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Research article

Decreased activation in left prefrontal cortex during role-play: An fNIRS study of the psychodrama sociocognitive model

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ABSTRACT

Despite widespread implementation of psychodrama, no empirical studies investigated neural mechanisms of its techniques. One gap lies in the sociocognitive model of role reversal (RR) which posits three processes: empathic role-taking, behavioural reproduction and role feedback. Related studies found deactivations in prefrontal cortex (PFC) during acting tasks, implicating inhibited self-related cognition. However, contrasting studies found PFC activations during role-taking, citing blurred boundaries between self and other that is characteristic of empathy. This study employs fNIRS to uncover neurophysiological correlates of the three processes. Three conditions (Naturalistic Conversation - NC, Role-Play - RP, Role Reversal - RR) were designed to introduce empathic role-taking and behavioural reproduction, and role feedback in transitions from NC to RP, and RP to RR respectively. 41 non-clinical adult dyads underwent all conditions. First-level General Linear Model from fNIRS signals was based on participants' role-related utterances and compared across conditions. Anterior left PFC activity decreased as participants produced role-related utterances during RP compared to NC, implying lowered recruitment of self-referential networks during empathic role-taking and behavioural reproduction, partially supporting patterns of brain activation that can be mapped to specific sociocognitive processes in RR. Findings partially support the involvement of self-referential networks in specific sociocognitive processes in RR.

Introduction

Psychodrama is a form of group psychotherapy capitalising on theatrical characteristics (e.g., role-play and group dynamics) to achieve therapeutic change by offering chances for clients to enact their problems in a safe space (von Ameln & Becker-Ebel, 2020; Karp et al., 1998). After 100 years of practice in over 100 countries (Lim et al., 2021; Haworth, 1998), ranging across major continents (e.g., Wang et al., 2020; Bacallao & Smokowski, 2017; Kähönen et al., 2012), studies have found psychodrama effective for its clients by improving social skills (Corey, 2012; Bohart, 1977), empathy (Şimşek et al., 2020; Dogan, 2018; Kipper & Ben-Ely, 1979) and expanding one's repertoire of role behaviours and expectations (von Ameln & Becker-Ebel, 2020; Schneider-Düker, 1989; Janis & Mann, 1965) across a variety of psychological conditions (Lim et al., 2021).

According to Shulman (2015), a session of psychodrama comprises three phases: warm-up, enactment, and sharing. During warm-up, participants introduce themselves, explore interpersonal relationships and get ready for the upcoming activities, which are then reflected upon during sharing (Giacomucci, 2021). It is the enactment phase that most distinguishes psychodrama from other forms of psychotherapy, as different role-play techniques are implemented. The most common technique in psychodrama, and also the technique thought to be most effective, is role reversal (Cruz et al., 2018; Rojas-Bermúdez, 1997; Yardley-Matwiejczuk, 1997; Kipper, 1986) where roles played between two individuals are switched (Moreno, 1953, 1946). To one of the pioneers of psychodrama, J.L. Moreno, role reversal not only facilitates interpersonal socialisation, but also integration of the self (e.g., by perceiving the self through another's eyes; Moreno, 1953). Role reversal hints at complex intra- and interpersonal perception, reflection and adaptation. By perceiving the self as played by another, the individual gains fresh perspective and achieves breakthroughs in self-conceptualisation and interpersonal relationships. According to Holmes et al. (1994), role reversal can be broken down into at least three sociocognitive processes: empathic role-taking, behavioural reproduction, and role feedback. In role-taking, the individual perceives a facet of the person within the context they are attempting to role-play, and recreates their target's inner experience. Next, the perceived inner

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experience is projected into the external world through the individual's attempt to recreate the role's behaviours. It was noted by Moreno (1972) that a perfect recreation, both in terms of the target's inner states and outer behaviours, is impossible; however, it is in the creation of a dynamic opportunity to interface with the self that drives the technique of role reversal. During role feedback, the individual reflects on their own and their partner's behaviours, as well as on the interaction, and continuously adapts their perception and behaviours related to the role being played based on this reflection. The sociocognitive model of role reversal necessitates complex psychological processes, especially in meta-cognition (in terms of an awareness and monitoring of at least two separate identities; Ownsworth et al., 2010) and theory of mind (in terms of mentalizing another's state of mind; Yaniv, 2012). Unfortunately, since the posit of the sociocognitive model of role reversal, there have been no empirical studies supporting it. It is still unclear if the three processes outlined above map to observable changes in the brain.

The rise of neuroscience methods in psychotherapies (Vaisvaser, 2021) offers a ripe opportunity for the investigation of such a model. Theoretical papers discussing possible neurological implications during role reversal have been published (Bilik, 2019; Yaniv, 2012), pointing to mirror neurons, the prefrontal cortex, as well as regions related to theory of mind. Although there are no neuroimaging studies on psychodrama to date, related studies on acting and perspective taking offer promising insights into the cognitive mechanisms of role-play techniques that parallel the suspicions of Yaniv (2012). For example, during an improvisational session involving trained actors where they either acted as themselves or as a fictional character, Brown et al. (2019), using a functional magnetic resonance imaging (fMRI) paradigm, showed significant deactivation in the dorsomedial and ventromedial prefrontal cortex and superior frontal gyrus during role-play. According to the authors, results are suggestive of deactivation-driven processes during role-play, especially in brain regions related to self-referential cognition. A related study by Karim et al. (2010) showed that inhibition of the anterior prefrontal cortex by transcranial direct current stimulation promoted significant improvement in expected role behaviour when participants role-played as thieves. Specifically, it was found that anterior prefrontal cortical inhibition was related to quicker and more skillful lying. Other studies have shown the prefrontal cortex to be a key region in self-referential cognition, noting differential recruitment of the dorsolateral and medial prefrontal cortices in self-referential encoding and retrieval (Guercio et al., 2020).

