

Integrating Core Conflictual Relationship Themes in neurobiological assessment of
interpersonal processes in psychotherapy

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Abstract

Interpersonal processes are a key target in counselling and psychotherapy. It is of paramount importance to sharpen their assessment using integrated methods. Hence, this methodological paper describes how fields of research in psychotherapy and neuroimaging can be integrated into one novel complementary neurobehavioural paradigm that can be applied to enhance our understanding of interpersonal processes in psychotherapy. To illustrate this integration, we present selected data from a pilot pre-post-study where the authors assessed interpersonal processes in brief treatment for Borderline Personality Disorder (BPD) using the Core Conflictual Relationship Theme (CCRT), functional Magnetic Resonance Imaging (fMRI) and outcome questionnaires. To do so, they measured individual changes in neural activity using an fMRI task pre and post treatment where clients gave feedback on the emotional valence of sentences extracted from their own Relationship Anecdote Paradigm (RAP) interviews mixed with neutral ones. In this paper, using data from two participants of said study, we discuss how to implement this methodology and what can be achieved in terms of results.

Keywords: methodological paper, functional magnetic resonance imaging, core conflictual relationship theme, neuroimaging assessment, interpersonal processes, borderline personality disorder

Interpersonal processes are a key target in counselling and psychotherapy. Across helping contexts, clients present problems in the interpersonal domain and therapists and counsellors are asked to intervene based on interpersonally informed intervention models (e.g., Benjamin, 2003; Pettit & Joiner, 2006; Schnell & Herpertz, 2018). A core task in many psychotherapy approaches has been to develop and validate descriptive methods aiming at the precise assessment of interpersonal processes (Barber & Crits-Christoph, 1993; Luborsky & Diguier, 1998), and of change observed in these processes over the course of treatment (Tompkins & Swift, 2014). In this context, interpersonal processes may be defined as the client's representations of interaction patterns which have been internalized and which generate current experiences and interaction styles (Benjamin, 2003).

Various interpersonal conceptualizations exist (Benjamin, 2003; Horowitz & Eells, 1997; Kiesler, 1996; Leary, 1957; Schaefer, 1965) but tend to focus on the represented pattern of interaction, leaving out, for the most part, the client's motivational component related to one's wishes, needs and fears. The Core Conflictual Relationship Theme, derived from Luborsky's work on psychodynamic psychotherapy (CCRT; Luborsky & Crits-Christoph, 1998) addressed this shortcoming of the earlier models and proposed to conceptualize mental representations of interaction patterns by using three components: a) the wish (desire, need or intention of the client), b) the response from others and c) the response of the self.

A few studies focused on neurobiological underpinnings of interpersonal processes in psychotherapy and psychopathology (Buchheim et al., 2006; Kessler et al., 2011). Whereas these studies used systematized methodologies to assess interpersonal processes, they did not specifically focus on core conflictual relationship processes as conceptualized within the CCRT tradition. This was done in the study by Loughhead et al. (2010). These researchers recruited healthy controls ($N = 16$) who underwent a Relationship Anecdote Paradigm (RAP; Luborsky, 1998) as psychological assessment, including a series of relationship episodes and

the participant's rating of emotional arousal related with the episode. A summary score of interpersonal processes' pervasiveness across the narratives serves as indicator of repetitiveness of a specific core theme for a particular participant. Six weeks later, the same participants underwent an fMRI assessment in which the specific narratives were presented in extended formats. The neural activations related to the individual's CCRT narratives are compared with the ones associated with neutral narratives; the latter had no autobiographical content, but were similar in terms of structure, emotion and CCRT content. The selection of the control sentences is central here and demonstrates the researchers' particular interest in the role of autobiographical memories in the interpersonal processes. Consistent with this approach, this study evidenced that the individual's CCRT correlated with activation in the left hippocampus, parahippocampal gyrus and middle occipital gyrus. Interpreting these results, Loughead et al. (2010) suggested that "the recall of RAP autobiographical relationship narratives leads to increased activation in region associated with autobiographical memory, emotion processing, theory of mind, and a putative mirror system" (p.330).

Given these findings, it appears that integrating the CCRT methodology with fMRI is promising, although several challenges need to be addressed beforehand. Mainly it is important to disentangle as best as possible the assessment of memory structures (e.g., a specific episodic memory of an interaction from the past) from interpersonal processes (e.g., a more schematic memory implying the representation of typical and repetitive interaction patterns).

