)	(0.488)	(0.507)
Average TASIT Total Score	0.116	0.084	0.005
	(0.120)	(0.109)	(0.122)
Average STOMP Index Score		23.920**	23.317**
		(7.598)	(7.516)
Full-scale IQ Estimate of WTAR			0.584
			(0.794)
Positive Symptom Severity (PANSS)			0.775
			(0.585)
Negative Symptom Severity (PANSS)			-0.888
			(0.654)
Random Effects (Variance)			
Intercept | Subject	23.666	18.230	16.558
Visit | Subject	4.829	4.805	4.337
Residual	10.007	10.040	10.420
Model Fit			
AIC	786.794	779.849	783.115
BIC	803.859	799.758	811.557
Log Likelihood	-387.397	-382.925	-381.558

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, ·$p < 0.1$

Note. Mixed-effects models assessing the effects of average performance on the explicit (TASIT) and implicit (STOMP) ToM measures on change in social functioning (average SFS domain scaled scores) with slope (standard error) estimates reported.

Hypothesis 4 Overview

Hypothesis 4 predicted that the number of ToM training exercises would be a significant, positive predictor of performance on both implicit and explicit ToM measures (see tables 8 and 9, respectively, for detailed results of these analyses), such that more ToM training exercises completed would be associated with higher scores on both the implicit and explicit ToM measures. This hypothesis was tested by determining whether the number of ToM training exercises completed by a participant at the time of each task administration impacted performance on the implicit ToM measure or explicit ToM measure in separate hierarchical analyses following a 4-step forward fitted modelling approach. As only individuals in the experimental treatment group took part in ToM training exercises, only the performance of individuals in the experimental treatment group were analyzed in these analyses.

Hypothesis 4a

In hypothesis 4a, Tx-Implicit model 0 tested the intercept of implicit ToM performance across all participants, treatment group status, and study visits. Tx-Implicit model 1 tested the main effects of study visit and the number of ToM training exercises completed by a participant. Tx-Implicit model 2 tested the predictors from Tx-Implicit model 1, as well as the interaction of study visit and the number of ToM training exercises. Tx-Implicit model 3 included the terms from model 2 and the covariates of full-scale IQ from the WTAR and positive and negative symptom severity scores from the PANSS, in order to determine if the inclusion of these covariates affected the statistical relationship between variables in previous models. Tx-Implicit model 1 explained significantly more variance than Tx-Implicit model 0, $\chi^2(2) = 6.99$, $p = .03$. Tx-Implicit model 2 did not explain significantly more variance than Tx-Implicit model 1, $\chi^2(1) = 0.04$, $p = .85$. Tx-Implicit model 3 did not explain significantly more variance than Tx-Implicit model 1, $\chi^2(4) = 2.95$, $p = .57$. As Tx-Implicit model 1 appeared to be the best fit of the data, this model will be described below.

As seen in Table 8, the results of Tx-Implicit model 1 indicated that the number of ToM training exercises completed by a participant was a significant, positive predictor of implicit

ToM performance, such that greater number of ToM training exercises completed by a subject was predictive of higher scores on the measure of implicit ToM. However, when additional variables, including the interaction of visit and the number of ToM training exercises and covariates accounting for IQ scores and positive and negative symptom severity were included in subsequent models, this relationship between ToM training and implicit ToM performance disappeared. As such, the relationship between ToM training and implicit ToM performance should be interpreted with caution and will be discussed in detail in the discussion section.

Table 8

Results of Hypothesis 4a

Fixed Effects	**Tx-Implicit Model 1**	**Tx-Implicit Model 2**	**Tx-Implicit Model 3**
(Intercept)	0.203^{***}	0.202^{***}	0.206^{***}
	(0.017)	(0.017)	(0.017)
Visit	-0.009	-0.009	-0.013
	(0.011)	(0.011)	(0.012)
ToM Training Sessions	0.001^{**}	0.001	0.002
	(0.000)	(0.002)	(0.002)
Visit * ToM Training Sessions		-0.000	-0.000
		(0.001)	(0.001)
Full-scale IQ Estimate of WTAR			-0.012
			(0.014)
Positive Symptom Severity (PANSS)			-0.007
			(0.012)
Negative Symptom Severity (PANSS)			-0.015
			(0.013)
Random Effects (Variance)			
Intercept | Subject	0.007	0.007	0.007
Visit | Subject	0.0002	0.0003	0.0002
Residual	0.006	0.006	0.006
Model Fit			
AIC	-182.844	-180.880	-177.793
BIC	-166.427	-161.726	-150.431
Log Likelihood	97.422	97.440	98.896

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$

Note. Mixed-effects models assessing the effects of the number of ToM training sessions completed by a participant on implicit ToM performance (i.e. STOMP Index) with slope (standard error) estimates reported.

Hypothesis 4b

Tx-Explicit model 0 for hypothesis 4b tested the intercept of explicit ToM performance across all participants, treatment group status, and study visits. Tx-Explicit model 1 tested the main effects of study visit and the number of ToM training exercises completed by a participant.