In contrast, another fMRI study investigating perspective taking found increased recruitment of self-mentalisation networks, including the ventromedial prefrontal cortex, when participants are instructed to think about another individual in first person (i.e., imagine that you are person X) rather than in third person (Ames et al., 2008). Findings here were thought to be indicative of enhanced empathy during perspective taking, where individuals experience a 'blurring' between self and other. While Ames et al. (2008) study corroborates the well-established link between empathy and role-playing (Rivers et al., 2016; Goldstein & Winner, 2012; Poorman, 2002; Martin-Smith, 1995), there were no empathy measures implemented in Ames' and colleagues' (2008) study that may confirm this interpretation.

Relationship between self-referential cognition and empathy

It is firmly established that heightened empathy is associated with clinical role-play (Rønning & Bjørkly, 2019) and more notably with even casual role-players (Rivers et al., 2016) who inhabit a fictional persona in gaming or recreational contexts, although it is still unclear how role-play and its associated sociocognitive processes contribute to increased empathy. It is perhaps because role-play techniques demand the individual's embodiment of another role or person, and therefore necessitating a change in point of view, that these techniques have been taken for granted to simply work as a therapeutic modality to increase empathy without evidence of how it is effective. Extant literature involving role-play techniques and psychodrama suffers a confound where these interventions are used as a means to achieve an intended outcome (e.g., Şimşek et al., 2020; Dogan, 2018; Kipper & Ben-Ely, 1979), and not studied in and of themselves. More specifically, in the studies by Şimşek et al. (2020), Dogan (2018), and Kipper and Ben-Ely (1979), psychodrama was implemented as an intervention to enhance client empathy. While pre- and post-intervention testing found improved empathic skills in these studies, it was not confirmed if these effects were observed as a result of psychodrama's role-play techniques.

Outside of the psychodrama context, however, relevant studies have been conducted that illuminate the relationships between self-referential cognition and empathy, with interesting implications when applied to psychodrama. For example, it had been previously found that the self-referential cognition is inextricably related to one's ability to empathise (Monteleone et al., 2020; Lombardo et al., 2007), although another study by Kanske et al. (2016) suggests that empathy in highly emotional contexts may interfere with mentalization. A landmark neuroimaging study by Majdandžić and colleagues (2016) investigated the mechanism by which mentalizing and empathy were related in the dorsomedial prefrontal cortex. Based on their study, it was found that increased empathy, particularly when directed towards dissimilar others, was related to the inhibition of self-mentalizing pathways and an enhancement of other-mentalizing neural processes, consistent with the above illustrated acting study by Brown et al. (2019). On the other hand, the mentalization of similar others, parallel to mentalizing others in the first person (Ames et al., 2008), activated similar neural pathways as self-mentalization (Majdandžić et al., 2016). Taking the protocols and findings from Brown et al. (2019), Majdandžić et al. (2016), and Ames et al. (2008) together, it appears that there are different brain activation patterns depending on how the participant was instructed to mentalise (e.g., imagine *yourself* as the other person as compared to imagine how the *other person* would feel while disregarding yourself).

Conversely, initial studies also show that individuals' baseline empathy affects role-play involvement and behaviour (West & Somer, 2020; Rivers et al., 2016). For example, Rivers and colleagues' (2016) comparative study showed that individuals who showed greater levels of empathic involvement were more likely to engage in fantasy role-play. Neuroimaging studies have also confirmed that individual differences in baseline empathy can be traced to structural (Yue et al., 2016; Banissy et al., 2012) and functional (Christov-Moore et al., 2020) differences in the brain, including the orbitofrontal and medial prefrontal cortex, and inferior frontal cortex (Schulte-Rüther et al., 2007). Therefore, it is important to understand how role-play may elicit changes in empathy, as well as how changes in brain activation during role-play are related to baseline empathy.

The present study

Taken together, the above studies paint an intriguing picture of brain activity during mentalization processes, with deep implication for psychodramatic role-play. This is especially because the role reversal techniques used in psychodrama rely on the central process of mentalization in order to take the perspective of another, before the individual can reproduce role behaviour and attend to role feedback. However, current literature failed to disentangle the complex sociocognitive processes that are active during role-play and role reversal. Additionally, while mentalization and empathy are associated with each other, individual differences in empathy are rarely investigated as a variable of interest when considering brain activation during role-play activities.