Description of the methodology

Two core aspects of the methodology we used are its integration of the CCRT in neurobiological assessments (fMRI) and the individualization of stimuli. To address the memory structures challenge (episodic/schematic), we standardized the individualized stimuli in a way that left more autobiographic markers out, so that they would evoke generalized

interactional patterns rather than autobiographical memories. We think that this way the proposed task assesses the process that was originally being conceptualized by the CCRT (Luborsky & Crits-Christoph, 1998). While the CCRT provides a validated and clinically relevant way of studying idiosyncratic interpersonal processes in counselling and psychotherapy, neuroimaging allows us to monitor its change at a neurobiological level. As shown in earlier studies (Hooley, Siegle, & Gruber, 2012) the use of personalized stimuli is productive under certain methodological circumstances (Kramer, 2019).

Pascual-Leone, Herpertz and Kramer (2016) described the sometimes overlooked problems researchers run into when they use standardized stimuli in experimental designs in the study of emotion. They argued that the assumption that a particular standardized stimulus (e.g., from a picture databank) evokes a comparable emotional reaction across participants is problematic. Instead of standardizing the emotional stimulus, Pascual-Leone et al. (2016) proposed to standardize the anticipated emotional response, and to individualize the emotional stimulus deemed to evoke the named emotional response. We would suspect that, even though this criticism mostly applies to emotion research, similar tenets might apply to the study of interpersonal processes in counselling and psychotherapy. The assumption that a standardized interpersonal stimulus (e.g., a picture or a movie demonstration of social exclusion) evokes a between-individual comparable reaction (substantiated by emotion arousal) is problematic. Individualizing the specific interpersonal stimulus (e.g., by providing the words used when rejecting *this* particular individual) enables to study the salient core process, and the individual's emotional reaction to it. Across time (and with effective psychotherapy), the individual's core meaning of social interactions may change across time points in a way that may let emerge increasingly adaptive information. This process might be underpinned by the regularities described from memory reconsolidation, where the construction of new and healthier narratives is the end-product of a complex process of memory recall, emotional

arousal and transformation (Lane, Ryan, Nadel, & Greenberg, 2015). Thus, we propose that assuming all individuals react to the same standardized interactional stimulus in the same way is problematic and undermines internal and external validity of an experimental design.

Assessment. Assessments should take place at least before and after the treatment. Clients should be tested in the fMRI at the same point of their menstrual cycles. The assessment of interpersonal processes on a neurobehavioural level should encompass (1) a behavioural assessment component and (2) a neuroimaging assessment component, planned 1 week apart for both assessment points. Treatment outcome and level of arousal should also be assessed.

Neurobehavioural assessment of interpersonal processes

(1) *Psychological assessment*, Individualized narrative descriptions of interpersonal functioning can be obtained from participants using the Relationship Anecdotes Paradigm (RAP). This method uses a semi-structured interview to elicit narratives about the individual's relationships with others (Luborsky, 1998). The RAP was designed to elicit Core Conflictual Relationship Patterns, and focuses primarily on the elicitation of negative CCRTs. As such, it provides a validated interview framework to directly assess the psychological components of the CCRT which are the Wish (W), the Response from Others (RO) and the Response from the Self (RS).

When well trained in the use of the method, CCRT judges achieve good reliability (Crits-Christoph et al., 1988) and Barber, Luborsky, Crits-Cristoph and Diguier (1995) found a high degree of agreement and fairly good kappas. Luborsky et al. (1985) found a good convergent validity of CCRT "improvement" with standard improvement measures such as the Hopkins Symptom Checklist total score (change in the main positive RO was significantly correlated with change on the Symptom Checklist, $r = -.79$, $p < .05$) and the Health-Sickness

Rating Scale (change in the pervasiveness of the main negative response to self was significantly correlated with change in Health-Sickness Rating Scale, $r = -.81$, $p < .05$, and change on the main wish, $r = -.73$, $p < .05$.)

