Assessing Deictic Relational Responding in Social Anhedonia: A Functional Approach to the Development of Theory of Mind Impairments

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The current study aimed to compare deictic relational responding and Theory of Mind (ToM) performances in 60 non-clinical young adults with a profile of high versus low social anhedonia in order to investigate a possible link between social anhedonia and ToM functioning. The results indicated that social anhedonic participants were less accurate than controls (matched on age, gender and general intellectual competencies) on ToM tasks (P<.001) and on complex deictic relational responding (P=.05). Accuracy on reversing deictic relations explains 52% of the variance of ToM performance (P=.000). These findings support the RFT approach to ToM and suggest the critical role of social contact for the remediation of deficits.

Premack and Woodruff (1978) have proposed the term “Theory of Mind” (ToM) to refer to one’s ability to infer the beliefs, intentions and thoughts of others in order to explain and predict their behavior. Understanding how ToM operates has been the subject of debate for more than twenty years in cognitive psychology, but has only recently been studied in behavior analysis. Although the concepts of ToM do not lend themselves readily to a functional interpretation, some behavioral researchers working under the rubric of Relational Frame Theory (RFT) have attempted to develop a behavioral interpretation of the types of repertoires that constitute a ToM (McHugh, Barnes-Holmes, & Barnes-Holmes, 2004a).

Relational Frame Theory is a modern behavior-analytic approach to the study of human language and cognition. At its core, this approach embraces the simple idea that language and cognition involve a number of limited but powerful behavioral processes, that allow individuals to relate stimuli or events in the world in new and untrained ways (as in generative language). A range of behavioral patterns emerge as a result of these relations between stimuli and these patterns are referred to as relational frames (see Hayes, Barnes-Holmes, & Roche, 2001). The simplest form of such relating can be referred to as coordination framing. An example of this type of framing might go as follows: a child could learn that the written word “DOG” is the same as the spoken word “DOG” according to the non-physical characteristics of these two stimuli while their physical form is very different. According to RFT, it is the uniquely human ability to learn to relate objects and events not based on their physical form but on external cues that allows for the generativity of human language. Among the different ways in which two stimuli can be related, Barnes-Holmes, Hayes, and Dymond (2001; see also Barnes-Holmes, McHugh, & Barnes-Holmes, 2004) have underlined the role of a specific class of relational responding termed deictic framing, which is assumed to underpin perspective-taking and, thus to be critically important with respect to the ability to infer the mental states of others.

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The three deictic frames involved in the acquisition of perspective-taking skills are the frames of I and YOU, HERE and THERE, and NOW and THEN, corresponding to interpersonal, spatial, and temporal dimensions, respectively. According to this view, perspective-taking skills emerge through a history of responding to questions such as « What am I doing now? » or « What did you do then? ». Many phrases during daily discourse include these relational frames, even if substituted words such as the names of places, people and time are frequently used instead of the actual terms of I and YOU, HERE and THERE and NOW and THEN.

Following the RFT approach to ToM, McHugh et al. (2004a) have proposed an RFT interpretation of the developmental levels of ToM described by Howlin, Baron-Cohen, and Hadwin (1999). That is, the authors suggested that levels from simple visual perspective-taking to the understanding of false-beliefs involve the ability to respond in accordance with deictic relational frames. Consider the following example of a well known false-belief task (Gopnick & Astington, 1988), in which a

participant is asked what is inside a closed candy box. After responding, the candy box is opened and the participant discovers that the candy box did not contain candy but actually contained pencils. Then s/he is asked « Before we opened the box, what did you think was inside? And what is really inside? ». The RFT view of this task is that a correct response coming from the participant is underpinned by relational frames as follows: « I did not see inside there and then, but I do see inside here and now».