Given limited and contrasting findings of previous studies investigating role-play, as well as a lack of empirical neuroimaging studies in psychodrama specifically, this study aims to (1) uncover the neurophysiological underpinnings of the sociocognitive model of RR and (2) investigate potential effects of baseline empathy on the brain during role-play. Three experimental conditions (Naturalistic Conversation, Role-Play, Role Reversal) were designed to reflect the three sociocognitive processes implicated in role reversal. By transitioning from Naturalistic Conversation to Role-Play, the first two stages (i.e., empathic role-taking and behavioural reproduction) are implemented, while role feedback is introduced in the transition from Role-Play to Role Reversal. The present study therefore introduces a novel within-subject experimental paradigm using fNIRS to investigate neurophysiological activation in the cortical surfaces of the prefrontal cortex during naturalistic role-play. Similar to the gold standard for neuroimaging, fMRI, fNIRS makes use of the Blood Oxygenation Level Dependent (BOLD) signal as a proxy measure for brain activation (Huppert et al., 2006; Strangman et al., 2002). In comparison to other neuroimaging modalities, however, fNIRS remains the leading neuroimaging tool of choice in ecological, dyadic studies due to its portability, ability to conduct hyperscanning (i.e., simultaneous recording between multiple individuals) and relative resistance to motion artifacts (Czeszumski et al., 2020). It demonstrates better spatial resolution as compared to other portable tools such as the electroencephalogram (EEG), but slightly poorer temporal resolution (Scholkmann et al., 2013).

Generally, the prefrontal cortex is understood as the seat of higher cognitive function and executive control. The prefrontal cortex was imaged as this region was relevant in past literature, particularly in terms of self-reference and role-play (Brown et al., 2019; Yaniv, 2012; Ames et al., 2008). This aligns with previous studies employing functional near-infrared spectroscopy (fNIRS) modalities that investigate the prefrontal cortex and particularly the midline structures in the investigation of mentalisation and empathy (Ng et al., 2021). It is hypothesised that there will be (1) differential activation in the prefrontal cortex across the three conditions, and (2a) participants' empathy will increase after going through the role-play condition; (2b) participants' baseline empathy will significantly correlate with changes in prefrontal cortical activation across conditions.

Methodology

Participants

A priori power analysis using G*Power (version 3.1.9.7, Windows 32-bit) reveals a sample size of 57 participants (i.e., 29 dyads) to detect at least medium effect size from the central one-sample statistical analysis with 0.95 power, but due to data quality reasons and inevitable discarding of fNIRS channels with bad/lost data during the preprocessing stage, an excess of participants was considered. Eventually, 41 peer dyads ($N = 82$; 24 female-female, 6 female-male, 11 male-male) aged between 18 and 35 years old ($mean = 21.95$, $SD = 3.11$) were recruited via convenience sampling from the undergraduate research participation pool of School of Social Sciences, Nanyang Technological University and social media sites. Dyads recruited should have an existing peer (i.e., friend) relationship to avoid potential confounds related to varying social distances during interaction (Ventola, 1979; Hasan, 1978), particularly as it was found that different types of relationships (e.g., teacher-student, classmates, lovers, friends and strangers) have varying degrees of neurological (Sun et al., 2021; Pan et al., 2017) and physiological co-regulation (Bizzego et al., 2019), which could have a confounding effect in the present study. In this sample, dyads had an average peer duration of 49.38 months or approximately 4 years. Further, participants declared an absence of diagnosed medical or psychiatric conditions. Participants were reimbursed with academic credits or cash upon completion, depending on the source of their recruitment. The study protocol and materials were approved by [BLINDED] Institutional Research Board (IRB 2021–03–013).

Materials and Equipment

Interpersonal Reactivity Index (IRI; Davis, 1980). IRI is a measure of empathy comprising 28 items rated on a 5-point Likert scale. It includes four subscales: Fantasy, Empathic Concern, Perspective Taking, and Personal Distress (Davis, 1980). IRI has previously been used to detect changes in empathy before and after clinical interventions (Song et al., 2018; Yamada et al., 2018; Airagnes et al., 2014). Due to the inclusion of the Fantasy subscale which measures empathy in fictional contexts, IRI was ideal for the present study on role-play. According to Péloquin and Lafontaine (2010), IRI is effective even when adapted to measure empathy towards specific persons within the context of same-sex and different-sex dyads. Similarly, in this study, to further specify the measurement of empathic change to the dyadic interaction during role-play, items in IRI were modified following the procedures of Péloquin and Lafontaine (2010) to measure empathy towards participants' role-play partners instead of others in general. Both original and modified IRI showed adequate internal consistencies (Péloquin & Lafontaine, 2010; Davis, 1980), with Cronbach's alpha in this study being 0.69 and 0.85 for pre- and post-session measurements respectively.

Role-playing Prompts

Upon identifying a target character to be role-playing during the experimental conditions, participants answered open-ended prompts (Supplementary Information) on a hardcopy template to be familiar with the roles they have identified.

Role-playing Stimuli

The first condition is Naturalistic Conversation. In pairs, participants conversed about a predetermined scenario (shopping for a gift for each other at a shopping mall) without role manipulations (i.e., participants act as themselves). The second condition is Role-Play, where participants identify two other mutually known friends, colleagues or classmates (i.e., maintaining equal social distances) to role-play the same scenario. In Role-Play, the processes of empathic role-taking and behavioural reproduction, with the exception of role feedback, are expected to occur as participants adopt the roles of other people. Role feedback is not expected to occur in this condition as participants are not role-playing as each other, leaving no opportunity for the dynamic, continuous adaptation of role perception and behaviours in real-time. The third condition is Role Reversal, where participants role-play as each other in the same scenario. In Role Reversal, all three sociocognitive processes (empathic role-taking, behavioural reproduction and role feedback) are expected to occur. Each condition lasted 5 min, during which experimenters left the room. Precise role-play instructions and design considerations are presented in Supplementary Information.

Role-play Ratings

After Role-Play and Role Reversal conditions, participants answered a short survey to rate their perceived accuracy and immersion during the scenario, as well as their perceived relatability to their chosen characters on a Likert scale from 1 (= Not at all) to 5 (= Extremely). This data was used in confirmatory analyses to ensure that role-play conditions were experienced similarly by participants. Please see Supplementary Information for the precise questions.