Using the RAP method, participants should be asked to recall and describe 6 meaningful interpersonal interactions they experienced within 3 different fields. The first one should be related to relationships episodes with friends, family members or significant others, the second one to work colleagues, bosses, teachers or school mates while the third and last one should be related to caregivers such as psychotherapists, psychologists, counsellors, psychiatrists or nurses. The RAP interview should last around 35 minutes, be video-taped, transcribed word by word and then used for two aims in the following step of the procedure: a) coding of the CCRT (Luborsky & Crits-Christoph, 1998) and b) extracting 15 stimulus sentences for the presentation during the neuroimaging assessment with the same client. The interviews should be transcribed and scored by trained raters using the standard CCRT method Luborsky and Crits-Christoph (1998).

(2) *Neuroimaging assessment.* Participants should undergo MRI scanning during a passive viewing task. The stimuli should be 15 individualized relationship brief sentences with identical syntax retrieved from their respective RAP interview and 15 standardized neutral unspecific brief sentences (see Tables 1 and 2). The sentences should be presented in a randomized order in the Cogent software developed by the Cogent 2000 team at the FIL and the ICN and Cogent Graphics developed by John Romaya at the LON at the Wellcome Trust Centre for Neuroimaging, University College London, UK. Cogent Graphics is a graphics toolbox for MATLAB on the PC that can be used to generate real-time graphical animations for use as stimuli in visual experiments. The participants should receive the following instruction: “Read the sentence and imagine the situation”. After each presentation of a stimulus, the

emotional arousal should be assessed on the Self-Assessment Manikin scale (Bradley & Lang, 1994; projected while in the scanner).

fMRI data acquisition. The neuroimaging experiments for fMRI data acquisition should follow the well-established methodology of blood-oxygen-level-dependant (BOLD) imaging followed by standard data processing and statistical analysis in the framework of SPM12. The fMRI data should be acquired on a 3T MRI scanner with a 64-channel head coil using a 2D EPI sequence. The acquisition parameters should be as follows: 3 x 3 x 3 mm³: TE = 30 ms, slice TR = 66 ms, 30 slices, flip angle = 90°. The structural MRI data should consist of T1-weighted MPRAGE images (TR = 2000 ms; TI = 920 ms; $\alpha = 9^\circ$; BW = 250 Hz / pixel; readout in inferior-superior direction; FoV = 256 x 232 mm; 176 slices) at 1 mm resolution. At the current stage of knowledge, a whole brain analysis should be used.

fMRI data pre-processing. All data pre-processing should be performed using the freely available Statistical Parametric Mapping software (SPM12; Wellcome Trust Centre for Neuroimaging, <http://www.fil.ion.ucl.ac.uk/spm/>) running under Matlab 7.13 (The MathWorks, Inc., Natick, Massachusetts, United States). EPI images should be realigned to the subject's average image across runs, corrected for spatial distortions using the SPM field-mapping tools (Hutton, 2002). The parameters of registration to standardized MNI space should be calculated on the anatomical image and the default settings of the "unified segmentation" framework followed by the diffeomorphic registration algorithm DARTEL (Ashburner & Friston, 2005; Ashburner, 2007). The spatial registration parameters should then be applied to the functional time-series co-registered to the corresponding individual's anatomical scan. Prior to statistical analysis, a spatial smoothing with a Gaussian kernel of 8 mm full-width-at-half-maximum should be applied.

Because of length constraints, further technical details on the fMRI assessment are available upon request to the first author.

(3) *Level of arousal*

Self-Assessment Manikin. The SAM (Bradley & Lang, 1994) is a self-assessed questionnaire using a single item to measure the momentary level of arousal using a 9-point Likert scale, ranging from “not excited at all”(1) to “very excited”(9). The scale is illustrated as a series of human shaped figures displaying varied levels of activation. It is widely used in emotion research and has proven its validity and reliability (e.g., Bradley & Lang, 1994).

While we applied this methodology in the context of a pilot pre-post-study for assessing interpersonal processes in treatment for Borderline Personality Disorder (BPD) and showed its feasibility in this context, the present methodological paper assumes the relevance of this methodology for any longitudinal assessment of interpersonal processes related to intervention in counselling and psychotherapy.