In order to study this interpretation, McHugh et al. (2004b) have established a developmental profile of deictic relational responding and examined its correspondence with stages of acquisition in traditional ToM tasks. The protocol of this research consisted of exposing participants from early childhood to adulthood to a battery of 62 trials that involved the three deictic relational frames and required changing perspective. Three levels of perspective-taking difficulty -or relational complexity- were used: simple (ex: "I have a red brick and you have a green brick: Which brick do I have? Which brick do you have?"); reversed (ex: "I am sitting here on the blue chair and you are sitting there on the black chair. If I was you and you were me, where would you be sitting? Where would I be sitting?"); double reversed (ex: "I was sitting then on the blue chair and now I am sitting here on the black chair. If here was there and there was here and if then was now and now was then, where would I be sitting now? Where would I have been sitting then?"). The results indicated that participants' performance increased with age while following an evolution similar to the levels of ToM acquisition proposed by Howlin et al. (1999). McHugh, Barnes-Holmes, Barnes-Holmes, & Stewart (2006) observed consistent results with a task that involved explicit deictic relational responding in false-belief understanding. Such findings support the capacity of RFT to account for ToM phenomena as generalized operant behavior. One of the characteristic features of Autism Spectrum Disorder (ASD) is deficits in ToM ability (Yirmiya, Erel, Shaked, & Salomonica-Levi, 1998). RFT suggests that ToM ability may be conceptualized in terms of deictic relational framing. Thus, RFT would suggest that individuals with ASD have a deficit in deictic relational framing. This assumption lead Rehfeldt, Dillen, Ziomek, and Kowalchuk (2007) to investigate whether children with high-functioning autism or Aspergers syndrome demonstrated relational learning deficits in a perspective-taking task when compared to their age-matched typically-developing counterparts. Additionally, these researchers compared accuracy level on the perspective-taking protocol with scores on two standardized instruments commonly employed in the assessment of ASD, the Vineland Adaptive Behavior Scales – Interview Edition (Sparrow, Balla, & Cicchetti, 1984) and the Social Communication Questionnaire (SCQ) – Current Form (Rutter, Bailey, & Lord, 2003). As predicted the findings indicated that the ASD group produced more errors overall on the perspective-taking protocol and this distinction was most pronounced on reversed relation test trial-types. The researchers correlated scores on the perspective-taking task and the SCQ, overall age equivalence as measured on the Vineland Adaptive Behavior Scales, and age equivalence on the communication, daily living, and socialization domains of the Vineland. A modest correlation between the percentage of errors on the NOW-THEN reversed relations and the Daily Living Skills domain of the Vineland was found, demonstrating a link between social skills and deictic relational responding. These results lend support to the RFT account of perspective taking not only in a typically developing population but also, in a population who has deficits in this area.

ToM impairments in schizophrenia

For the past decade, schizophrenia has particularly attracted the interest of ToM researchers due to the presence of deficits in this domain of abilities. People with schizophrenia present difficulties in inferring mental states in a range of experimental ToM tasks consisting of sequencing false-belief stories (Langdon et al. 1997), inferring intentions (Corcoran, Mercer, & Frith, 1995; Sarfati & Hardy-Baylé, 1999), understanding metaphors in proverbs (Brüne & Bodenstein, 2005) and understanding humorous pictures (Corcoran, Cahill, & Frith, 1997) (see Brüne, 2005 for a review and Sprong, Schothorst, Vos, Hox, & Van Engeland, 2007 for a meta-analysis).

One of the most widely employed tasks in the ToM literature on schizophrenia consists of attributing intentions behind indirect speech (namely, the "Hinting Task" designed by Corcoran et al., 1995). In an example of the items presented to the participant, a character, Paul has to go to an

interview and he is running late. While he is cleaning his shoes, he says to his wife, Jane: "I want to wear that blue shirt, but it's very creased." The participant is then asked: "What does Paul really mean when he says this?". A relational responding interpretation of this task would be as follows: in order to infer the intention of the character, the participant must change perspective and thus derive deictic relations between I-YOU, HERE-THERE and NOW-THEN, that is, "If I were that character (I-You) in that particular place (Here-There) and at that moment (Now-Then), I would intend to…".

