Schizophrenia Research: Cognition 1 (2014) e11–e19

Contents lists available at ScienceDirect

Schizophrenia Research: Cognition

journal homepage: http://www.schizrescognition.com/

A novel, online social cognitive training program for young adults with schizophrenia: A pilot study

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ARTICLE INFO

Article history:
Received 24 October 2013
Received in revised form 22 January 2014
Accepted 24 January 2014
Available online 12 March 2014

Keywords:
Social cognition
Early psychosis
First episode
Computerized training
Cognitive remediation

ABSTRACT

Background: Pervasive social cognition deficits are evident early in the course of schizophrenia and are directly linked to functional outcome, making them an important target for intervention. Here, we tested the feasibility of use, and initiated the evaluation of efficacy, of a novel, neuroplasticity-based online training program (SocialVille) in young adults with schizophrenia.
Methods: Schizophrenia patients (n = 17) completed 24 hours of online SocialVille game play either from home or at a clinic, over a 6–10 week period. We examined training feasibility, gains on the SocialVille exercises relative to matched healthy controls (n = 17), and changes on measures of social cognition, social functioning, global functioning and motivation.
Results: Subjects adhered to training requirements, and rated SocialVille in the medium to high range in satisfaction, enjoyment, and ease of use. Subjects demonstrated significant, large improvements on the speeded SocialVille tasks, and small to moderate improvements on the working memory tasks. Post-training performance on the SocialVille tasks were similar to initial performance of the healthy controls. Subjects also showed improvements on standard measures of social cognition, social functioning, and motivation. No improvements were recorded for emotion recognition indices of the MSCEIT, or on quality of life scales.
Conclusion: This study provides an initial proof of concept for online social cognition training in schizophrenia. This form of training demonstrated feasibility and resulted in within-subject gains in social functioning and motivation. This pilot study represents a first step towards validating this training approach; randomized controlled trials, now underway, are designed to confirm and extend these findings.

1. Introduction

In recent years, special emphasis has been given to the need for early intervention in schizophrenia (Insel, 2010; McGorry, 2011; Wykes et al., 2007). It is now acknowledged that the early phase of psychotic illness is crucial in terms of the emergence of a range of cognitive deficits that have prognostic implications (Bartholomeusz and Allott, 2012; Birchwood et al., 1990) – and that early intervention can potentially prevent further worsening of symptoms and improve functioning. An important target for early intervention is the domain of *social cognition*, the mental operations that underlie understanding, interpretation and perception of social information (Fiske and Taylor, 1991). Severe social cognition deficits, often comparable to those seen in chronic patients, have been repeatedly documented in early-phase schizophrenia (e.g. Bertrand et al., 2007; Green et al., 2012a; Williams et al., 2008). These deficits span the domains of affect perception (e.g. Edwards et al., 2001), social cue perception (including gaze perception, e.g. Hooker and Park, 2005; Rosse et al., 1994; Tso et al., 2013; Tso et al., 2012), theory of mind (ToM; e.g. Bertrand et al., 2007) and attributional style (e.g. Humphreys and Barrowclough, 2006). Importantly, social cognition deficits have been strongly associated with poor functional outcome in schizophrenia (e.g. Fett et al., 2010). Specifically, affect recognition and social perception have been each linked with community functioning, social problem solving

Abbreviations: SZ, Schizophrenia; HC, Healthy Control.
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http://dx.doi.org/10.1016/j.scog.2014.01.003

and social skills (Couture et al., 2006; Irani et al., 2012); ToM, as well as affect perception and social perception, have been found to mediate the relationship between neurocognition and functional outcome (Addington et al., 2006a, b; Billeke and Aboitiz, 2013; Brekke et al., 2005; Couture et al., 2011; Fett et al., 2010; Sergi et al., 2006).

Surprisingly, however, only a few studies to date have examined the direct effects of social cognition training in young adult or early psychosis patients (Bartholomeusz et al., 2013; Eack et al., 2007; Eack et al., 2009), and none have evaluated a computerized intervention. Studies testing the effects of Cognitive Enhancement Therapy, a computer-based cognitive training with group-based social skills training (Eack et al., 2007, 2011; Eack et al., 2009) and of SCIT, a social cognitive group intervention (Combs et al., 2007; Penn et al., 2005) in first episode patients report promising effects on neurocognitive, social cognitive and functional outcome measures. However, these encouraging outcomes are limited by the practicality of applying these treatments in many clinical settings, given long treatment durations, the need for a trained clinician team, and the necessity of organizing patient groups for program delivery.

Computer-based training has the potential to overcome these limitations by allowing individualized treatment that can be more flexibly performed from home, and at a considerable cost savings (Ventura et al., 2013). A few recent studies (Frommann et al., 2003; Hooker et al., 2012; Hooker et al., 2013; Russell et al., 2006; Sacks et al., 2013; Wolwer et al., 2005) tested computerized training of facial affect recognition and mental state decoding in *chronic* patients, with promising results in emotion perception, management and social functioning (Kurtz and Richardson, 2012). These results in chronic patients show that improving social cognition and social skills using a single-user, computer-based intervention is feasible and is potentially beneficial. However, it is unclear whether younger patients would comply with computerized social cognitive training, and with the requirement to individually train from home for several hours each week over a several week long therapeutic epoch.