Tx-Explicit model 2 tested the predictors from Tx-Explicit model 1, as well as the interaction of study visit and the number of ToM training exercises. Tx-Explicit model 3 included the terms from model 2 and the covariates of full-scale IQ from the WTAR and positive and negative symptom severity scores from the PANSS, in order to determine if the inclusion of these covariates affected the statistical relationship between variables in previous models. Tx-Explicit model 1 did not explain significantly more variance than Tx-Explicit model 0, $\chi^2(2) = 0.63$, $p = .73$. Tx-Explicit model 2 did not explain significantly more variance than Tx-Explicit model 0, $\chi^2(3) = 0.63$, $p = .89$. Tx-Explicit model 3 explained significantly more variance than Tx-Explicit model 0, $\chi^2(6) = 15.83$, $p = .01$. As Tx-Explicit model 3 appeared to be the best fit of the data, this model will be described below.

As seen in Tx-Explicit model 3 from Table 9, there were no significant relationships found between the proposed variables of interest of visit, the number of ToM training sessions completed, or the interaction of visit and ToM training sessions. There was, however, a significant relationship between explicit ToM performance and negative symptom severity and IQ score, such that greater IQ scores and lesser severity of negative symptoms predicted improved explicit ToM performance.

Table 9

Results of Hypothesis 4b

Fixed Effects	**Tx-Explicit Model 1**	**Tx-Explicit Model 2**	**Tx-Explicit Model 3**
(Intercept)	44.648***	44.641***	44.657***
	(1.096)	(1.106)	(0.967)
Visit	-0.406	-0.408	-0.433
	(0.535)	(0.537)	(0.573)
ToM Training Sessions	0.011	0.015	0.034
	(0.018)	(0.077)	(0.077)
Visit * ToM Training Sessions		-0.002	-0.014
		(0.036)	(0.037)
Full-scale IQ Estimate of WTAR			2.592**
			(0.853)
Positive Symptom Severity (PANSS)			0.919
			(0.655)
Negative Symptom Severity (PANSS)			-2.165**
			(0.703)
Random Effects (Variance)			
Intercept | Subject	40.746	40.767	26.677
Visit | Subject	0.000	0.000	0.099
Residual	15.721	15.717	15.771
Model Fit			
AIC	816.461	818.458	809.263
BIC	833.526	838.368	837.705
Log Likelihood	-402.230	-402.229	-394.632

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$

Note. Mixed-effects models assessing the effects of the number of ToM training sessions completed by a participant on explicit ToM performance (TASIT) with slope (standard error) estimates reported.

Discussion

Summary of Findings

This study found that individuals in the computerized social cognitive intervention group known as SocialVille showed a greater rate of positive change on their STOMP index scores, a measure of implicit ToM, than individuals in the control group across study visits. When measuring the direct impact of the amount of ToM training received by each participant, there was a significant, positive relationship between ToM training and implicit ToM performance, such that more training led to a steeper slope of positive change on implicit ToM performance, but when the predictors of the interaction of visit and ToM training and the covariates of IQ estimate and symptom severity were added to the analysis, the relationship between ToM training and implicit ToM performance became non-significant. Taken together, the results of these analyses indicated that individuals in the experimental treatment group improved significantly more on the implicit ToM measure compared to the individuals in the control group, and that the ToM training received as a part of the social cognitive intervention did not fully account for the changes in implicit ToM performance.

Furthermore, average implicit ToM performance was found to be a significantly better predictor of social functioning performance than average TASIT performance (a measure of explicit ToM), such that higher scores on the measure of implicit ToM predicted greater social functioning performance above and beyond average explicit ToM performance. This suggests that implicit ToM performance may be useful as a predictor of social functioning, even when compared to performance on explicit ToM measures. Detailed results of the study, limitations, and future directions are discussed below.

Research Hypotheses

For hypothesis 1, I predicted that individuals in the experimental treatment group known as SocialVille would exhibit an increased rate of change on performance of implicit ToM (hypothesis 1a), explicit ToM (hypothesis 1b), and social functioning (hypothesis 1c) across the study visits when compared to individuals in the control group. The results of the analyses testing this hypothesis found support for hypothesis 1a but not for hypothesis 1b or 1c. Specifically, the results revealed that individuals in the experimental treatment group exhibited an increased rate of change on the measure of implicit ToM when compared to individuals in the control group, providing support for hypothesis 1a. Furthermore, the experimental group was found to have a lower implicit ToM score than the control group at baseline, and both treatment groups exhibited simple effects of study visit on performance of the implicit ToM measure when covariates and interaction terms were included in the analyses, such that average implicit ToM scores decreased over time for individuals in the control group and increased for individuals in the experimental treatment group. The groups did not exhibit any significant performance differences on explicit ToM or social functioning, which do not support the predictions made in hypothesis 1b and hypothesis 1c, respectively.