The role of social anhedonia in the development of ToM impairments

According to a growing body of literature, specific dimensions of personality are linked to the development of schizophrenia. In particular, schizotypy is a personality construct based on sub-clinical manifestations of characteristics of schizophrenia (including impulsive non-conformity, perceptual aberration, magical ideation, physical and social anhedonia -Chapman, Chapman, & Kwapil, 1995-). When a young person presents this profile (i.e., a score above two standard deviations on schizotypal dimensions), the risk for the development of a schizophrenic spectrum disorder is considerably increased (Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994; Gooding, Tallent, & Matts, 2005). In line with the augmentation of the symptoms' severity between schizotypy and schizophrenia, subtle ToM impairments have been observed in non-clinical populations scoring high on schizotypy scales (Langdon & Coltheart, 1999; Platek, Critton, Myers, & Gallup, 2003; Irani et al., 2006).

Among the dimensions of schizotypy, social anhedonia, which is characterized by social disinterest, withdrawal and a lack of pleasure from social contact (Eckblad, Chapman, Chapman, & Mishlove, 1982), appears to be a major factor of vulnerability to schizophrenic spectrum disorders (Kwapil, 1998; Gooding et al., 2005), even when it is not associated with the other dimensions of schizotypy (Horan, Brown, & Blanchard, 2007). According to RFT and to previous research in the field of cognitive psychology (Bartsch, 2002), attributing mental states is learned through social interactions. Since high social anhedonia is associated with a lack of contact with others (Brown, Silvia, Myin-Germeys, & Kwapil, 2007), we argue that this personal characteristic could be a cause of ToM impairments of people with schizophrenia. If this assumption is true, young people with a high level of social anhedonia should present a subtle deficit in ToM, which might precede more severe difficulties when the illness arises.

The current study aimed to examine whether ToM impairments are linked to social anhedonia and whether such impairments could be accounted for in terms of deficits in deictic relational responding. To that end, first, participants with high social anhedonia and age/gender/intelligence matched controls will be exposed to a traditional ToM task consisting of attributing intentions behind indirect speech (modelled on the "Hinting Task" of Corcoran et al., 1995). Poorer performance of these participants would support the prediction that ToM deficits in schizophrenia might be usefully understood as a by-product of social anhedonia. Second, the perspective-taking protocol (developed by McHugh et al., 2004b) will be employed in order to assess the level of deictic relational responding associated with high social anhedonia. If poorer performance on the perspective-taking protocol is observed in the high social anhedonic group, and if a link emerges between the scores on the two tasks in the whole sample of participants, this would support the RFT interpretation of ToM.

METHOD

Measures

The Revised Social Anhedonia Scale (SAS) (Eckblad et al., 1982) is a true-false self-report questionnaire that measures social withdrawal, a lack of interest in social relationships and/or a lack of pleasure derived from interpersonal relationships with 40 items such as "I sometimes become deeply attached to people I spend a lot of time with" (keyed false) or "If given the choice, I would much rather be with others than be alone" (keyed false). One thousand two hundred and fifty five first-year psychology students participated in the study by completing the SAS. Thirty participants chosen randomly among individuals with a high score (i.e.: scoring at or above two SD's from the mean of the same sex sample) constituted the experimental group. Thirty participants chosen randomly among individuals scoring not higher than 0.5 SD from the mean of the same sex sample were retained to

constitute the control group2. Exclusion criteria included any head injury or psychiatric illness and French as a second language.

Although ToM impairments have been observed in schizotypy and schizophrenia after controlling for effects of IQ, intellectual competencies seemed to have an influence on ToM performance in several studies (see Sprong et al., 2007). Thus, Raven's Progressive Matrices were employed to assess intellectual competencies of all the participants selected for the experimental protocol in order to examine the effect of social anhedonia independently from general intelligence.

Participants3

Experimental group: 10 males and 20 females. Ages ranged from 18 to 21 years (mean 19.33 years; SD: 0.8). Mean score on the SAS: 22.07 (SD: 4.76). Mean score on Raven's Progressive Matrices: 48.7 (SD: 4.47).
Control group: 10 males and 20 females. Ages ranged from 18 to 22 years (mean 19.27 years; SD: 1.05); there was no significant difference in age between the experimental and control group: $t(58)=0.28$, $P>.05$). Mean score on the SAS: 7.13 (SD: 1.17). Mean score on Raven's Progressive Matrices: 48.6 (SD: 4.37); there was no significant difference between the experimental and control group: $t(58)= 0.03$, $P > .05$).
No significant correlation emerged between participants scores on the SAS and scores on Raven's Progressive Matrices ($r = .08$, $P>.05$).
All the participants took part in the study to meet part of their course requirements.