Here, we examined the feasibility and initial efficacy of a new, online training program (SocialVille by Brain Plasticity Institute of Posit Science; Nahum et al., 2013a), in young adults with schizophrenia. SocialVille aims to treat social cognition deficits using the principles of neuroplasticity-based learning (Merzenich, 2013; Nahum et al., 2013b), by targeting the impaired brain systems underlying social cognition rather than the impaired social behaviors per-se that are targeted by molar social skills training approaches. The SocialVille exercises aim to improve efficiency of stimulus representation and processing speed in the specific neural systems that underlie social cognition, and have been shown to function abnormally in schizophrenia (e.g. Crossley et al., 2009). The rationale behind this approach was successfully applied to address general cognitive deficits in chronic schizophrenia (e.g. Fisher et al., 2009; Subramaniam et al., 2012): that directly strengthening the fidelity of representations of socially-relevant information in the brain should improve an individual's social behavior. The SocialVille exercises employ psychophysical principles of training and exploit implicit learning mechanisms: they continuously adapt in difficulty, based on individual performance. The user learns through tasks that involve many socially-relevant stimulus examples while given feedback on correct and incorrect discriminations. These neuroplasticity-based principles, which provided the basis for the construction of SocialVille, have been recently summarized in a review paper (see Nahum et al., 2013b for full details) (Fig. 1).

To assess feasibility, we predicted that at least 75% of enrolled participants would complete the training and that they would report satisfaction with the exercises with ratings of over 4 on the 7-point Likert scale items. We measured learning rates by assessing improvement on the SocialVille exercises. We hypothesized that participants would show improvements on the trained exercises, as well as learning generalization to proximal social cognition measures. We explored whether more distal measures of functioning and motivation would improve with this form of computerized training.

2. Materials and methods

2.1. Participants

Schizophrenia (SZ) subjects (n = 17) and matched healthy controls (HC) (n = 17) completed the study protocol in two sites at university-based early psychosis programs at the University of California, San Francisco and Los Angeles (Table 1). SZ subjects met the following inclusion/exclusion criteria: Diagnosis of schizophrenia, schizophreniform, or schizoaffective disorder via the Structured Clinical Interview for DSM-IV (SCID-IV; First et al., 1996); good general physical health; age 18–31 years; Premorbid IQ ≥ 70 (estimated using WTAR; Wechsler, 2001); No neurological disorder or history of traumatic brain injury; No substance dependence or serious substance use in the past 6 months. SZ Symptom severity at baseline was assessed using the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987). We note that nine subjects were within 2 years of psychosis onset, seven more within 5 years, and that only one was more than five years from onset (7.2 years). All subjects had achieved clinical stability (outpatient status for at least 3 months prior to study participation) and were stable on psychiatric medications for at least one month prior to study onset.

UCSF site participants (n = 10) were either active or former patients at the early psychosis clinic (EPC), which provides medication management and some psychotherapy; for the duration of the study, 4 were receiving no treatment, 3 were receiving outside treatment and 3 were seen at the EPC. UCLA participants were enrolled in the Aftercare Program protocol, and all were receiving psychosocial treatment, medication, and case management there. None of the UCLA participants were in other cognitive remediation training during their SocialVille training.

HC subjects (status verified through the SCID-Nonpatient edition) were recruited to match the SZ cohort at a group level in terms of age, gender and education (Table 1).

2.2. Study Procedures

SZ subjects: Following informed consent, eligible participants underwent baseline assessments. Subjects from the UCSF clinic (n = 10) were then loaned laptop computers, given logins and asked to complete the intervention from home. The UCLA clinic

Table 1
Sample characteristics of the patient and healthy control groups.

Variable	Schizophrenia (SZ)(n = 17)	Healthy control (HC)(n = 17)	Analyses [a]		
			χ^2	df	P
Male/female	13/4	12/5	.151	1	.69
	Mean (SD)	Mean (SD)	F	df	P
Age, years	23.8 (±3.2)	23.6 (±3.6)	.20	32	.84
Education, years	12.8 (±1.7)	13.5 (±1.5)	−1.28	32	.21
IQ (WTAR)	101.2 (±16.2)	110.7 (±11.3)	−1.95	32	.06
Time since psychosis onset, months	38.5 (±23.9)	–	–	–	–
PANSS[b]					
Positive	13.1 (±1.2)	–	–	–	–
Negative	16.2 (±1.4)	–	–	–	–
General psychopathology	27.8 (±2.1)	–	–	–	–
TOTAL	57.1 (±4.1)	–	–	–	–
Medication (chlorpromazine equivalent)	281.5 (±31.1)	N/A	–	–	–

Total training times are marked in bold type.
[a] Independent samples *t*-test or chi-square analysis for categorical data.
[b] Positive and Negative Syndrome Scale.

subjects (n = 7) came into the clinic twice a week to complete the intervention there, as they were already coming to the clinic twice each week anyway. Subjects from both sites were asked to complete 24 hours of training with the SocialVille online program (1–2 hours per day, 2–5 days per week for 6–12 weeks). Following training completion, subjects completed the post-training assessment battery.

HC subjects: following consent and initial screening, participants completed the SocialVille exercise-based assessments only, i.e. one block of every SocialVille social cognitive exercise (see details below). Subjects received monetary compensation for participating in the study.

Assessments were conducted by psychology practicum graduate students (UCSF site) or by case managers and research assistants (UCLA site); assessors were not directly paid by Posit Science for their services.

2.3. Social Cognition Training Intervention (SocialVille)

SocialVille is an online program designed to treat social cognition deficits in schizophrenia. It consists of 19 computerized exercises targeting speed and accuracy of neural functions dedicated to processing of social information (e.g. Nahum et al., 2013a; Nahum et al., 2013b). Specifically, the SocialVille exercises target the social cognitive domains of affect perception (both visual and vocal), social cue perception, ToM and self-referential processing (see Table 2). A full description of the SocialVille program is provided in Supplemental Document 1. Each SocialVille session consisted of 6 exercise blocks, each taking about 10 minutes to complete.