Several possibilities exist for these findings. This is the first study of a computerized intervention that assessed change in implicit ToM, and the changes found in implicit ToM in individuals in the experimental group suggest that SocialVille could be a helpful tool for improving implicit ToM. SocialVille utilizes a drill and practice approach to training that involves individuals learning skills implicitly through the repetition of social cognitive stimuli that increase with difficulty over time. This type of computerized approach has been found to be an effective strategy for individuals with schizophrenia (Prikken et al., 2019). While determining the exact mechanism of change for SocialVille's impact on implicit ToM will require further testing, it is possible that repeated training in attempting to understand the mental states of others led individuals to be more likely to think about and discuss these mental states without being prompted to do so. This is similar to how attention shaping interventions have improved emotion perception in individuals with schizophrenia by drawing attention to faces as a means of determining the mental states of others (Combs et al., 2011).

While I hypothesized changes in both social functioning and explicit ToM based on past studies of social cognitive interventions that found improvements in social functioning (Kurtz & Richardson, 2012) and explicit ToM (Vass et al., 2018), the studies cited in this paper in support of this hypothesis did not utilize a computerized treatment paradigm. While there are several studies showing that social cognitive computerized interventions can improve some aspects of social cognition (Byrne et al., 2015; Kurtz et al., 2015; Roberts et al., 2015), this is one of the first studies to examine the effects of social cognitive computerized interventions on ToM and social functioning. It is possible that computerized interventions, or this drill and practice intervention in particular, may not be an ideal training medium for improving explicit ToM, and potential limitations of the treatment that could have impacted its ability to improve functioning and explicit ToM are detailed later in the discussion. Explicit ToM may be better improved by strategic training, which involves the explicit learning and application of techniques and strategies to improve performance (Wykes et al., 2011).

The lack of improvement in explicit ToM and social functioning despite changes in implicit ToM is also supported by past research. Langdon et al. (2017) measured both implicit and explicit ToM in individuals with schizophrenia spectrum disorders and concluded that implicit and explicit ToM were distinct constructs and not related to single underlying ability.

As such, it is possible that a change in one of these constructs would not necessarily lead to a change in the other, as seen in this study.

Sacks et al. (2013) found that a computerized social cognitive intervention that led to the improvement of emotional intelligence in individuals with schizophrenia did not improve the social functioning of this group. This study concluded that while improving social cognition may enhance an individual's skills necessary to navigate a social situation, it may not immediately lead to changes in real-world functioning. This discrepancy can further be explained as the difference between what an individual is capable of doing given an increased social cognitive capacity versus what an individual actually does in a social situation. Additionally, that same study further suggested that longer term follow up may be needed to more accurately understand the impact that social cognitive interventions have on social functioning (Sacks et al., 2013).

In hypothesis 2, I predicted that average implicit and explicit ToM performance and change in implicit and explicit ToM would be significant predictors of social functioning. The results of this analysis partially supported hypothesis 2a, which examined the impact of implicit ToM performance on social functioning performance. The analyses designed to test hypothesis 2a revealed that an individual's implicit ToM score averaged across visits was a significant, positive predictor of social functioning performance, such that higher averaged implicit ToM scores were associated with greater social functioning. This result remained significant even when accounting for change in performance on the measure of implicit ToM and covariates of positive and negative symptom severity and IQ scores. However, change in performance on the measure of implicit ToM across study visits did not predict social functioning performance and no relationship between average explicit ToM performance or change in explicit ToM performance and social functioning performance was found. As such, hypothesis 2b, was not supported by the results of this study.

Finding that implicit ToM and social functioning were related in this study was corroborated by past studies finding that implicit ToM performance is associated with social functioning for individuals with schizophrenia (Stewart et al., 2009; Ventura et al., 2015). Implicit ToM is critical for functioning in social settings. If one does not think to consider the mental states of others in social situations, being able to accurately identify the mental states of others serves very little benefit. For example, one can be taught to accurately recognize how to identify the mental states of others when cued to do so (explicit ToM), but this knowledge is of little use if one does not spontaneously use this information to navigate social situations. The lack of a significant relationship between performance on explicit ToM and social functioning contributes to the mixed literature regarding these constructs. Some studies have found evidence that explicit ToM is associated with social functioning for individuals with schizophrenia (Brune et al., 2005; Bora et al., 2006; Pijnenborg et al., 2009; Piovan et al., 2016), while others have found that explicit ToM is not a significant predictor of functioning after controlling for neurocognition (Cook et al., 2013).

For hypothesis 3, I hypothesized that one's unprompted description of the mental states of others (implicit ToM) would be more closely associated with functioning in the real world than one's capacity to understand the mental states of others when prompted to do so. Consistent with this hypothesis, analyses indicated that average implicit ToM performance was a better predictor of social functioning than average performance on the measure of explicit ToM. As no published studies have examined the relationship between both implicit and explicit ToM and social functioning in the same study, this hypothesis was based on the idea that the unprompted use of mentalizing would more closely resemble real life social situations when compared to the cued use of ToM and would therefore more likely impact social functioning. The results of hypothesis 3a suggest that implicit ToM may be an important factor involved in the social functioning of individuals with schizophrenia. Future interventions interested in improving the social functioning of individuals with schizophrenia should consider finding ways to further increase an individual's attendance to the mental states of others, especially as this may be a better predictor of social functioning than explicit ToM.