Procedure

The two experimental tasks and Raven's Progressive Matrices were presented individually with the entire protocol lasting approximately 60 minutes. The presentation order of the tasks and Raven's test was counterbalanced.

Task 1 (ToM):

The ToM task was modeled on the "Hinting Task" of Corcoran et al. (1995), because it is one of the most widely employed tasks in the ToM and schizophrenia research area. In addition, and in contrast to many other ToM tasks, the Hinting Task has strong ecological validity. That is, certain experimental tasks have proven efficient in discriminating between schizotypal individuals, those diagnosed with schizophrenia and control participants, however, many of these tasks lack sense in everyday life. The "Hinting Task" incorporates events that often happen in everyday life; therefore, it is likely that performance on this task may reflect more accurately an ability to interact with others than performance on other tasks that involve, for example, interpreting comic strips.

The ToM task contains 20 short scenes read randomly to the participant. Each scene involves an interaction between two characters and the participant must guess what they really want to say. A complementary cue was also provided to the participants after their first answer.

For example:
"John has been on the phone with his friend for over an hour. John says: 'My mother ought to call me in few minutes'
Question 1: What does John really mean when he says this?
Cue: John says: 'I could call you back tomorrow'.
Question 2: What does John want to do?"
Correct response: John wants to hang up the phone.

Each scene was evaluated from 0 to 3 points (2 points for a correct first answer and 1 point for a correct second answer). Participants' responses were evaluated independently by three different blind experimenters (for each response, points were attributed to the majority of the experimenters).

As in the Corcoran et al. (1995) task, a cue and a second question was added to each scenario in order to avoid high failure rates from participants who found the task difficult (thus avoiding a floor effect). But in contrast to the original task, the

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[2] The inclusion criteria for the constitution of two groups were the same as those of most of the studies on social anhedonia and schizotypy (see for instance Chapman et al., 1994; Collins, Blanchard, & Biondo, 2005; Gooding & Tallent, 2003; Gooding, Kwapil, & Tallent., 1999; Gooding et al., 2005 ; Horan et al., 2007; Kwapil, 1998; Tallent & Gooding, 1999).

[3] The participants were the same as those who took part in another study involving deictic relational responding (in preparation). However, the presentation order of the two protocols was counterbalanced.

complementary cue was provided across all tasks (even after a correct first answer) in order not to influence participants' answers during the experiment. This procedure was employed in order to provide a more accurate assessment of participants' spontaneous responses.

Task 2 (deictic relational responding):
An E-Prime® (version 1.1) program was compiled in order to present the protocol designed by McHugh et al. (2004b) to the participants on a Personal Computer with a 660 MHz processor, a 15-inch color monitor and a numeric pad. All trials in the program were presented in French (black letters, font 26). The task included a set of 62 trials (two questions per trial). Trials differed based on the deictic relation they tested for (I-YOU, HERE-THERE or NOW-THEN) and the level of relational complexity (simple, reversed and double reversed relations) involved. These combinations were presented across eight trial-types (see appendix for full protocol).

The first three trial-types corresponded to eight trials of simple relations: two I-YOU, two HERE-THERE and four NOW-THEN. The NOW-THEN trial-type differs from the other two simple trials because, although the relational frame of I-YOU is present, it does not involve responding to I and YOU simultaneously. This procedural modification is necessary because in the frame of NOW-THEN, the target relations become unspecified when I and YOU relations are combined. For example, in "Yesterday I was watching television, today you are reading", what I am doing today and what YOU did yesterday is not specified. Thus, simple NOW-THEN was presented with I and with YOU separately and that is why simple trial types contained four NOW-THEN trials.

There were 36 reversed trials with three trial-types: eight I-YOU, 12 HERE-THERE and 16 NOW-THEN. As for simple trial-types, I and YOU were presented separately with NOW-THEN, so there were two times more trials for NOW-THEN than for I-YOU. There were four additional trials for HERE-THERE than for I-YOU because four trials are associated with only I, four with only YOU and four with I and YOU simultaneously. All these precautions were taken in order to assess specific performance on each frame and on each level of relational complexity.