Functional Near-infrared Spectroscopy (fNIRS)

During the laboratory session, participants' neurophysiological activity in the prefrontal cortex was recorded using fNIRS (NIRSport, NIRx Medical Technologies LLC). As participants attended the study in a pair, hyperscanning mode was used at a sampling rate of 7.81 Hz with 760 nm and 850 nm light wavelengths (Ferrari & Quaresima, 2012). NIRScap configuration is based on a 20-channel system with 8 sources and 7 detectors. Optode and channel positions were configured on NIRStar (v15.2, Windows 64-bit) to be similar to the international 10–20 system used in EEG recordings (Homan et al., 1987). Previous fNIRS studies have used the same channel configuration and corresponding brain regions (Azhari et al., 2022, 2020, 2019; Yamauchi et al., 2015). In this study, the fNIRS channels were further aggregated into four spatial clusters corresponding to frontal left, medial left, frontal right and medial right regions of the prefrontal cortex as reported by Azhari and colleagues (2019, 2022).

Procedure

After obtaining informed consent, an online survey containing IRI and demographic questions (e.g., participant age, sex) was completed at participants' own time. Lab sessions are arranged, where possible, within a week of the survey's completion.

The lab session adopted a within-subjects design with three experimental conditions presented in a counterbalanced randomised order. Experimental set-up consisted of two chairs angled 45 degrees to each other (Fig. 1). Videos were recorded during experimental conditions to obtain supplementary verbal data to be used during data pre-processing. Role-play prompts were completed by participants before commencing Role-Play and Role Reversal conditions. Prior to beginning each condition, role-play instructions were conveyed to participants both verbally and visually by flashing the scenario on a placard and reading its contents aloud.

After Role-Play and Role Reversal conditions, role-play ratings were completed. Additionally, IRI was administered again at the end of the lab session as a post-study measurement. Finally, participants were thanked and verbally debriefed on the purpose and significance of the study.

Data Analysis Plan

Pre-processing. From the five minutes of each experimental condition, the first and fifth minutes of data were truncated as beginnings and endings of conversations are structurally different to the main interaction (Levinson, 2013). Videos were therefore used to identify analysis timeframes, as well as to create conversational transcripts, from which irrelevant utterances demonstrating deviation from the role-play scenario and their corresponding fNIRS signals were identified and discarded. These utterances were identified based on a set of linguistic criteria from Andresen (2005), who characterised differences between participants engaged in role-play and metacommunication (i.e., communicating about communicating in role-play), as well as content relevance (e.g., whether participants were adhering to stimuli instructions). Exclusion criteria characterising metacommunication and irrelevant utterances are reported in Supplementary Information. Three post-graduate independent coders were trained on the criteria and achieved substantial inter-rater agreement (Light's Kappa = 0.65; Danilov et al., 2021; Landis & Koch, 1977; Light, 1971). At this point, data from Role-Play and Role Reversal conditions of 1 dyad were discarded entirely as their conversations were completely unrelated to the stimuli.

fNIRS data were pre-processed using the pyphysio Python package (Bizzego, Battisti et al., 2019), customised to the requirements of the present study using the Python programming language (Van Rossum & Drake, 1995). Signal quality of each channel was assessed using a trained machine learning model, based on convolutional neural networks (Bizzego et al., 2022). Motion artifacts were detected and corrected using a two-step procedure (Di Lorenzo et al., 2019) based on spline interpolation (Scholkmann et al., 2010) and wavelet filtering (Molavi & Dumont, 2012). Next, fNIRS raw signals were converted to oxygenated and deoxygenated haemoglobin (HbO and Hb) concentrations using the modified Beer-Lambert Law. To remove components not associated with brain activity, a third order, butterworth bandpass (0.01–0.5 Hz) Infinite Impulse Response bandpass filter was applied (Pinti et al., 2019). Finally, preprocessed HbO data were normalised and aggregated into four PFC clusters described above.

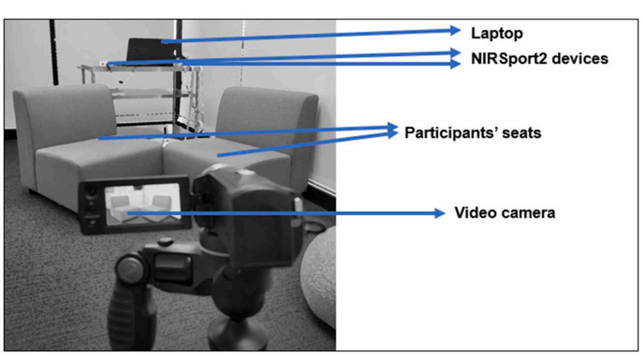

Fig. 1. Experimental set-up.

Following a naturalistic event-related approach for 1st-level general linear modelling (GLM), beta values of individuals' HbO data were calculated based on signals corresponding to onset times of relevant utterances. As experimental conditions were naturalistic in nature and not all participants produced utterances of similar lengths, varying windows of event durations lasting 2.5 s, 5 s, 7.5 s and 10 s were used, similar to the procedure in Bizzego et al. (2021). The use of different event durations account for various limitations with the data: event durations that are shorter may not be able to adequately model hemodynamic response after taking into account potential event onset delay during complex tasks (Li et al., 2019; Voss, 2016). At the same time, however, durations that are longer may suffer a higher likelihood of poor signal quality and smaller sample sizes. For example, for event duration = 2.5 s, utterances that were used in GLM calculations had to be at least 2.5 s long, and excessively long utterances were trimmed and only the initial 2.5 s used. As a result, at each event duration, a different number of participants produced valid data for each cluster (Table 1).