2.4. Outcome measures

2.4.1. SocialVille training program feasibility and ease of use:

(i) Attrition rate: percentage of subjects who actually completed the 24 hours of training
(ii) Adherence with training schedules: number of training sessions/week
(iii) SocialVille program rating: upon completion of training, SZ subjects were asked to complete a questionnaire in which they rated enjoyment, satisfaction, ease of use, program attractiveness, frustration level and program security concerns using a 7-point Likert scale (1 = strongly disagree through 7 = strongly agree).

2.4.2. Social Cognition Learning: SocialVille Exercise-based Assessments

Performance levels on the SocialVille exercises (i.e. social cognition abilities) were assessed at baseline (SZ and HC participants) and post-training (SZ only) using the *exercise-based assessments* embedded in the SocialVille program. Each assessment is a single 'block' of each exercise (except for two exercises, see Table 2), for which performance threshold is determined using an adaptive staircase algorithm (e.g. Levitt, 1971) within 5–15 minutes. A full description of the exercise-based assessments is included in Supplemental Document 1.

For each exercise-based assessment, we derived normalized (Z) scores relative to the mean score of the HC group on that assessment. This was done to allow the creation of composite scores by summing assessment scores across domains, and to more easily visually depict test scores across a variety of scales (e.g. reaction time in ms, number of correct items, % correct, etc.).

The remainder of the outcome measures were administered to the SZ group only:

2.4.3. Social cognition outcome measures

(i) Facial memory: The performance-based Penn Facial Memory Test (Gur et al., 2001) assessed immediate and delayed (following 30 minutes) memory of neutral faces.
(ii) Emotional prosody identification: The performance-based Prosody Identification Test (PROID; Russ, 2008) assessed subjects' accuracy and reaction time in identifying the emotional prosody in a series of sentences.
(iii) Emotion and social perception: Assessed the perceiving emotions and managing emotions branches of the performance-based Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT; Mayer et al., 2003) battery.

2.4.4. Functioning

(i) Functioning: the clinician-rated Global Functioning: Social and Role Scales assessed social and occupational functioning (Cornblatt et al., 2007).
(ii) Social functioning was also assessed with the self-report Social Functioning Scale (SFS; Birchwood et al., 1990).
(iii) Quality of life: The clinician-rated Quality of Life Scale–Abbreviated (QLS; Bilker et al., 2003).

Table 2
SocialVille exercises and total time spent on each exercise during 24 hour course of training.

Exercise name	Exercise description	Time (hours)
Speeded exercises		
S[1] Gaze ID*	A speeded gaze identification task (select the peripheral object)	1
S Gaze Match*	A speeded gaze matching task (match gaze direction of target face)	1
S Face Match*	A speeded face matching task	1.2
S Face Emotion ID*	A speeded facial emotion identification task (stills)	2
S Face Emotion ID (Clips)*	A speeded facial emotion identification task (video clips)	1.2
S Face Emotion Match	A speeded facial emotion matching task (stills)	1.6
S Valence Match*	Delayed match of the valence of a target picture	1
Facial Emotion CPT[3]*	Withhold response for neutral faces, press for emotional faces	1
Emotion Maintenance*	Select the smiling face when faces keep changing	1
Facial Affect ToM*	Select the correct affective (facial) response in a given situation	1.2
Total time on speeded exercises		**12.2**
WM[2] exercises		
WM Facial Emotions	Match pairs of facial emotion cards in a WM task	1
WM Facial Emotion (clips)*	Match pairs of facial emotions and labels in a WM task	1.5
WM Vocal Emotions	Match pairs of vocal emotion cards in a WM task	1
Faces Span	Arrange the faces in the order they were presented	1.3
Facial Emotion Span	Arrange the facial emotions in the order they were presented	1
Face Stories Span*	Memorize sequences of faces and personal facts on the faces	1
Total time on WM exercises		**6.8**
Other exercises		
Vocal Emotion ID	Identify the prosody of the sentence with the neutral content	1.2
Social Stories[NM]	Answer questions regarding social interactions in a segmented story	2.5
Vocal Affect ToM[NM]	Select the correct prosody (vocal affect) response in a given situation	1.5
Total time on other exercises		**5.2**

Total training times are marked in bold type.
[1] S: Speeded Task.
[2] WM: Working Memory.
[3] CPT: Continuous Performance Task.
* A task for which there was a significant improvement in threshold following training; [NM]A task for which threshold performance was not measured.