I predicted that the amount of ToM training that a participant received would be a significant positive predictor of implicit ToM performance (hypothesis 4a) and explicit ToM performance (hypothesis 4b). However, despite the number of ToM training sessions completed by a participant at each time point being a significant predictor of implicit ToM performance when included as the only predictor variable, the relationship between ToM training sessions and implicit ToM performance was no longer significant, when accounting for visit, the interaction of visit and the number of ToM training sessions, IQ, positive symptom severity, and negative symptom severity. While none of these additional factors reached the level of statistical significance, the addition of these factors increased the standard error associated with the effect of the number of ToM training sessions. There was no significant relationship between the number of ToM training sessions and explicit ToM performance.

While I predicted that the ToM training specifically would be a positive predictor of change in ToM, there are several ways to explain this finding. First, the metric utilized by this study to measure ToM training was the number of ToM training modules that a participant had participated in prior to the specific study visit. This is not an ideal metric, as it suggests that participants improved in equal amounts from each training and that each training provides equal benefit to the participant. Unfortunately, due to the way that the training data was coded and how training was structured to change over time to adapt to the participant's performance, I was unable to find a better way to utilize the training data as a predictor of change in outcome variables.

Furthermore, while I predicted that ToM training would be the best predictor of change in ToM, this treatment paradigm provided training on a number of different social cognitive domains, many of which are likely to be related to improvement in ToM, such as the ability to identify an emotion from a face or from one's tone of voice. The results of this hypothesis suggest that the ToM training alone was not a significant predictor of change in ToM and not that the training was ineffective. It is possible that the SocialVille training modules designed to improve other social cognitive domains, such as affect recognition, may have led to changes in implicit ToM. In fact, past social cognitive interventions that targeted affect recognition led to improvements in ToM without directly targeting ToM (Wölwer and Frommann, 2011; Gaudelus et al., 2016). The results of this study that suggest ToM training alone did not account for all changes in implicit ToM are in line with the intention of the creators of SocialVille of first improving lower level social cognitive processes, such as emotion perception, prior to targeting higher level social cognitive domains, such as ToM (Rose et al., 2015).

Limitations

While this study's design included a number of advantages over past studies of social cognitive interventions, including utilizing blinded raters of assessment measures, a treatment paradigm that does not explicitly rely on skills of which individuals with schizophrenia exhibit large deficits, a large set of stimuli and scenarios to increase the generalizability of training effects, and a training format that allows for adjustment to the needs and deficits of an individual participant, this study featured a number of methodological issues and limitations that could, in part, explain the limited changes in explicit ToM and social functioning seen in this study.

First, the small sample size used in this project limited the power of the statistical analyses involved with the study. Furthermore, the experimental treatment known as SocialVille is a novel treatment paradigm and its effects on advanced social cognitive abilities, like ToM, and social functioning are unknown. While other computerized approaches have been found to improve aspects of social cognition, such as emotion perception (Byrne et al., 2015; Kurtz et al., 2015; Roberts et al., 2015), as of the writing of this manuscript, no computerized approaches have been shown to improve ToM performance and most have either not assessed or not reported on this specific domain of social cognition. This is the first published study to find that a computerized treatment can lead to changes in any aspect of ToM. However, it is possible that more targeted treatment and instruction are required for the improvement of explicit ToM.

Treatment interventions that have attempted to directly improve explicit ToM and led to improvements in this domain appear to differ from the SocialVille treatment in one to two meaningful ways. The SocialVille treatment paradigm is similar to the targeted ToM interventions described by Vass et al. (2018), in that they utilize vignettes and other stimuli as training tools to directly effect change in ToM. However, while these targeted ToM interventions attempted to improve ToM directly, similar to SocialVille, they did not attempt to target and improve other social cognitive domains. It is possible that by attempting to improve all domains of social cognition that the effects of SocialVille were spread thin across multiple domains and limited the effect on explicit ToM. For example, it is possible that individuals with schizophrenia tested in this study could have had a hard time shifting between training in different social cognitive domains and that perhaps there could be a greater impact of training if training focused on a single social cognitive skill during each training session. A recent meta-analysis concluded that individuals with schizophrenia have difficulties compared to healthy controls with tasks that require cognitive flexibility, a skill associated with the ability to shift rules and one that may be helpful for the SocialVille training that utilizes different games in the same training day with different sets of rules (Thai et al., 2019). Additionally, treatment may not have lasted long enough to effect significant, meaningful change in explicit ToM. The meta-analysis conducted by Kurtz et al. (2016), found that the most common duration of social cognitive training was 6 months, while SocialVille is designed to take approximately 8 weeks from baseline to posttest.

In addition to the limitations of the treatment, there may be problems with the study measures utilized in this manuscript. Few studies have utilized the STOMP as a measure of implicit ToM and no studies have fully examined its psychometric properties (Rice & Redcay, 2015). Future studies of implicit ToM should consider alternative measures of implicit ToM, such as the Silent Animations Task (Castelli et al., 2000), in addition to or instead of the STOMP, in order to ensure an accurate and reliable metric of implicit ToM and to replicate the findings of this study.