Illustration of a study applying this methodology in the context of psychotherapy research

We present here two female participants’ complete dataset related to their interpersonal processes from a pre-post pilot study. Both clients were diagnosed with BPD and received a brief 10-session treatment as part of the study. More details on the study design, the treatment and the sample of this pilot study can be found in the original study that took place in a French-speaking University environment (Kramer et al., 2018). We chose Linda and Suzan (names were changed in order to protect their identity) because of their marked between-person differences in relationship patterns as reflected in their individualized stimuli (see Table 1). Both were assessed by trained clinicians using the SCID-II, a diagnostic structured interview used to determine DSM-IV Axis II disorders (First & Gibbon, 2004). They were non-medicated, right-handed and presented no neurological disorders, bipolar disorder I nor schizophrenia. They accepted that their data be used for research and the trial

was approved by the competent institutional ethics board (internal identification number 125/15).

Treatment outcome

Outcome Questionnaire–45.2

This self-report questionnaire encompasses 45 items aiming at assessing results yielded from treatment (Lambert et al., 2004), including a global score and three subscale scores: symptomatic level, interpersonal relationships, and social role. These items were assessed on a Likert-type scale ranging from 1 (never) to 4 (always); a total sum score (ranging from 0-180) and scores per subscale were computed. On the total score, which is calculated by summing all 45 items, the higher the score, the more disturbed the client. There is a cut-off score at 63 or more that indicates symptoms of clinical significance. The scale has been translated and validated in French (Emond et al., 2004). This questionnaire was given at intake and at discharge of treatment. Cronbach's alpha for the 8 participants sample was $\alpha = .89$.

Borderline Symptom List

The Borderline Symptom List (BSL-23) is a self-report questionnaire that assesses specific borderline symptomatology using 23 items, and it is a short version of the more extensive BSL-95 (Bohus et al., 2007), for which excellent psychometric properties were reported. Similar results were found for the short version (Bohus et al., 2009). The items are assessed using a Likert-type scale ranging from 0 (absent) to 4 (clearly present); an overall mean score is computed (0-4). The French translation (Page, Kramer, & Berthoud, unpublished data, 2010) was approved by the authors of the scale. Cronbach's alpha for the 8 participants sample was $\alpha = 0.90$.

Procedure

Linda and Suzan received information concerning confidentiality, the voluntary aspect of their participation and on the detailed study procedure. A member of the research team reviewed the different points of the informed consent with each participant making sure they were thoroughly understood and answered any questions. Both participants agreed and signed the informed consent. Linda and Suzan were assessed pre and post treatment. They both met a researcher who led the psychological investigation. They answered self-reported questionnaires (OQ-45, BSL-23, and SAM) and completed the semi-structured Relationship Anecdotes Paradigm (RAP) interview. Specific narratives stimuli were then extracted and turned into 15 individualized sentences. One week after that, they were invited to the neuroscience lab where they underwent a functional magnetic resonance (fMRI) imaging. During the fMRI, they were shown their individualized interpersonal sentences and standardized sentences in a randomized order (see Tables 1 and 2). They were asked to rate their emotional arousal after seeing the stimuli. Right after the end of the treatment, they underwent the same assessment (self-reported questionnaires and RAP interview, fMRI). For the post-therapy fMRI assessment, the clients were exposed to their own sentences that were extracted from the post-therapy psychological assessment (RAP). On a methodological level, the decision to present different stimuli at T1 and T2 was made to avoid an habituation effect. On a conceptual one, we chose to use different individualized stimuli at T1 and T2 because our aim was to assess change in the individual's representation of interpersonal processes, their psychological and neurofunctional correlates at both time points, rather than the change in the individual's reaction to the initial formulation of the CCRT. Providing new stimuli at the second assessment leaves the door open to new content, which is more central to the individual, so it ultimately is in keeping with our fundamental assumption of the centrality of the individual's own content at each time point.

Behavioural data analysis. For the behavioural outcome, we calculated the pervasiveness for each component of the CCRT (W, RO, RS) of each participant's RAP interview – that is, one before the treatment and one after it.

Results

Post-treatment, both Linda and Suzan had good outcome. They both showed clinically significant improvement on their OQ-45 and BSL-23 scores implying a reduction in symptoms' severity. On the OQ-45 total score, Linda's score decreased of 34 points (-64.2%) going from 95 pre-therapy to 61 post-therapy whereas on the BSL-23 she showed a 0.6 point decrease (-51.3%) going from a 1.17 mean pre-therapy to a 0.57 one post-therapy. On the OQ-45 total score, Suzan's score decreased of 55 points (-35.9%) going from 153 pre-therapy to 109 post-therapy and showed a 1.65 point decrease (-45.2%) on her BSL-23 mean, going from 3.65 pre-therapy to 2.00 post-therapy.