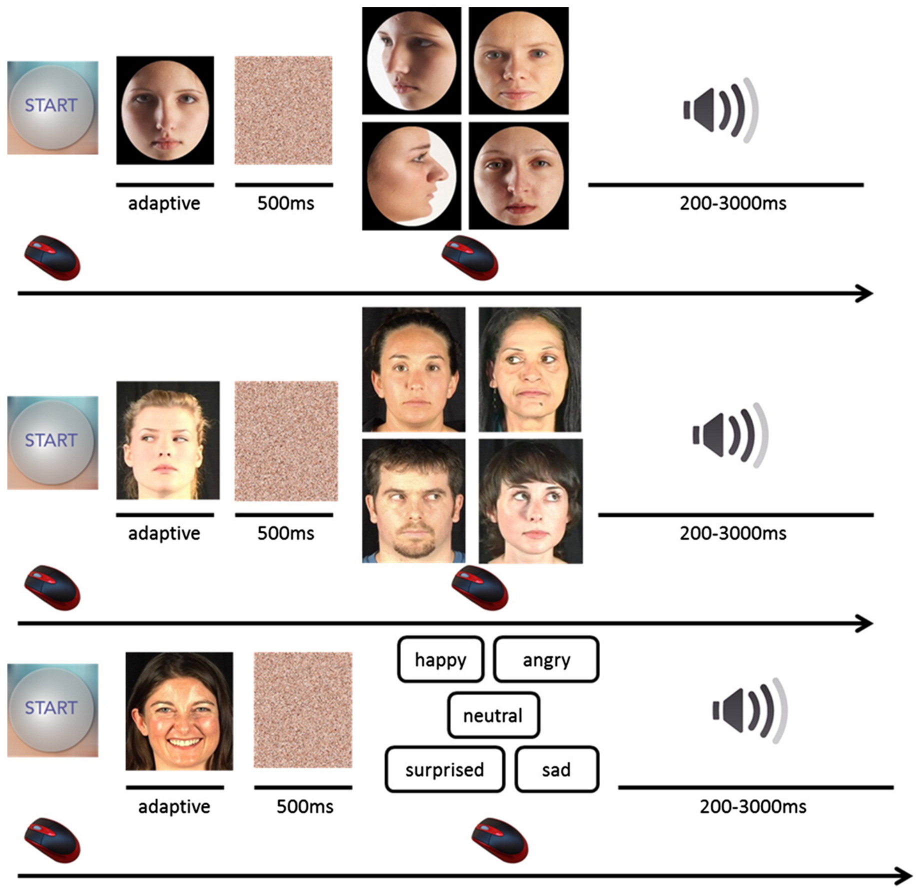

Fig. 1. Examples of the SocialVille tasks. Top: Face Perception ('S Face Match') exercise. Once the user clicks on the 'start' button, a face appears for a short duration, followed by a visual mask for 500 ms. Then, an array of faces appears, and the user should select the target face. A feedback is provided following the selection. The duration of presentation of the target face is adaptively determined based on the user's responses. Middle and Bottom: Gaze Perception ('S Gaze Match'; middle panel) and Emotion Identification ('S Face Emotion ID'; bottom panel). The same trial structure as described above is employed for these exercises as well, but here the user needs to either match the gaze direction of the target face ('S Gaze Match') or identify the facial expression.

2.4.5. Self-report motivation measures

(i) Motivation: The self-report Behavioral Inhibition Scale/Behavioral Activation Scale (BIS/BAS; Carver and White, 1994) was used to assess two motivational systems, each with a unique neural signature, that regulate approach and withdrawal behavior.

(ii) Reward sensitivity was assessed with the self-report Temporal Experience of Pleasure Scale (TEPS; Gard et al., 2006), which assesses anticipatory pleasure and consummatory pleasure. Anticipatory pleasure is closely linked to motivation and goal-directed behavior while consummatory pleasure is associated with satiation (i.e. wanting versus liking). Research indicates that schizophrenia patients have a deficit in anticipatory pleasure, but normal consummatory pleasure (Gard et al., 2007).

2.5. Data analysis

All variables were screened and normally distributed after winsorising of outlying values. Group differences in gender were tested using a chi-square test. Independent Samples t-tests tested for group differences in age, education level, IQ and the exercise-based assessments.

Paired samples two-tailed t-tests were used to examine whether SZ participants made significant gains on the training exercises and to test changes from baseline to post-training on all other outcome measures. Two-tailed tests with no correction for multiple comparisons were used because gains were hypothesized and because of the preliminary nature of the study.

3. Results

3.1. Clinical and demographic data

Demographic and clinical data is summarized in Table 1. The HC and SZ groups did not differ significantly in gender or education. As is typical with this population, the groups differed slightly in IQ, with the difference approaching statistical significance ($F(1,32) = -1.95$; $p = .06$).

3.2. SocialVille program feasibility

3.2.1. Attrition Rate

Twenty-two (22) SZ participants were recruited (UCSF: $n = 13$; UCLA: $n = 9$). Seventeen completed the study. Five subjects (3 from UCSF and 2 from UCLA) dropped out at initial phases (4 before being given the training laptop and one after completing 2 training sessions). The reasons provided for dropping out were as follows: due to increased stress at work/school ($n = 2$), hospitalization ($n = 1$), boredom ($n = 1$) and unknown reason ($n = 1$). Attrition rate was not different for the two sites (23% and 22% at UCSF and UCLA, respectively).

3.2.2. Compliance with online SocialVille training

Adherence to the online training schedule. Subjects were asked to complete 2–5 one-hour sessions of training per week for 6–12 weeks (24 sessions total). On average, subjects took 8.1 ± 2.5 weeks to complete training (range: 5–12 weeks), with only 4 subjects