Statistical Analysis. Statistical analyses were conducted on RStudio (v1.3.1093, Windows 64-bit) using the R language (R Core Team, 2021), irr (v0.84.1; Gamer et al., 2019) and ltm packages (v1.2–0; Rizopoulos, 2006). Missing questionnaire data arising from technical errors on the survey platform, which represented 0.46% of the dataset, were addressed by imputation. Data were then assessed for normality using Shapiro-Wilk test (full results and descriptive statistics are reported in Supplementary Information). Due to non-normal distributions, non-parametric tests were used. Repeated-measures two-tailed Wilcoxon Rank-Sum test for role-play ratings was conducted to investigate potential perceived differences between conditions.

To investigate the first research hypothesis on the psychodrama sociocognitive model of RR, fNIRS beta values derived from 1st-level GLM were subtracted from each other (Role-Play - Naturalistic Conversation, Role Reversal - Role-Play) to obtain δ_1 and δ_2 respectively. Obtained values were then tested against a theoretical mean of 0 (i.e., no difference in activation between conditions) using a one-sample two-tailed Wilcoxon Rank-Sum test (Woolson, 2007). Contrast testing in neuroimaging studies is a common way of isolating relative changes in brain activation as a result of a change in stimuli, but it should be noted that absolute activation levels cannot be derived from this approach. Additionally, to explore and rule out potential effects of demographic variables (e.g., participant sex, age, and duration of friendship between the dyad), exploratory between-groups Mann-Whitney U-test (for the nominal variable of sex) and Spearman correlations (for the continuous variables of participant age and dyadic relationship duration) against significant δ values were also conducted. P-values were corrected across

Table 1
Remaining valid fNIRS beta values after pre-processing.

Cluster	2.5 s / n (%)	5 s / n (%)	7.5 s / n (%)	10 s / n (%)
Frontal Left	60 (73.17)	44 (53.66)	22 (26.83)	11 (13.41)
Medial Left	59 (71.95)	44 (53.66)	22 (26.83)	13 (15.85)
Frontal Right	47 (57.32)	34 (41.46)	15 (18.29)	9 (10.98)
Medial Right	46 (56.10)	34 (41.46)	15 (18.29)	11 (13.41)

Note: Percentages are calculated out of a total of N = 82 participants.

four prefrontal cortex clusters with False Discovery Rate (FDR) adjustment (Benjamini & Hochberg, 1995).

To investigate the second hypothesis concerning the effect of role-play on empathy, repeated-measures two-tailed Wilcoxon Rank-Sum test on pre-/post-lab IRI and its subscales was conducted (Hypothesis 2a). Spearman correlation with baseline (pre-lab) empathy scores and δ_1 and δ_2, where they emerged significant, were conducted to understand the relationship between empathy and changes in brain activation during role-play (Hypothesis 2b).

Results

Non-significant results are reported in full in Supplementary Information.

Role-play ratings and demographic variables

Repeated measures two-tailed Wilcoxon Rank-Sum test for role-play ratings revealed no significant differences ($p > 0.05$) between how Role-Play and Role Reversal conditions were perceived.

Assessing sociocognitive model of psychodrama role reversal

Table 2 reports findings of one-sample two-tailed Wilcoxon Rank-Sum tests across all four prefrontal cortex clusters, for each event duration, for δ_1 and δ_2. It was noted that there was a consistent significant finding of the frontal left cluster for most event durations for δ_1, where median was significantly lower than 0 (i.e., significantly lower activation during Role-Play as compared to Naturalistic Conversation). However, only δ_1 results tested from the 5 s event duration remained significant after FDR correction (V = 199, corrected $p = 0.0014$, 95% CI = [−0.50, −0.180]) with an estimated median of − 0.35. Therefore, in subsequent analyses, 1st-level GLM values from 5 s event duration were adopted.

To further elucidate the activation pattern in the frontal left cluster, exploratory analysis across all three conditions using Friedman Rank-Sum test was conducted. Results were significant ($\chi^2(2) = 8.3182$, $p = 0.016$). Post-hoc pairwise comparisons using Wilcoxon Rank-Sum exact tests revealed significant differences in activation between Naturalistic Conversation with Role-Play and Role Reversal (W = 1366, corrected $p = 0.0023$, 95% CI = [−0.50, −0.13] and W = 713, corrected $p = 0.0498$, 95% CI = [−0.34, −0.01] respectively), but no significant differences between Role-Play and Role Reversal ($p > 0.05$). Relative activation across conditions and the corresponding regions implicated in the frontal left cluster are visualised in Fig. 2.

Table 2
Test results between conditions.