Despite having very distinct individualized sentences (Table 1), Linda and Suzan have roughly similar predominant CCRT patterns on the level of the CCRT categorical system (Table 4). For both of the participants, the RO themes are identical pre- and post-therapy: "They are rejecting and opposing me" (CCRT cluster 5). Similarly, their post-therapy RS themes also identical: "I am disappointed and despaired" (CCRT cluster 7). However, they differ in their W themes pre- and post-therapy: "To be distant, avoid conflict" (CCRT cluster 4) and "To be loved and understood" (CCRT cluster 6) for Linda and twice "To be close to others and accept them" (CCRT cluster 5) for Suzan.

Regarding the individualized stimuli related to their CCRT, it appears that for Linda, the main RS' associated emotion is sadness and hopelessness ("I feel sad", "I feel powerless") whereas for Suzan, it seems that it is rather anger and hostility ("I feel angry", "I'm acting haughty"). Thus, despite having received the same diagnosis both clients show great

discrepancy in their RS which may speak to an individualized perspective on assessment of interpersonal processes.

Figures 1 and 2 represent statistical parametric maps (SPMs) of blood-oxygen-level-dependent (BOLD) correlates of neural activity changes in Linda's brain obtained using our integrative neuro-behavioural approach. fMRI data acquired during the interpersonal task are analysed on voxel-by-voxel basis using the General Linear Model. SPMs projected on a T1-weighted image in standard Montreal Neurological Institute (MNI) space represent the statistically significant voxels corresponding to greater neural activity changes over time associated with the personalized sentences compared with neutral ones. Given the fact that we present statistical results from a single individual at two time points, the validity of our inferences is limited. Nevertheless, the fact that we demonstrate intervention-associated changes in neural activity in the hippocampus, the insula and nucleus accumbens representing part of the limbic network, lends some confidence in our approach. Given the many distinct and simultaneous brain activations required to read (individualized) stimuli that can interfere with our research target - the change of CCRTs during treatment - we rely on the assumption of cognitive subtraction (i.e. additive effects, see Price, Moore, & Friston, 1997) to infer on CCRTs unique contribution. Here, the inference on CCRT-associated neural activity is calculated using the differential contrast between individualized stimuli vs neutral stimuli over time, rather than the main effect of individualized stimuli versus the rest condition over time. In this way, we are convinced that the cognitive subtraction strategy, particularly in the context of time/intervention-dependent changes will minimize the polluting effect of additional cognitive resources on the specific networks underlying CCRT. Of course, the assumption of cognitive subtraction precludes the absence of interaction effects at different levels that will surely be true for at least some of the studies functions.

Illustrations of specific clinical material

Table 1. Linda’s and Suzan’s individualized fMRI stimuli pre- and post-therapy

	Linda	Suzan
Pre-therapy	<ul style="list-style-type: none"> • I want to say goodbye to my grandfather (W), he dies (RO) and I feel sad (RS) 	<ul style="list-style-type: none"> • I want to be respected by the therapist (W), he interrupts me (RO) and I feel angry (RS)
	<ul style="list-style-type: none"> • I want my girlfriends to support me, they are against me and I feel like a loser 	<ul style="list-style-type: none"> • I want my father to leave me alone, he shouts at me and I feel angry
	<ul style="list-style-type: none"> • I want to be respected by my family, I am being ignored and I feel sad 	<ul style="list-style-type: none"> • I want my physician to listen to me, he does not respect me and I feel angry
	<ul style="list-style-type: none"> • I want Laura to defend me, she’s tough and I feel powerless 	<ul style="list-style-type: none"> • I want to be respected by my physician, he is on his phone and I feel angry
	<ul style="list-style-type: none"> • I want to trust Diana, she turned the whole class against me and I feel sad 	<ul style="list-style-type: none"> • I want my brother to listen to me, he does not respect me and I’m acting haughty
	<ul style="list-style-type: none"> • I want my grandmother to stay here, she leaves and I feel sad 	<ul style="list-style-type: none"> • I want to be respected by the caregivers, they do not respect me and I do as I please