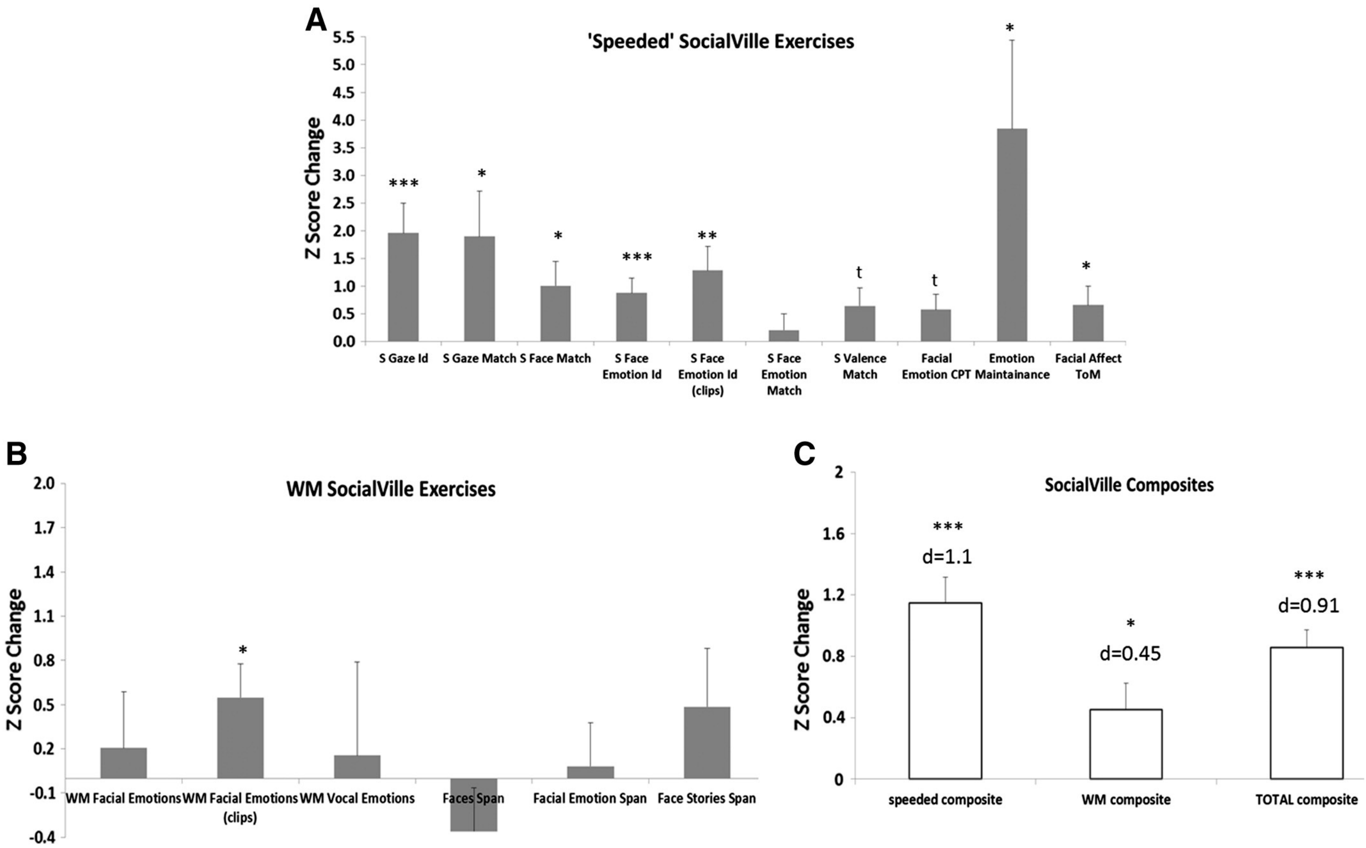

Fig. 2. Normalized SocialVille Exercise-based Assessment Data. Averaged (+SEM) Z score changes on the 'speeded' (A), WM (B), and composites (C) SocialVille exercises following training. The composites were derived as averages across all exercises in the same category; the 'total' composite is the average across all exercises (excluding prosody). Note the different scales on the three panels. *p < .05; **p < .01; ***p < .005.

taking more than 10 weeks to complete the program. The average number of weekly sessions completed was 3.15 ± 0.8.

SocialVille program rating. Following training, subjects rated their satisfaction in playing SocialVille on a 7-point Likert scale. The following averaged ratings were obtained: (a) Satisfaction rating ('I felt satisfied after the training') of 5 ± 1.9 (5 corresponds to 'somewhat agree'); (b) Program clarity rating ('the exercise instructions and tutorials were easy to understand') of 6 ± 1 (6 corresponds to 'mostly agree'); (c) Ease of navigation rating ('the program was easy to navigate') of 5.8 ± 1.3; (d) Ease of use rating ('the program makes it quick and easy for me to start playing each day') of 4.7 ± 2 and ease of fit into daily schedule ('the program easily fits into my daily schedule') of 4.5 ± 1.8; (e) Attractiveness rating ('the program graphics were attractive') of 4.5 ± 1.9; (f) Program usage difficulty ("the program was difficult to use') was rated as 3.06 ± 2.1 ('somewhat disagree'); (g) Security concerns of using the online program ('I was worried about the security of my log-in account') were 2.3 ± 1.9 (corresponding to 'mostly disagree' with the statement).

3.3. Social Cognition Learning: SocialVille Exercise-based Assessments

For 17 of the 19 SocialVille exercises, we calculated a normalized z-score for the SZ group relative to the HC baseline performance on each exercise. For two exercises, no thresholds were derived due to a data recording error, hence they were not included in the normalized composites (see Table 2). Results are summarized in Fig. 2, in Supplementary Figure 1 and in Supplementary Table 1. On the 'speeded' SocialVille exercises (i.e. tasks that required speeded processing of stimulus on every trial, Fig. 2A), significant z-score changes from baseline to post-training were evident on all but one of the exercises (two were at trend-level). Following training, patients' performance on these tasks was similar to that of the initial performance of the HC group (see Supplementary Figure 1). On the 6 WM-based SocialVille exercises, improvements were evident on 5 of the exercises, however only one of these reached statistical significance (Figure 2B). We further derived composite scores for the speeded tasks, the WM tasks and a total composite score. Significant z-score changes were seen on all composite scores (speeded: $t(16) = -6.9$, $p < .0001$; WM: $t(16) = -2.6$, $p < .02$; Total: $t(16) = -7.4$, $p < .0001$). The pre- to post-test gain on the speeded task composite score was large (1.15 SD), while the gain in the WM composite score was small to moderate (0.45 SD).

3.4. Social cognition outcome measures

Outcome measures data for the study are summarized in Table 3.