One possible explanation for finding changes in implicit ToM performance without change in explicit ToM performance involves the differences in the tasks themselves. The STOMP (implicit ToM) does not assess for accuracy of ToM, while TASIT (explicit ToM) is scored for accuracy only. The change in implicit ToM performance seen in the experimental group does not necessarily suggest that individuals in this group became better at identifying the mental states of others, only that they spontaneously described the mental states of others at an increased rate compared to individuals in the control group. As recognizing that others have internal, mental states appears to be a prerequisite to accurately identifying the mental states of others, it is possible that a change in implicit ToM could be a precursor to change in explicit ToM. Further work is needed to establish the relationship between implicit and explicit ToM and identify the best measures to assess this relationship.

Future Directions and Conclusion

Despite the limitations discussed above, this research contributes to the study of computerized social cognitive interventions, with both their possible limitations and future directions. This is the first study to assess the effects of a computerized social cognitive intervention on explicit or implicit ToM within a schizophrenia population and one of the first to examine the treatment protocol set forth by Rose et al. (2015), which is currently being examined by the FDA for widespread use with individuals with schizophrenia. The findings of this study suggest that a drill and practice type intervention (like SocialVille) may lead to changes in implicit ToM performance, while its effect on explicit ToM and social functioning appear limited given the timeframe of the study. The results of this study indicate an increased need for longer term follow-up and possibly an increased length of treatment, especially as it relates to assessing change in social functioning. Additionally, implicit ToM performance was found to be a better predictor of social functioning than explicit ToM performance. This suggests that further research of implicit ToM and ways to measure implicit ToM are warranted.

This study also supports the rationale behind the bottom-up approach to improvement of ToM. The combined results that individuals in the experimental group exhibited increased implicit ToM performance compared to the control treatment group and finding that the ToM training did not specifically predict performance on this measure suggests that other factors of the training paradigm may be leading to the change in implicit ToM performance. SocialVille's theoretical foundation included the need to first train lower order social cognitive domains (e.g.

emotion perception) prior to more advanced domains (e.g. ToM), which could be a possible explanation of these findings (Rose et al., 2015). Studies designed to examine changes in emotion perception and other social cognitive domains across study visits could give us a better understanding of this treatment approach.

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VITA

EDUCATION AND TRAINING

University of Illinois at Chicago (UIC) 2015-Current
Ph.D. Candidate in Clinical Psychology
Dissertation defended November 2020
Title, "Does a computerized social cognitive intervention improve implicit or explicit theory of mind?"

Preliminary Exam completed February 2019
Title, "Theory of mind across the schizophrenia spectrum"

Master of Arts completed April 2017
Thesis Title, "Social judgments based on a series of encounters in healthy and schizophrenia participants"

University of North Carolina at Chapel Hill (UNC) 2007-2011
Bachelor of Arts, Psychology, Minor in Cognitive Science
Graduated with Highest Distinction

CLINICAL EXPERIENCE

PSYCHOTHERAPY EXPERIENCE

Student Counseling Services, Mississippi State University 2020-Current
Clinical Psychology Intern with Major Rotation in Athletics
Supervisor: Ty Stafford, Ph.D., Angel Brutus, Psy.D.

- Conduct short-term evidence-based psychotherapy with undergraduate students with a spectrum of difficulties (mood and anxiety disorders, chronic pain, post-traumatic stress disorder, difficulties with adjustment to illness, compliance issues, sleep disturbances, risk of self- or other- directed violence, substance use/abuse, and other subclinical symptoms) in a college counseling center setting.
- Co-facilitate group therapy sessions for individuals in the LGBTQ+ community.
- Lead workshops for college students and student athletes on sleep hygiene and sleep disturbances.
- Provide individual performance enhancement and evidence-based psychotherapy, as well as outreach services, for college athletes and athletic staff.

Edward Hines Jr. Veterans Administration Hospital 2019-2020
Primary Care Behavioral Health Psychology Extern
Supervisor: Daniel Goldstein, Ph.D.

- Conducted short-term evidence-based psychotherapy and functional assessments with Veterans with a spectrum of difficulties (mood and anxiety disorders, chronic pain, post-traumatic stress disorder, difficulties with adjustment to illness, compliance issues, sleep disturbances, risk of self- or other-directed violence, substance use/abuse, and other subclinical symptoms) in a hospital setting.
- Led Cognitive-Behavioral Therapy (CBT) and Acceptance and Commitment Therapy (ACT) for Pain treatment groups and provide individual psychotherapy for Veterans with chronic pain.
- Engaged Veterans in biofeedback training.
- Provided consultation to interdisciplinary medical treatment teams.

- Conducted manualized prolonged exposure for Veterans who have experienced trauma.
- Administered the Unified Protocol for Transdiagnostic Treatment of Emotional Disorders (UP) to Veterans diagnosed with a mood disorder.
- Provided co-located, integrated care services in primary care.
- Conducted hospital-wide behavioral medicine services (e.g. pain and sleep classes and groups).
- Engaged in weekly individual and group supervision and regularly scheduled didactic trainings.

Office of Applied Psychological Services, UIC 2015-2020
Clinical Practicum Student
Supervisors: Jenna Rowen, Ph.D., Ellen Herbener, Ph.D., Bibiana Adames, Ph.D., Jon Kassel, Ph.D.