Finally, there were 18 double reversed trials with two trials types: I-YOU/HERE-THERE and HERE-THERE/NOW-THEN. Once again, the trial type involving NOW-THEN contained two times more trials than the other one: there were six I-YOU/HERE-THERE and 12 HERE-THERE/NOW-THEN trials.

The participant was instructed that s/he could answer by means of pressing either of the two activated keys of the numeric pad relevant to the task. Both accuracy rates and response times were recorded (with longer response times predicted to reflect poorer performance). The recording was conducted as follows: Once the participant had read the first statement (example: "I have a red brick and you have a green brick. If I was you and you were me,"), s/he had to press the key "Enter". Then, the question and the two allowable responses appeared on screen (example: "Which brick would you have?" Green brick/Red brick). Response times were recorded between the participant pressing "Enter" after having read the first statement and his/her response by pressing one of the two activated keys. No feedback was given after the participant's response. The trials were presented randomly.

RESULTS

ToM task
The mean rate of accuracy was very high for both groups, but more notably in the control group (0.94 versus 0.86 for the experimental group). These data were analyzed using a t test and revealed that the difference between the two groups was significant ($t(58)= 4.56$, $P<.001$). An ANCOVA was conducted with the score on Raven's test as a co-variate. The effect of group remained significant ($F=20.48$, $P<.001$) and the effect of the score on Progressive Matrices was not significant ($F=0.03$, $P>.05$). These results show that the difference between the two groups was independent of level of intellectual competencies. The mean rate of amelioration (a correct second answer after an incorrect first one) was 0.57 for the experimental participants and 0.67 for the controls. This difference was not significant ($t(58)= 0.93$, $P=.35$), indicating that participants from both groups benefited equally from additional cues to correct their mistakes. To summarize, though they were able to respond correctly to the majority of the questions and to improve their performance

after receiving an additional cue, high social anhedonic participants were less accurate than controls when inferring the intentions of the characters.

Deictic relational responding task

Accuracy

The percentage of accuracy was calculated for each participant. These results were then grouped by SAS level and trial-type and are presented in Figure 1. The data indicated that, across the whole sample of participants, the rate of accuracy decreased as a function of relational complexity. The rate of accuracy was similar in both groups for the simple trials. The high social anhedonic group produced slightly more errors than the control group on reversed I-YOU and HERE-THERE trials, while almost the same rate of accuracy was observed for the two groups on reversed NOW-THEN. On double reversed trials, the difference between the two groups was more evident, with the high social anhedonic group demonstrating almost two times more errors on I-YOU/HERE-THERE trials and 40% more errors on HERE-THERE/NOW-THEN trials than the control group.