(i) Facial memory: the median RT for correct responses of the Penn Facial Memory test significantly decreased for both immediate and delayed recall (Fig. 3B).
(ii) Prosody identification: following training, PROID accuracy showed a non-significant tendency to increase and median RT significantly decreased (Fig. 3A).
(iii) Emotion and social perception: no significant changes were seen on the perceiving emotions or managing emotions subscales of the MSCEIT test.

3.5. Functioning

Subjects showed a significant increase in GFS's social functioning, and no significant change in role functioning (see Fig. 4A). On the SFS there was a trend-level increase on the interpersonal communication

Table 3
Scores on the study outcome measures before (baseline) and after (post-training) 24 hours of SocialVille training.

Outcome measure	Baseline	Post-training	Stats		
	Mean (±SD)	Mean (±SD)	t	p	Effect size
Emotional Prosody ID (PROID)					
# Correct responses	40.06 (±1.87)	42.9 (±1.96)	1.8	**0.09**	0.37
Median RT	3940 (±129)	3540 (±144)	2.94	<**.01**	0.71
Facial Memory (Penn Test) – immediate recall					
# Correct responses	30.06 (±1.1)	31.6 (±1.1)	1.4	0.16	0.22
Median RT	2025 (±164)	1679 (±116)	3.14	<**.007**	0.6
Facial Memory (Penn Test) – delayed recall					
# Correct responses	30.5 (±1.1)	31.1 (±1.4)	.49	0.63	0.11
Median RT	1870 (±217)	1415 (±87)	2.43	<**0.03**	0.73
MSCEIT					
Perceiving Emotions SS[1]	107.3 (±3.3)	105.1 (±4.1)	.63	0.54	0.12
Managing Emotions SS	91.9 (±3.7)	94.1 (±4.9)	.72	0.42	0.15
Global Functioning Scale (GFS)					
GFS: Role Current SS	5.2 (±0.7)	5.5 (±0.6)	.85	0.41	0.085
GFS: Social Current SS	5.8 (±0.47)	6.6 (±0.43)	2.5	<**0.03**	0.4
Social Functioning Scale (SFS)					
SFS: Interpersonal Communication SS	113.2 (±3.9)	119.1 (±4.6)	1.6	**0.12**	0.37
Behavioral Inhibition/Behavioral Activation Scale (BIS/BAS)					
BIS Total	3.11 (±0.12)	2.96 (±0.14)	2.2	**0.04**	0.28
BAS Reward Responsiveness	3.24 (±0.14)	3.14 (±0.18)	1.07	0.39	0.17
BAS Drive	2.52 (±0.18)	2.71 (±0.2)	1.76	**0.09**	0.24
BAS Fun Seeking	2.94 (±0.13)	2.99 (±0.18)	.70	1	0
The Temporal Experience of Pleasure Scale (TEPS)					
TEPS: Anticipatory SS	38.06 (±2.6)	41.1 (±2.5)	2.29	<**0.04**	0.28
TEPS: Consummatory SS	33 (±2.2)	32.3 (±2.2)	.54	0.6	0.07
Quality of Life Scale Total	3.29 (±0.3)	3.26 (±0.3)	.17	0.86	0.02

Significant or trend-level p values are marked in bold type.
[1] SS: Subscale.

subscale (Fig. 4B), and no significant change on the other SFS subscales. There were no significant changes on the Quality of Life Scale.

3.6. Motivation/reward sensitivity

(i) Motivation: we found a significant decrease on the Behavioral Inhibition Total scale and a trend-level increase in the Behavioral Activation-Drive subscale (Fig. 4C). Changes on the two other BIS/BAS subscales were non-significant (see Table 3).
(ii) Reward Sensitivity: we found an increase on the TEPS Anticipatory Pleasure subscale and no significant change on the Consummatory Pleasure subscale (Fig. 4D).

4. Discussion

We tested the feasibility and preliminary efficacy of SocialVille, a new online training program targeting deficits in social cognitive processing speed and working memory (WM) in young adults with schizophrenia. Following 24 hours of training performed over a 6–12 week period, we found: relatively high adherence with the training requirements, satisfaction with the exercises; significant pre- to post-training improvements on the SocialVille social cognition exercise composite scores; significant improvements on proximal measures of social cognition (prosody identification and facial memory); and significant improvements on social functioning, motivation and reward sensitivity.

These findings suggest that an online training approach is feasible in early psychosis, and that social cognitive deficits may be addressed early in the course of schizophrenia. Given the importance of early intervention (Birchwood et al., 1998; Marshall and Rathbone, 2011), and the link between social cognition and functional outcome in schizophrenia (Fett et al., 2010; Sergi et al., 2007) this study provides an initial scalable way of targeting a set of critical core deficits. Although promising, the results are preliminary and not case-controlled. An appropriately powered, randomized controlled trial is required to determine whether these effects are replicable.

To the best of our knowledge, our study is the first to demonstrate the feasibility of online social cognitive training in young adults with