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- Post-therapy
- I want the physician to be warm, he is cold and I feel uncomfortable
 - I want my father to accept me, he excludes me and I feel sad
 - I want my therapist to be present, he distances himself and I distance myself
 - I want to be left alone by ma mother, she controls me and I feel sad
 - I want Karin to understand me, she ignores me and I distance myself
 - I want my friend to support me, she criticizes me and I scream
 - I want my psychiatrist to explain how he can help me, he doesn't understand and feel frustrated
 - I want my former psychologist to give me a certificate, she doesn't understand and I cry
 - I want my social worker to leave me alone, she doesn't care and I feel helpless
 - I want my social worker to explain how she can help me, she refuses and I feel depressed
 - I want my psychiatrist to leave me alone, he doesn't care and I feel incomprehension
 - I want my ex-boyfriend to leave me alone, he refuses and I cry

Note. Names were changed, in order to protect the identity of the persons involved. W = wish. RO = Response from the Object. RS = Response form the Self. All stimuli have a similar syntax. _____

Table 2. Neutral fMRI stimuli pre- and post-therapy for both Linda and Suzan

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- › I want to trust the cashier (W), she helps me (RO) and I feel ok (RS)
 - › I want to avoid conflict with the tick office employee, he respects me and I feel ok
 - › I want to deal with an open-minded pharmacy assistant, she supports me and I feel ok
 - › I want to assert myself with the vegetables salesman, he cooperates and I feel ok
 - › I want to be independent from the cleaning lady, she respects me and I feel ok
 - › I want to be open with the receptionist, he helps me and I feel ok
 - › I want to be respected by the theatre employee, he gives me what I need and I feel ok
 - › I want to be myself with the stewardess, she understands me and I feel independent
 - › I want to be accepted as I am by the swim teacher, he facilitates my independence and I feel ok
 - › I want to be helped by the cleaning lady, she is open to it and I feel ok
 - › I want to be correct with the flowers salesman, he accepts me and I feel ok
 - › I want to succeed in what I am doing with the fitness instructor, he supports my ambition and I feel ok
 - › I want to be correct with the cashier, she respects me and I feel ok
 - › I want to be supported by the butler, he helps me and I feel ok
 - › I want to trust the taxi driver, he understands me and I feel ok
-

Table 3. Changes in Linda's and Suzan's symptoms pre- and post-therapy

Time points	Questionnaires	Linda	Suzan
	OQ-45 (0-180)	95	153
Pre-therapy	BSL-23 (0-4)	1.17	3.65

	OQ-45 (0-180)	67	109
Post-therapy	BSL-23 (0-4)	0.57	2.00

Table 4. Linda's and Suzan's CCRT themes pre- and post-therapy

	Linda	Suzan
	W	W
	<ul style="list-style-type: none"> To be distant, avoid conflicts (40%) 	<ul style="list-style-type: none"> To be close to others and accept them (67%)
	RO	RO
	<ul style="list-style-type: none"> They are rejecting and opposing me (60%) 	<ul style="list-style-type: none"> They are rejecting and opposing me (50%)
Pre-therapy	RS	RS
	<ul style="list-style-type: none"> No specific response (20%) 	<ul style="list-style-type: none"> I am disappointed and despaired (71%)
	W	W

	<ul style="list-style-type: none"> To be loved and understood (67%) 	<ul style="list-style-type: none"> To be close to others and accept them (83%)
	RO	
	<ul style="list-style-type: none"> They are rejecting and opposing me (33%) 	<ul style="list-style-type: none"> They are rejecting and opposing me (83%)
	RO	
Post-therapy	RS	
	<ul style="list-style-type: none"> I am disappointed and despaired (67%) 	<ul style="list-style-type: none"> I am disappointed and despaired (50%)
	RS	

Figure 1. Statistical parametric maps (SPMs) interaction analysis between SENTENCES (personalized [PERS] or neutral [N]) and TIME (time point 1 [TP1] versus time point 2 [TP2]) in the bilateral hippocampus for Linda. T-values surviving $\alpha = 0.05$ uncorrected for multiple comparisons projected on a canonical anatomical image in Montreal Neurological Institute (MINI) space.