Event Duration / s	Prefrontal Cortex Cluster	δ_1 / estimated median (uncorrected p)	δ_2 / estimated median (uncorrected p)
2.5	Frontal Left	-0.16 (0.02 **)	0.02 (0.85)
	Medial Left	0.08 (0.34)	-0.01 (0.90)
	Frontal Right	-0.01 (0.87)	0.03 (0.60)
	Medial Right	-0.07 (0.41)	0.05 (0.28)
5	Frontal Left	-0.35 (0.00035 ***)	0.12 (0.10)
	Medial Left	-0.00093 (0.97)	-0.01 (0.85)
	Frontal Right	-0.01 (0.88)	-0.06 (0.39)
	Medial Right	-0.16 (0.08)	0.09 (0.26)
7.5	Frontal Left	-0.27 (0.07)	0.12 (0.37)
	Medial Left	-0.01 (0.89)	0.18 (0.06)
	Frontal Right	0.08 (0.31)	-0.17 (0.07)
	Medial Right	-0.07 (0.64)	0.13 (0.14)
10	Frontal Left	-0.39 (0.02 *)	0.09 (0.37)
	Medial Left	-0.22 (0.16)	-0.25 (0.15)
	Frontal Right	0.03 (1)	0.35 (0.13)
	Medial Right	-0.10 (0.52)	0.14 (0.70)

Note: * , * *, * ** represent significance at $p < 0.05$, 0.01, 0.001 respectively.

Independent sample Mann-Whitney U-test between participant sex and significant δ_1 values were not significant ($p > 0.05$). Additionally, Spearman's correlations between these values with participant age and the dyad's relationship duration were also not significant ($p > 0.05$).

Assessing relationships between empathy and role-play

Repeated measures two-tailed Wilcoxon Rank-Sum test for empathy revealed significant pre-post changes in overall IRI (W = 4874, corrected $p = 1.64\text{e-}06$, 95% CI = [6.00, 12.00]), as well as in the Empathic Concern (W = 5407.5, corrected $p = 7.72\text{e-}11$, 95% CI = [4.00, 6.00]) and Perspective Taking subscales (W = 4671.5, corrected $p = 2.56\text{e-}05$). Changes in Fantasy and Personal Distress subscales were insignificant ($p > 0.05$).

When baseline empathy measures were correlated with δ_1 in the Frontal Left cluster, only the Fantasy subscale showed significant results ($\rho = 0.36$, uncorrected $p = 0.016$), but failed to remain significant following correction.

Discussion

The current study posed two research objectives: (1) to uncover neurophysiological underpinnings of the sociocognitive model of role reversal, (2a) to investigate pre-/post-role-play changes in empathy and (2b) to investigate correlations between baseline empathy on prefrontal cortical activity during role-play. Two hypotheses addressing the respective objectives are as follows: (1) there is differential prefrontal cortical activation across the three conditions, (2a) participants' empathy will increase after going through the role-play conditions and (2b) baseline empathy significantly correlates with prefrontal cortical activation changes across conditions.

Hypothesis 1. was partially supported. There was lowered activation in the frontal left cluster during Role-Play as compared to Naturalistic Conversation, although there were no significant differences between Role-Play and Role Reversal. Therefore, results partially support the sociocognitive model of psychodramatic role reversal, where introducing role-taking and behavioural reproduction processes from Naturalistic Conversation to Role-Play was correlated to significant changes in brain activation. Additionally, exploratory comparisons between all three conditions show significant differences between Naturalistic Conversation and role-play conditions Role-Play and Role Reversal, contributing to the notion that empathic role-taking and behavioural reproduction are processes during role-play that can be mapped to differential prefrontal cortical activity. Specifically, the frontal left cluster of the prefrontal cortex covers areas such as rostrolateral prefrontal cortex (i.e., lateral anterior prefrontal cortex; Bunge et al., 2009), inferior prefrontal cortex and the middle frontal gyrus.

Findings support previous reported patterns of deactivation (Brown et al., 2019) and particularly the implicated region of anterior prefrontal cortex in Karim and colleagues (2010). This region has been previously found to be involved in self-cognition (Herold et al., 2016; Denny et al., 2012; D'Argembeau et al., 2007; Heatherton et al., 2006). Lowered activation in this region follows the cognitive demands of perspective taking during Role-Play, as individuals rely less on self-knowledge and more on relevant memories of others as well as improvisational application of these memories in a spontaneous scenario. A related study by McCaig and colleagues (2011) highlights the importance of rostrolateral prefrontal cortical regulation in meta-cognition ability, which was trained by turning one's attention towards and away from one's own thoughts. During Naturalistic Conversation, greater rostrolateral prefrontal cortical activation may indicate increased self-monitoring of internal thoughts, including the coordination, integration and evaluation of one's thoughts (McCaig et al., 2011), suggesting a greater awareness of the self. In contrast, the demands of naturalistic role-play, although cognitively more complex, may reduce the need for