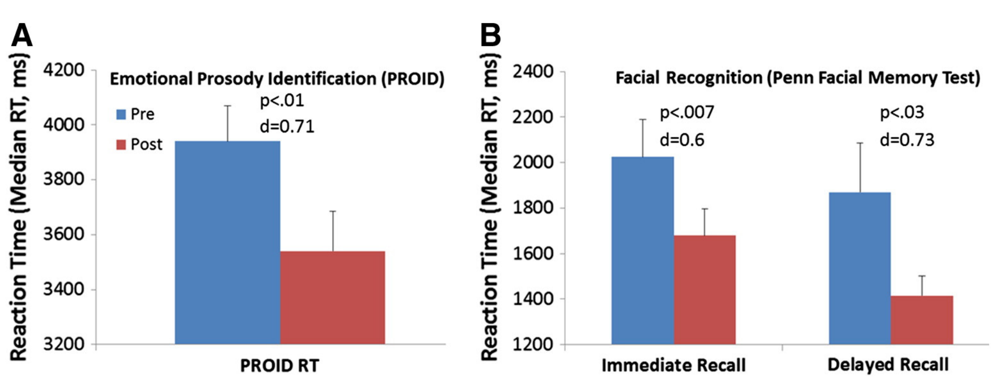

Fig. 3. Outcome measures data. Averaged performance (±SEM) before (blue bars) and after (red bars) SocialVille training. (**A**) Median reaction time (RT, in ms) for correct responses on the PROID task; (**C**) Facial recognition test (Penn) data: median reaction time (RT, in ms) for immediate (left) and delayed (right) recall of faces. *p values and Cohen's d values are shown; n.s. non-significant.

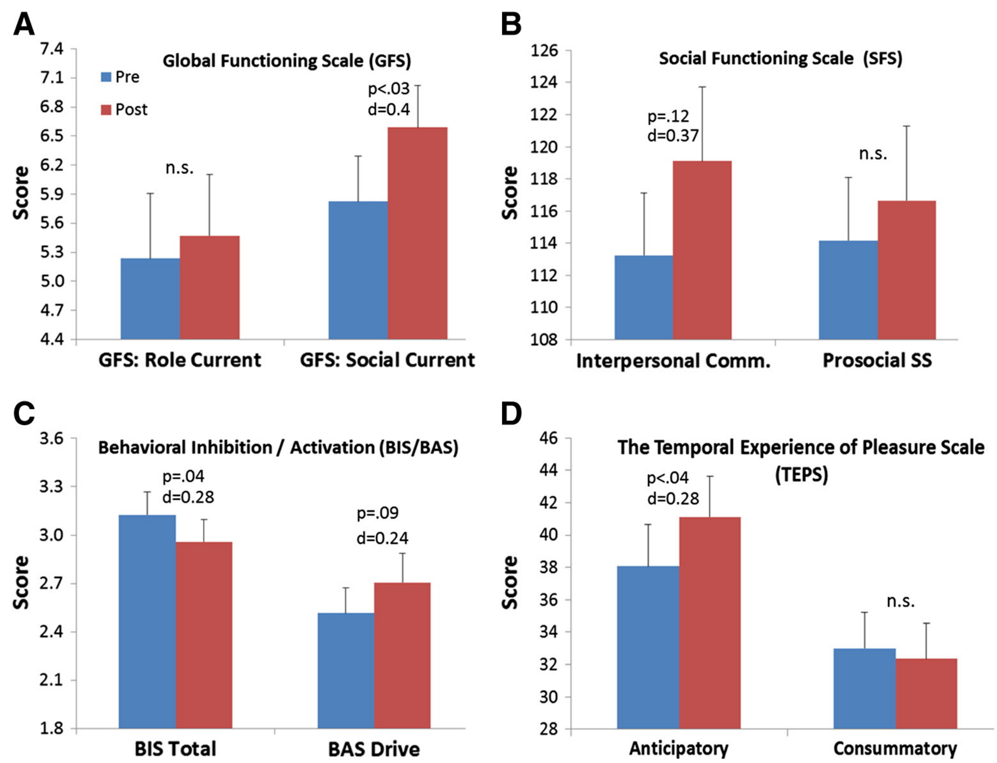

Fig. 4. Outcome measures data. Averaged performance (+SEM) before (blue bars) and after (red bars) training. (**A**) Global Functioning Scale (GFS), Role Current and Social Current subscales; (**B**) Social Functioning Scale (SFS), interpersonal communication and prosocial subscales; (**C**) Behavioral Inhibition/Behavioral Activation (BIS/BAS) test, BIS total and BAS drive subscales. (**D**) Temporal Experience of Pleasure Scale (TEPS), anticipatory (left) and consummatory (right) subscales.

schizophrenia (see recent review in Bartholomeusz and Allott, 2012). Two other studies tested the feasibility of social cognitive training in early psychosis, both using group-based interventions administered in clinic (SCIT, Bartholomeusz et al., 2013; CET, Eack et al., 2007). CET uses computerized 'cold' cognition training with group-based social skills training. SCIT is a group-based therapy as well, comprised of 18 sessions focused on three phases of understanding emotions, social cognitive biases, and integration, in which trainees practice the acquired social skills in everyday situations (Penn et al., 2005). These two interventions, although including some computer-assisted parts, are administered in a therapist-instructed group format. Here, we show the feasibility of a fully-computerized intervention, which can be completed either at home or at the clinic, using internet-connected computers. Gains were obtained after a relatively short period of treatment (less than 12 weeks). The attrition rate in our study is similar to other training studies in young clinical populations (e.g., Marshall and Rathbone, 2011). Moreover, the high compliance with the training schedule indicates that this form of individual online training is feasible with young adults, comparable to clinic-based group training. We note that at-home participants needed weekly phone-calls and/or emails to reliably adhere to training requirements, thus clinical staff involvement in the form of solution-focused conversations was still required. Future studies will determine whether combining our computer-based training with psychosocial interventions (e.g. social skills groups) enhances generalization. Still, our study provides the first demonstration of a potentially highly-scalable form of treatment that could be easily used in practically every household or clinical facility equipped with an internet connection, thus providing treatment options to under-resourced areas and to patients who are unable or unwilling to come in to the clinic.