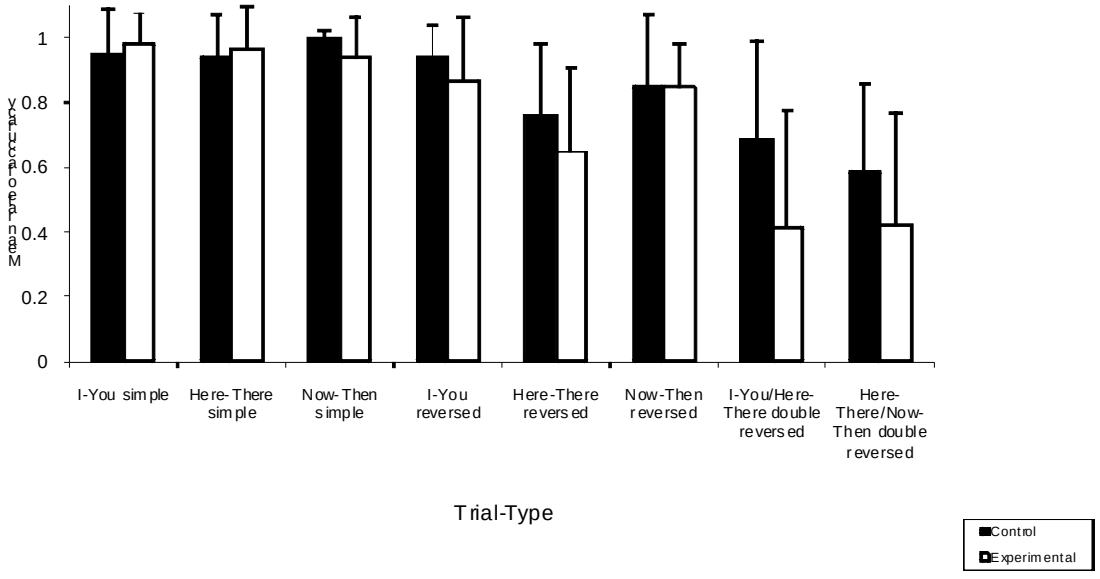

Figure1

Accuracy (proportion correct) for experimental and control participants on the eight trial-types of the deictic relational responding task

A 2 x 8 mixed repeated measures multivariate analyses of variance (MANOVA) with the type of participant (low vs. high score on the SAS) as the between subject variable and trial-type as the within subject variable and with accuracy and response times as the two dependent variables was employed. The main effect of group was significant (Wilk's F(2, 57)= 3.16, P=.05). There was a significant main effect of trial-type (Wilk's F(14, 45)= 29.91, P=.000). The interaction between group and trial-type was also significant (Wilk's F(14, 45)= 3.85, P=.000), indicating that the two groups were differently affected by the type of perspective-taking tested.

Univariate analysis of the mean rates of accuracy revealed a significant main effect of group (Wilk's F(1, 58)= 6.41, P=.01). The main effect of the trial-type was significant (Wilk's F(7, 406)=61.88, P=.000). The interaction between group and trial-type was also significant (Wilk's F(7, 406) = 4.64, P=.000), indicating that there was a difference between the two groups on accuracy as a function of the type of perspective-taking tested. Though no difference appeared between the score of the two groups on Raven's test, an ANCOVA was conducted to examine if the effect of the type of group remained significant. The results of this analysis revealed a significant effect for group type (F=2.99, P=.01) and no significant effect of the Raven's test score (F=1.04, P=.42). Thus, general

intellectual competencies did not influence accuracy on the perspective-taking task.

Planned comparisons were conducted between the two groups and across the eight trial-types (using Bonferroni corrections to control for Type I errors). These tests revealed that the experimental participants were significantly less accurate than controls on double reversed I-YOU/HERE-THERE trials, t (58) = 3.16, P = .02; the difference on double reversed HERE-THERE/NOW-THEN did not reach significance, t (58) = 2.12, P = .27. No significant difference appeared on any simple and reversed trials at the .05 level. To summarize, participants who scored highly on the SAS produced more errors than controls at the highest level of relational complexity involving the frame of I-YOU.

Another series of planned comparisons was conducted to analyze the effect of relational complexity in both groups. Experimental participants were significantly less accurate on reversed I-YOU than on simple I-YOU, t (29) = 3.19, P = .02, whereas controls were equally accurate on both levels of complexity, t (29) = 0.10, P >.05. The two groups of participants were less accurate on reversed HERE-THERE than on simple HERE-THERE: t (29) = 5.89, P = .000 for experimental participants and t (29) = 4.53, P = .000 for controls. Finally, the two groups were less accurate on reversed NOW-THEN than on simple NOW-THEN: t (29) = 4.01, P = .01 for experimental participants and t (29) = 3.74, P = .01 for controls. These results indicate a general tendency for performance of all participants to decrease as the perspective-taking required becomes more complex. Nevertheless, the pattern of responses in accordance with the interpersonal deictic frame was not the same in the two groups. No comparison was conducted between the reversed and the double reversed and between the simple and the double reversed trial types because relational complexity and relation type cannot be separated in these comparisons. For example, when comparing simple I-YOU with double reversed I-YOU/HERE-THERE trials, any effect that would emerge could be due to relational complexity (simple versus double reversed) or to the type of relation (I-YOU alone versus I-YOU combined with HERE-THERE).