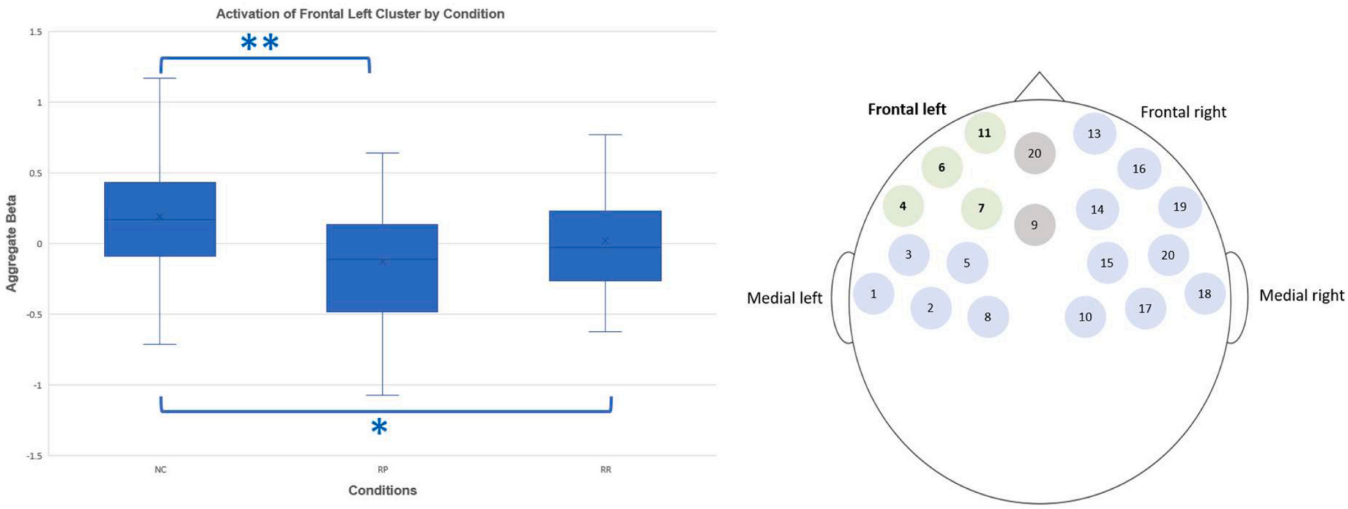

Fig. 2. (A) Relative activation in the FL cluster across conditions. (B) Implicated brain regions in FL cluster (green) include rostrolateral prefrontal cortex, inferior prefrontal cortex and the middle frontal gyrus. Numbers correspond to fNIRS channels included in each cluster.

rostrolateral prefrontal cortical activation due to the shifted focus away from the 'true self', and towards the role-play persona. Findings from Wicker et al. (2003), where decreased activation of the medial frontal gyrus was found when participants were tasked to focus on the external world as compared to internal self-referential tasks, corroborate this interpretation.

The lack of significant difference in prefrontal cortical activation between Role-Play and Role Reversal may be due to the dyadic nature of role feedback. Role feedback, as it entails bidirectional observation of the self and other and continuous adaptation of one's behaviour, is a process that can only be achieved in a social interaction and not in silo. Likewise, role feedback may not be characterised by differences in the individual's brain activation, but rather interpersonal co-regulation of brain activity (e.g., neurophysiological synchrony). Brain-to-brain synchrony is a burgeoning field of neuroimaging that studies the coordination of neural activity, especially in sociorelational contexts that rely heavily on interpersonal coordination and attunement (Carollo et al., 2021). Recent studies investigating synchrony in unstructured and improvisational tasks provide initial support for this conjecture. For example, it was found in Noy et al. (2015) study that behaviour mimicry in a spontaneous motor task (the mirror task) was characterised by synchronously increased heart rate in both participants. Movement data captured in an unstructured conversation by Fujiwara and Daibo (2016) also showed greater instances of synchrony between actual dyads during the interaction that are absent in pseudo-matched data. In other words, the dynamics of each social interaction elicit unique dyadic co-regulation that cannot be replicated among unrelated participants going through the same task. In this context, the adoption of each other's personas during Role Reversal requires heightened levels of observation, reflection and adaptation that may therefore influence dyads' neurophysiological co-regulation and synchrony, even if the specific neural processes implicated in these conditions remain similar. Future studies may consider dyadic characteristics as well as interpersonal measurements of brain activity to address this gap.

Incidentally, the robustness of GLM findings based on 5 s event duration lends support to a previous study conducted by Khan and Hong (2021) who determined an optimal stimuli duration of 5 s in fNIRS paradigms. In this study, 5 s event duration provided a feasible compromise between maintaining an appropriate sample size and obtaining quality fNIRS signals to model a hemodynamic response (Li et al., 2019; Voss, 2016).

Hypothesis 2a. was supported. Results showed significantly increased post-lab empathy compared to baseline, corroborating extensive literature on the effect of role-play on empathy (Rivers et al., 2016; Goldstein & Winner, 2012; Poorman, 2002; Martin-Smith, 1995). Based on the present findings, participants, after going through the lab study, were more likely to spontaneously adopt their partner's point of view and demonstrate other-oriented feelings of sympathy. In contrast to self-oriented empathic feelings measured in the Personal Distress subscale, which showed no significant changes, the present findings paint a favourable picture of the effects of role-play on developing adaptive empathy as opposed to destructive empathy whereby an individual is crippled by overwhelming distress in the face of others' suffering (Kim & Han, 2018; Batson, 2014). It is also encouraging that Perspective Taking subscale, which showed significant pre-post increases, is directly related to sociocognitive processes manipulated in the experimental conditions. Despite these findings, it should be noted that gains in empathy could not be attributed to any specific experimental condition due to the study design.