Study participants made larger gains on the 'speeded' SocialVille composite (i.e. processing speed of social information), whereas improvements on the 'WM' composite (i.e. WM manipulations of social information) were smaller. The fact that large pre-post gains were found in processing speed is encouraging: recent 'cold cognition' studies consider speed of processing deficits among the largest cognitive impairments in recent-onset schizophrenia (Mesholam-Gately et al., 2009; Milev et al., 2005) and hence an important target for early intervention. While speed of processing during "cold cognition" tasks and social cognitive tasks may be quite different, our results suggest that speed-of-processing deficits of social information are evident in early psychosis, and that training drives improvements in this fundamental ability.

Although there are currently no rigorous studies of computerized social cognition training in early schizophrenia, our outcomes are comparable to recent reports of social cognition training in *chronic* schizophrenia (see Kurtz and Richardson, 2012 for review; Lindenmayer et al., 2013), and further strengthen the notion that social cognition is linked to social functioning and functional outcome in schizophrenia (Billeke and Aboitiz, 2013; Brekke et al., 2005). Interestingly, while SocialVille includes training on facial affect, we did not find significant changes on the MSCEIT emotion perception and management subscales. However, our findings still suggest that subjects improved on emotion recognition abilities, as is evident by improvements on SocialVille emotion exercises and on vocal affect recognition. We hypothesize that this negative result is likely due to the focus of SocialVille on processing speed, while affect perception and management is measured differently in the MSCEIT (see similar arguments in Roberts et al., 2006). The short duration of training relative to that included in other studies (e.g. Eack et al., 2007; Eack et al., 2009) might have also contributed to the lack of improvement on the MSCEIT.

Following training, participants improved on motivation and reward sensitivity: participants showed decreased behavioral inhibition and increased drive, as well as increased anticipatory pleasure. To our knowledge, this is the first demonstration of changes in motivation following cognitive training in early schizophrenia. Interestingly, motivation is generally considered a stable trait in healthy individuals, not subject to change. A few recent reports (e.g. Gard et al., 2009; Green et al., 2012b) have shown that motivation plays a significant and mediating role between neurocognition, social cognition and functional outcome. Our preliminary finding that motivation can be enhanced with social cognitive training provides strong support for this model, and further stresses the importance of targeting social cognition in schizophrenia (see also Choi and Medalia, 2010).

Our study had several limitations. These include the small sample size, the lack of a control group, and the fact that participants were provided remuneration for participation in the study. Further, we cannot rule out practice effects or non-specific effects of study participation. These factors all limit our ability to attribute improvements to the SocialVille training itself. Furthermore, since the main goal of the study was to establish feasibility in early schizophrenia patients, no general cognition and symptom outcome measures were included. Future, well-controlled studies are required to further establish the efficacy of computerized social cognitive training administered with no additional neurocognitive training (see discussion in Pinkham and Harvey, 2013). Also, the results of our pilot study do not rule out the possibility that improvements are driven by non-specific effects of training such as increased attention span or general improved processing speed. Still, results from several recent studies (e.g. Fisher et al., 2009; Lindenmayer et al., 2013; Sacks et al., 2013) imply that non-social cognitive training does not improve social cognition and social function. Finally, we note that there is currently no consensus on the best social cognition outcome measures to be used in intervention studies, as many of them are considered to have poor psychometric characteristics (see Pinkham et al., 2013). Future studies should consider applying additional or different outcome measures, given new psychometric information on outcome measures (see, for example, Green et al., 2013; Kern et al., 2013).

We conclude that SocialVille is a promising intervention which is feasible and resulted in initial positive outcomes in social cognition, social functioning, and motivation in young individuals with schizophrenia. Given the importance of early intervention, and the lack of effective treatment options, there is a clear need for effective, scalable treatments. Future randomized controlled trials will determine whether these preliminary findings are replicable and are needed to discover the 'active ingredients' of training that allow for learning to transfer to everyday functioning.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.scog.2014.01.003.

Role of Funding Source

The study was funded by a National Institute of Mental Health SBIR Grant (1R43MH091793-01A1) to author M.N.

Contributors

Author M.N. developed the training program, designed the study, supervised the study, conducted data analysis and wrote the first draft of the manuscript. Author M.F. helped supervise the UCSF site study, conducted data analyses and wrote the manuscript. Author R.L. supervised the trial and managed patient recruitment and participation. Author G.P. supervised the assessments and outcome measures. Authors J.V. and K.N. supervised the UCLA site study and provided input on the development of the training program. Authors C.H. and MFG provided input on the development of the training program. Author M.M. helped develop the training program and design the study. Author S.V. helped develop the training program, designed the study and supervised the UCSF site study. All authors contributed to and have approved the final manuscript.

Conflict of interest

The social cognitive training software used in this study (SocialVille) was developed by Posit Science. Dr. Nahum is a paid employee of Posit Science and was the main developer of the program. In addition, she received SBIR grant from NIMH to develop and test the SocialVille software. Dr. Merzenich is the founder and CSO of Posit Science. Drs. Vinogradov, Hooker, Green and Ventura are paid consultants to Posit Science and were all involved in the construction of the training program. Dr. Nuechterlein is an unpaid consultant to Posit Science, and holds research grants from Janssen Scientific Affairs and Genentech. He serves as a consultant to Otsuka and Genentech. Dr. Vinogradov serves on advisory boards for Genentech, Envivo, and Hoffman-LaRoche. Dr. Green reports having been a consultant to Abbott Laboratories (AbbVie), Biogen, DSP and Roche. He is a member of the scientific board for Mnemosyne, and has received research funds from Amgen. Dr. Ventura has received research support from Brain Plasticity Inc. (a company merged with Posit Science) and from Janssen Scientific Affairs. Dr. Loewy has received research funding from Genentech.

Drs. Fisher and Poelke report no conflicts of interest.

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