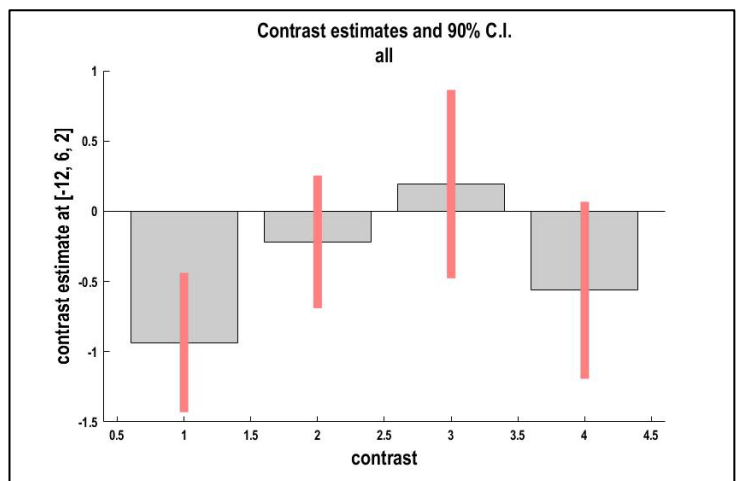
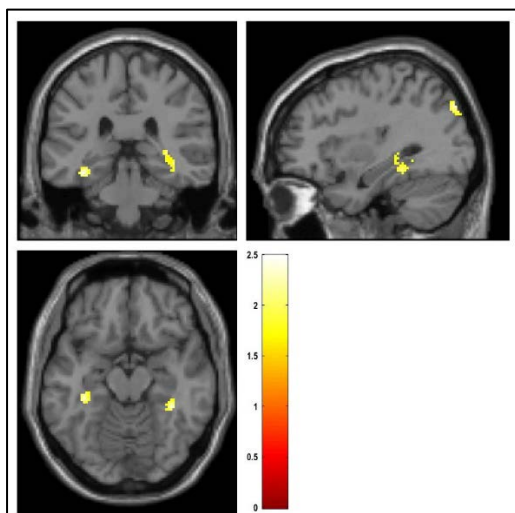
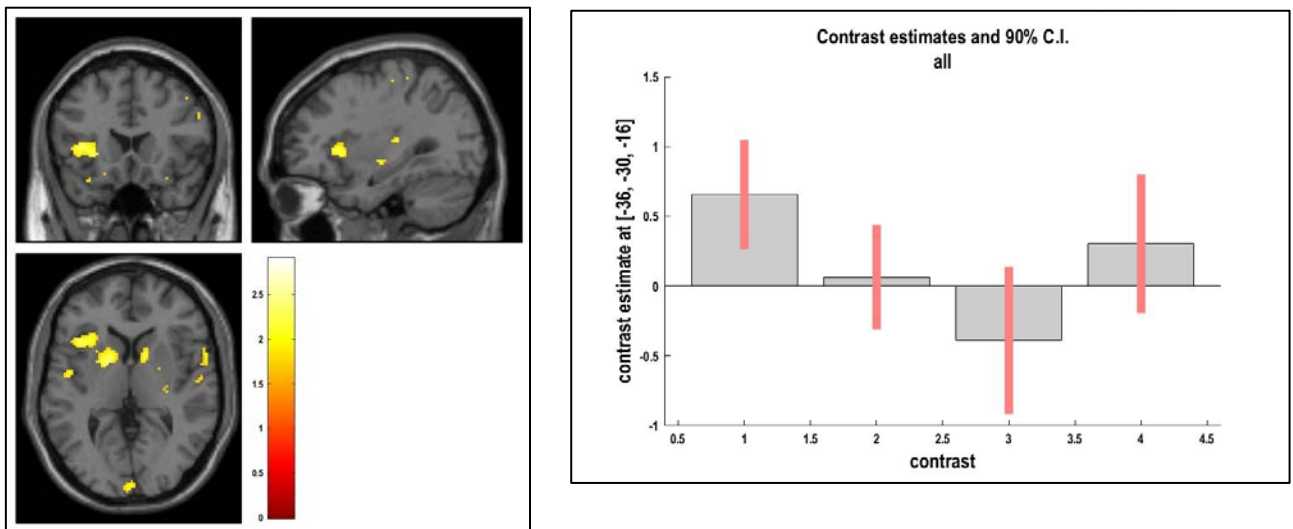


Figure 2. Statistical parametric maps (SPMs) interaction analysis between SENTENCES (personalized [PERS] or neutral [N]) and TIME (time point 1 [TP1] versus time point 2 [TP2]) in the nucleus accumbens and the insula for Linda. T-values surviving $\alpha = 0.05$ uncorrected for multiple comparisons projected on a canonical anatomical image in Montreal Neurological Institute space (MINI).