Hypothesis 2b. was not supported. Non-significance of this result may be due to non-normally distributed IRI data, resulting in statistical tests with less power. Although insignificant, it should also be noted that overall directions of correlation between empathy and brain activation changes are in agreement with Ames and colleagues (2008), where higher baseline empathy (especially within fictitious domains) is related to greater frontal left activation during Role-Play than Naturalistic Conversation. This finding may be explained by the overlaps in self- and social-processing in the frontal left cluster of the prefrontal cortex, as well as the perceived similarities between the self and the role-play character. Studies have shown that the anterior prefrontal cortex is consistently activated during both self- and other-related thoughts (McCaig et al., 2011). Mentalising about the self and others may recruit the same midline structures in the prefrontal cortex (Keysers & Gazzola, 2007), although studies by Majdandžić and colleagues (2016) and Mitchell et al. (2006) suggests that this overlap applies more strongly only when the other is similar (as compared to dissimilar) to the self. In this study, individuals with greater ability to empathise with another within fictional contexts (characterised by higher scores on the Fantasy subscale), and therefore can more closely represent their characters' inner states, may be able to recruit typically self-processing regions to a greater extent when mentalising and portraying another character. This conjecture may need to be confirmed in future studies. Beyond the prefrontal cortex, Herold and colleagues (2016) describe differential activations between self- and social-processing in other regions such as the temporoparietal junction, which was activated specifically in social-processing. As subcortical structures are excluded in fNIRS paradigms, whole brain imaging may be considered in future role-play studies to further understand neural recruitment during Role-Play and Role Reversal as compared to Naturalistic Conversation.

Limitations

The study has several limitations. Firstly, we could not disentangle the processes of empathic role-taking and behaviour reproduction using the present experimental design. While it may be possible to introduce an additional condition where participants were instructed to think of themselves as the character they had chosen but not act it out (i.e., isolating the process of empathic role-taking from behaviour reproduction), it would not have been feasible to adopt an event-related approach during data analysis due to the need for an observable behavioural output. To further enhance the robustness of the present study design, future studies may also consider including a comparable control condition.

Secondly, data was collected between August 2021 and August 2022 when mask-wearing mandates were enforced due to the COVID-19 pandemic. Therefore, 29.27% (n = 24) of participants had undergone the lab session masked and their facial expressions could not be observed by their partners and the research team. Facial cues are essential to the perception and communication of inner states, particularly as facial perception and mimicry contributes to the detection and expression of empathy (Balconi et al., 2011). Shepherd and Rippon (2023) found impediments to expression recognition, with implications on empathic concern when individuals were masked. It was observed that overcompensation via ocular movement and surrounding eye muscles is required to convey the same affect as when unmasked (Okazaki et al., 2021), indicative of potential altered behaviours in response to mask wearing (Wagemann et al., 2022). Neuroimaging studies also report parallel findings, indicating differences in resting brain activity and functional connectivity when masked (Wu et al., 2023), resulting in a 'neural signature' related to impaired expression recognition as a product of exposure to masked faces (Prete et al., 2022). In the present context of role-play, remaining masked may affect the robustness of behavioural reproduction and role feedback processes, potentially explaining the lack of significant findings surrounding δ_2. While not the aim of the current study, an exploratory comparison of delta activations between masked and unmasked participants was conducted and reported in Supplementary Information, but interpretation of the results would require the contribution of future studies.

Thirdly, as this study focused purely on the technique of role reversal and its theoretical sociocognitive model, some elements of psychodrama were omitted from the study design. This included the presence of a qualified psychodramatist, as well as auxiliary egos (other participating group members; Giacomucci, 2021). The full psychodrama structure including warm-up and sharing is also excluded, which may limit the generalisability of the study findings to longer, more intensive psychodrama sessions. Additionally, the study recruited only participants from non-clinical settings, and only participants who share similar pre-existing social relationships. This limits the generalisability of study results to those with diagnosed psychological conditions, who represent the bulk of clients pursuing psychodrama interventions, as well as participants from more diverse backgrounds and social relationships. Furthermore, it has been shown that individuals with depression show differential activation patterns pertaining to self-reference (Sheline et al., 2009), which further changed over the course of the disorder (Lemogne et al., 2010). On the aspect of differing social relationships, changing dynamics and social distances between individuals may also have an impact on role-play behaviour and consequently empathy. In fact, an interesting neuroimaging study by Meyer et al. (2013) confirm that empathy towards strangers and friends recruit different regions of the brain and therefore implicate different sociocognitive processes. Therefore, the same pattern of results needs to be replicated in clinical populations and expanded to consider participants with more diverse social backgrounds and relationships.

Finally, the choice of self-report empathy measures opens up issues related to desirability biases and lack of insight. Other measures of empathy such as second- and third-party ratings (Lima & Osório, 2021), as well as behavioural observations may be considered in future studies to provide corroborative evidence.

Conclusion

The study represents an initial investigation into neurophysiological mechanisms underpinning role reversal, a cornerstone technique of psychodrama interventions. Results showed lowered activation in the anterior left region of the prefrontal cortex during Role-Play as compared to Naturalistic Conversation. Due to the region's involvement in self-cognition, findings may be due to decreased recruitment of self-referential networks during Role-Play as compared to Naturalistic Conversation (i.e., participants behaving as themselves), where self-referential knowledge is needed. Findings provide partial support to the sociocognitive model of role reversal, although further studies are necessary.

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CRediT authorship contribution statement

Conceptualization, M.L., G.E.; Methodology, M.L., A.B., S.H.A.C., G. E; Software, A.B.; Formal analysis, M.L.; Writing - original draft. M.L., A. C., A.B.; Writing - review & editing, M.L., S.H.A.C., G.E.; Visualization, M.L.; Supervision, S.H.A.C., G.E.; Funding acquisition, G.E. All authors contributed to the article and approved the submitted version.

Conflict of Interests

The authors declare no conflicting interests.

Data availability

The raw data supporting the conclusions of this article will be made available by the authors on request, without undue reservation.

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Appendix A. Supporting information

Supplementary information associated with this article can be found in the online version at doi:10.1016/j.aip.2023.102098.

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