- Provided outpatient, evidence-based individual and couples psychotherapy to up to 4 weekly clients from diverse backgrounds across race, ethnicity, culture, sexual orientation, socioeconomic status, religion, spirituality, and physical and mental ability in a school-based mental health clinic at UIC.
- Conducted individual psychotherapy sessions with Division I varsity athletes and Olympic level coaches.
- Provided feedback to and serve as clinical leader for clinical psychology graduate students conducting psychological intake interviews.
- Trained in provision of CBT, the UP, Motivational Interviewing (MI), and mindfulness-based therapies for presenting concerns, including but not limited to generalized anxiety, major depressive, eating, social anxiety, post-traumatic stress, insomnia, and alcohol misuse.
- Engaged in weekly individual supervision involving reviewing video recordings, discussing case conceptualization, and reviewing relevant literature to inform treatment.

PERFORMANCE ENHANCEMENT EXPERIENCE

USA Weightlifting 2018-Current
Performance Psychology Consultant
Supervisor: Gloria Balague, Ph.D.

- Conduct individual performance enhancement sessions with athletes and coaches with diverse racial, ethnic, socioeconomic, and religious backgrounds from across the country.
- Work with coaches and staff to develop and implement a plan (including bimonthly webinars on sport and performance psychology principles, evaluating mental performance progress of athletes, and attending international competitions and training camps) to enhance the performance and quality of life of Team USA Weightlifters.
- Attend International Weightlifting Federation (IWF) competitions and training camps, including the 2018 and 2019 IWF Senior World Championships in Ashgabat, Turkmenistan and Pattaya, Thailand, as well as the 2019 IWF Youth World Championships in Las Vegas, Nevada.

Chicago Bulls and Windy City Bulls 2019-2020
Performance Psychology Practicum Extern
Supervisor: Wendy Borlabi, Psy.D.

- Assisted in providing performance enhancement services with professional athletes.
- Provided consultation for coaches and staff regarding psychological principles of performance and assessment performance of athletes.
- Collaboratively developed presentations for use with professional athletes and coaches.

- Engaged in individual supervision with the Sport Psychologist of the Chicago Bulls.

UIC Women's Basketball and UIC Men's Baseball 2019-2020
Performance Psychology Practicum Extern
Supervisors: Wendy Borlabi, Psy.D., Gloria Balague, Ph.D.

- Conducted individual and group performance enhancement services with Division I college athletes with diverse backgrounds from across the country.
- Attended weekly team meetings with players, coaches, and staff.
- Provided consultation regarding psychological principles of performance to coaches and staff.

Chicago Bears 2017-2019
Clinical Sports Psychology Practicum Extern
Supervisor: Gloria Balague, Ph.D.

- Developed a working rapport with professional athletes with diverse racial, ethnic, socioeconomic, and religious backgrounds from across the country.
- Collaboratively designed an injury intervention protocol utilizing performance psychology, MI, and CBT techniques and modalities.
- Provided biofeedback and relaxation training to elite athletes.
- Administered, scored, and interpreted communication and attention assessments, and provided feedback to athletes.
- Assisted in the development of talks and presentations on sports psychology principles to be presented to athletes to enhance psychological correlates of athletic performance.
- Involved in consultation and supervision with the Sport Psychologist of the Chicago Bears.

ASSESSMENT EXPERIENCE

Social Neuroscience and Psychopathology Lab, Rush University 2016-2020
Graduate Research Assistant
Supervisors: Christine Hooker, Ph.D., Kristen Haut, Ph.D.

- Conducted psychodiagnostic and cognitive testing for individuals with schizophrenia spectrum disorders and those at risk of developing a psychotic syndrome.
- Trained in provision and interpretation of measures of psychopathology, neurocognition, social cognition, and social functioning.

Herbener Lab, UIC 2015-2020
Graduate Research Assistant
Supervisor: Ellen Herbener, Ph.D.

- Administered social cognitive and psychodiagnostic assessment battery to individuals across the schizotypy spectrum.
- Trained in provision and interpretation of measures of social cognition, social functioning, and physical synchrony.

Office of Applied Psychological Services, UIC 2015-2018
Assessment Practicum Student
Supervisors: Ellen Herbener, Ph.D., Amanda Lorenz, Ph.D.

- Administered comprehensive psychodiagnostic evaluations with child, adolescent, and adult patients.

- Administered diagnostic intake interviews and psychodiagnostic measures to potential psychotherapy clients to screen for psychopathology and appropriateness for services at the clinic.
- Completed 6 integrated reports (4 adults, 2 children/adolescents).
- Trained in provision and interpretation of measures of clinical psychopathology, intellectual ability and functioning, and tests of achievement.

Penn Lab, UNC 2012-2014
Study Coordinator
Supervisor: David Penn, Ph.D.

- Conducted psychodiagnostic and neuropsychological testing for participants with schizophrenia and healthy controls.
- Trained in provision and interpretation of measures of social cognition, symptom evaluation, social functioning, and neurocognition.