Discussion of the illustration

The present methodological contribution aims to argue in favour of an integrated methodology drawing from psychotherapy process and neuroimaging, when assessing interpersonal processes. We argued that the use of individualized stimuli might, under certain

circumstances, be a productive way of assessing the multi-level activations related with interpersonal processes in psychotherapy and their expected change over time. The main advantage of combining methods from the field of psychotherapy research and of neuroimaging is to address interpersonal processes with various complementary perspectives to better grasp its properties, but also inherent limitations. There is a partial overlap between our observations and those of Drapeau and Perry (2009), providing further evidence that the diagnosis of BPD is associated with very specific, and individual-dependent narrative descriptions of interpersonal functioning and processes. The use of the proposed integrated methodology allows for a more detailed information collection. Between T1 and T2, there is a reduction of Linda's RO's pervasiveness (Table 4) which is also associated with a reduction in symptomatology (Table 3) and may be reflected on the neurobiological level in changes in parts of the limbic network, namely the hippocampus, the insula and nucleus accumbens (figures 1 and 2).

The psychological component alone of the proposed methodology can inform practice and lead to the use of CCRT manual-based treatments (Jarry, 2010; Perry, Knoll, & Tran, 2019; Sahin, Barber, & Luborsky, 2017). The clinical application of using the conjunction of a CCRT and an fMRI assessment remains unclear. However, studies using the proposed integrated methodology could help setting benchmarks in regard of what changes at a psychological as well as a neurofunctional level can be expected to happen, in what timeframe and where in the brain. When a client in a clinical setting would deviate from such newly developed norms, clinicians could adjust the treatment accordingly. Following our protocol, let us take the example of a patient diagnosed with a BPD following a treatment. He/she would change as expected on the psychological level (CCRT) but would present with a different pattern of neurofunctional activation at the end of the treatment, for example an increased activation in prefrontal areas rather than the expected decrease observed in the other

clients. The clinician, mindful of this divergence in his/her client could then focus on the themes brought up by this client in order to help him/her moving past repetitive interpersonal patterns, or clarify and transform the traumatic origins of the memories incorporated in the CCRT. The treatment would have been informed by the neurobehavioural integrated methodology and adjusted accordingly.

Although challenging to implement, this integrated neurobehavioural paradigm may be useful, notably for assessing processes of change in complex mental disorders, where there is evidence of interpersonal processes affecting both the psychological structures, as well as neurofunctional activations: Borderline Personality Disorder (Marceau, Meuldijk, Townsend, Solowij, & Grenyer, 2018; Ruocco, Amirthavasagam, Choi-Kain, & McMains, 2013). It may also be of interest for the assessment of other clinical presentations like Antisocial Personality Disorder (Herpertz, 2013), hostility (Mancke, Herpertz, & Bertsch, 2015) or the interpersonal aspects of depression/chronic depression (Schnell & Herpertz, 2018). More generally, it may cast lights on the interpersonal processes unfolding in counselling and psychotherapy such as alliance ruptures and repair (Eubanks, Muran, & Safran, 2018). Moreover, understanding of the brain activation during key interpersonal processes could lead to more precise research conclusions and more tailored – and presumably more effective – psychotherapies (Schnell & Herpertz, 2018).

For practice-based research, once the interpersonal task we propose is well validated and explored thanks to the state-of-the-art fMRI technology, one promising “lighter”, less time-consuming assessment could be the functional near-infrared spectroscopy (fNIRS). As demonstrated in their study, Ruocco et al. (2016) it is possible to use the fNIRS neuroimaging procedure in clinical settings.

In conclusion, because interpersonal processes are as crucial in everyday interaction (Lieberman, 2007) as in counselling and psychotherapy (Henry, Schacht, & Strupp, 1990), we

must develop ingenious research methodologies to study them. Integrating CCRT procedure in a neurobiological assessment of interpersonal processes in psychotherapy and counselling might be one reasonable solution to face this challenge.

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