PUBLICATIONS

1. Buck, B., **Iwanski, C**., Healey, K. M., Green, M. F., Horan, W. P., Kern, R. S., . . . Penn, D. L. (2017). Improving measurement of attributional style in schizophrenia; A psychometric evaluation of the Ambiguous Intentions Hostility Questionnaire (AIHQ). *Journal of Psychiatric Research*, *89*, 48-54.

2. Meyer, P., Johnson, D., Parks, A., **Iwanski, C.**, & Penn, D. (2012). Positive living: A pilot study of group positive psychotherapy for people with schizophrenia. *The Journal of Positive Psychology*, *7*(3), 239-248.

MANUSCRIPTS UNDER REVIEW AND IN PREPARATION

1. **Iwanski, C**., Lokey, S. B., Demos, A. P., & Herbener, E. S. (2019). *Social judgments based on a series of encounters in healthy and schizophrenia patients*. Manuscript in preparation.

2. **Iwanski, C.** & Herbener, E. S. (2019). *Theory of mind across the schizophrenia spectrum*. Manuscript in preparation.

3. Keutmann, M., **Iwanski, C.,** & Herbener, E. S. (2019). *Time period effects on recall and prediction of affective experience*. Manuscript in preparation.

4. Lokey, S. B., Huddleston, A., Reina, W., Harnisch, N., Gandhi, K., **Iwanksi, C**., Rameshkumar, S., Lynch, J., & Herbener, E.S. (2019). *Emotion processing and social cognition in schizotypy.* Manuscript in preparation.

RESEARCH EXPERIENCE

Social Neuroscience and Psychopathology Lab, Rush University 2016-2020
Graduate Research Assistant
Supervisors: Christine Hooker, Ph.D., Kristen Haut, Ph.D.

- Conducted study protocols assessing the efficacy of a computerized social cognitive intervention for individuals at high risk of developing a psychotic syndrome and individuals with a schizophrenia spectrum disorder.
- Assisted with development and improvement of measures of social cognition, including a measure of implicit theory of mind.
- Coached individuals with severe-mental illness and those at risk of developing a severe mental illness through a computerized cognitive intervention protocol aimed to improve domains of social cognition.

Herbener Lab, UIC 2015-2020

Graduate Research Assistant

Supervisor: Ellen Herbener, Ph.D.

- Designed and conduct study protocols examining relationship between schizotypy personality trait, social behavior, and sense of self.
- Created Institutional Review Board (IRB) protocols and manage subsequent correspondence.
- Trained, supervised, and mentored undergraduate research assistants, tested research participants, analyzed data, and conducted independent research studies.
- Oversaw data management, data analysis, and dissemination of findings from the lab via peer-reviewed manuscripts and professional presentations.

Lineberger Comprehensive Cancer Center, UNC 2014-2015

Assistant Study Coordinator

Supervisor: Leslie Schreiner, B.S.

- Served as assistant study coordinator for multiple studies testing the efficacy and effectiveness of experimental cancer medications.
- Oversaw scheduling and screening of participants, database management, and study analysis.

Penn Lab, UNC 2012-2014

Study Coordinator

Supervisor: David Penn, Ph.D.

- Served as study coordinator for an NIH funded study examining the impact of social cognition on social functioning for individuals with schizophrenia.
- Oversaw administrative needs of study, including maintaining compliance with the IRB of UNC, database management, and data analysis.

TEACHING EXPERIENCE

Clinical Program Teaching Assistant, UIC 2017-2019

- Selected as Clinical Program Teaching Assistant by Clinical Program faculty at UIC.
- Assisted in making changes to Clinical Program curriculum and administrative procedures, organized faculty hiring process and applicant interview day, and implemented student oversight of changes to Office of Applied Psychological Services student-staffed clinic.
- Attended weekly faculty meetings as student-faculty liaison.

Psychology of Interviewing Teaching Assistant, UIC 2017-2019

- Provided supervision to undergraduate students regarding their abilities to conduct an interview in the Psychology of Interviewing course.
- Engaged in supervision of supervision with the Director of the Office of Applied Psychological Services.

Abnormal Psychology Teaching Assistant, UIC 2016-2019

- Developed and presented a lecture on suicide awareness.
- Graded essays related to student research on clinical psychopathology.

Lab in Clinical Psychology Teaching Assistant, UIC 2016-2017

- Assisted in the creation of an independent research project, involving manipulation development, data analysis, and write-up.
- Provided ongoing and actionable feedback of student research projects.

Introduction to Research in Psychology Teaching Assistant, UIC 2017

- Led weekly discussion sections to teach new course material and review course material taught in lecture.
- Graded weekly assignments and mid-terms.

Psychological Interventions Teaching Assistant, UIC 2016

- Developed and presented a lecture on CBT for schizophrenia spectrum disorders.
- Collaborated with students in developing a "self-intervention," which intended to have students utilize intervention methods to produce behavior change.
- Graded and provided feedback on student exams.

Introduction to Psychology Teaching Assistant, UIC 2015-2016

- Led weekly discussion sections to review material taught during lecture.
- Assisted in the development of course material, including the development of a lesson plan to improve knowledge of the brain and its functions.
- Graded assignments and essays related to course material.

WORKSHOPS AND TRAININGS

Motivational Interviewing Workshop, Edward Hines VA Medical Center 2019

- Attended half-day MI training, including lectures, demonstrations and roleplays of clinical skills and applications.

Mindfulness Based Stress Reduction Workshop, UIC 2016

- Attended four-hour Mindfulness Based Stress Reduction (MBSR) workshop which covered the history and research of MBSR and a review of the clinical skills and applications. The workshop included lectures, demonstrations, and role-playing.

Clinical Skills with Racially Diverse Patients, UIC 2015

- Attended three-hour training which covered a discussion of the necessity and rationale for providing culturally sensitive clinical care to racially diverse patients. Training included lectures and demonstrations.

AWARDS/HONORS

Psychology Department Student Travel Award (Total Award $1,200)	2016-2017
Phillips Travel Fellowship (Total Award $9,000)	2011
Phi Beta Kappa Honors Fraternity	2011
Tar Heel Voices A Cappella Group, President, Business Manager	2008-2011
Dean's List, University of North Carolina	2007-2010

INVOLVEMENT WITH PROFESSIONAL ASSOCIATIONS

American Psychological Association's Division 47: Exercise and Sport Psychology Member	2019-Current
Association for Applied Sport Psychology (AASP) Member	2019-Current
Ad Hoc Student Reviewer for Clinical Psychological Science	2017-2019

ACADEMIC PRESENTATIONS AND PERFORMANCE WEBINARS

1. **Iwanski, C**. (2019, October). Suicide Awareness and Prevention. *Lecture for Abnormal Psychology Course at the University of Illinois at Chicago*. Chicago, IL.

2. **Iwanski, C.** (2019, July). Imagery and Visualization. *Webinar delivered to United States Weightlifting Team and Coaches*. Chicago, IL.

3. **Iwanski, C**. (2019, June). Performance Enhancement as a Means to Improve Athletic Performance. *Presentation at Olympic Athlete Summit*. Colorado Springs, CO.

4. **Iwanski, C.** (2019, March). Sport and Performance Psychology. *Presentation for OAPS Weekly Meeting*. Chicago, IL.

5. **Iwanski, C**. (2019, February). Strategies for Managing Competition Anxiety. *Webinar delivered to United States Weightlifting Team and Coaches*. Chicago, IL.

6. **Iwanski, C**. (2018, December). Confidence and Effective Self Talk. *Presentation at the American Open Finals for Olympic Weightlifting*. Milwaukee, WI.

7. **Iwanski, C**. (2018, November). Mental Toughness. *Webinar delivered to United States Weightlifting Team and Coaches*. Chicago, IL.

8. **Iwanski, C**. (2018, August). Sports Psychology and Mental Tools. *Presentation at Training Camp for Elite Junior Athletes*. Columbus, OH.

9. **Iwanski, C**. (2018, June). Suicide Awareness and Prevention. *Lecture for Abnormal Psychology Course at the University of Illinois at Chicago*. Chicago, IL.

10. **Iwanski, C**. (2018, March). CBT for Psychosis. *Lecture for Clinical Interventions Course at the University of Illinois at Chicago*. Chicago, IL.

11. **Iwanski, C**. (2017, May). Eating Disorders in Athletes. *Lecture for Sports Nutrition Course at DePaul University*. Chicago, IL.

12. **Iwanski, C**. (2016, May). Eating Disorders in Athletes. *Lecture for Sports Nutrition Course at DePaul University*. Chicago, IL.

POSTER PRESENTATIONS

1. Lokey, S. B., Huddleston, A., **Iwanksi, C.**, Reina, W., Harnisch, N., Gandhi, K., Rameshkumar, S., Lynch, J., and Herbener, E.S. (2019, June). Emotion processing and social cognition in schizotypy:
   A lexical and psychometric analysis. *International Consortium for Schizotypy Research*. New Orleans, LA.

2. Keutmann, M., **Iwanski, C.**, Rameshkumar, S., Lynch, J. & Herbener, E. (2017, September). Accuracy of Recalled and Predicted Pleasure: An Ecological Momentary Assessment (EMA) Study of Anhedonia in Schizophrenia. *Poster Session Presentation at the Society for Research in Psychopathology*. Denver, CO.

3. **Iwanski, C**., Galindo, B., Eihentale, L., Taylor, T., Lechowicz, A., Telagi, P., … Herbener, E. (2017, September). Implicit theory of mind across the schizophrenia spectrum: Preliminary analysis. *Poster Session Presentation at the Society for Research in Psychopathology*. Denver, CO.

4. Rameshkumar, S., Keutmann, M., **Iwanski, C.,** & Herbener, E. (2016, October). Effects of social context on social judgements in persons with schizophrenia. Poster Session *Presentation at the Society for Research in Psychopathology*. Baltimore, MD.

5. **Iwanski, C**., Keutmann, M., Rameshkumar, S., & Herbener, E. (2016, October). Social judgments based on a series of encounters in healthy and schizophrenia participants. *Poster Session Presentation at the Society for Research in Psychopathology*. Baltimore, MD.