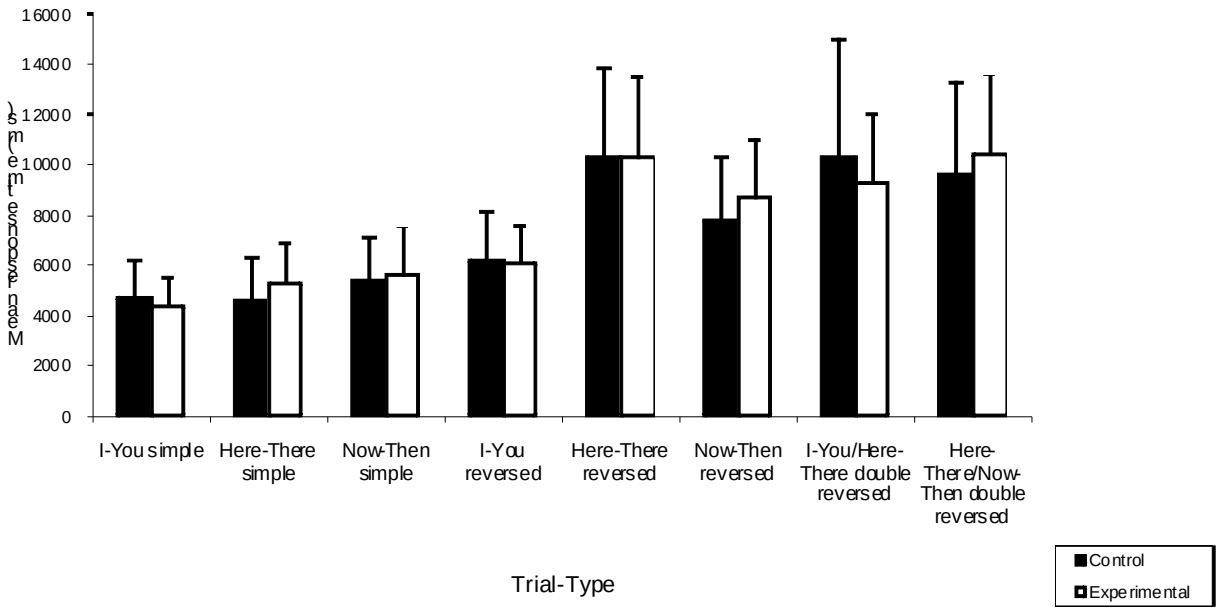

Figure 2

Response times (ms) for experimental and control participants on the eight trial-types of the deictic relational responding task

Because accuracy rates of 0.5 in a two-response protocol can be interpreted as chance level responding, the proportion of each group's participants whose scores were over 0.67 was

calculated. These proportions were not significantly different between the two groups for simple and reversed trial-types but were superior in the control group for double reversed I-YOU/HERE-THERE: 70% for controls versus 37% for experimental participants ($\chi^2(1)=6.7$, $P<.01$). Though 50% of the controls obtained more than 0.67 of accuracy on double reversed HERE-THERE/NOW-THEN versus only 33% for experimental participants, this difference was not significant ($\chi^2(1)=1.71$, $P>.05$). Furthermore, the proportion of participants who scored under 0.67 on double reversed I-YOU/HERE-THERE and HERE-THERE/NOW-THEN was inferior in the control group (20% vs. 57% for the experimental group: $\chi^2(1)=3.77$, $P=.05$). These results show once again that experimental participants produced more errors than controls on the highest level of relational complexity but the difference between the two groups was more important on double reversed I-YOU/HERE-THERE, which is consistent with the previous analyses of variance.

Response times[4]

Response times results are presented in Figure 2. These data indicate that the response times of the two groups were very close across all trial-types. In general, the response times increased as a function of relational complexity.

Univariate analysis of response times revealed no significant effect of the type of group (Wilk's $F(1, 58)= 0.04$, $P=.85$), a significant main effect of trial-type (Wilk's $F(7, 406)= 87.11$; $P=.000$) and no significant interaction between the type of group and trial-type (Wilk's $F(7, 406) = 1.8$, $P=.09$), indicating that the trial-type did not differentially affect the two groups of participants response times.

Planned comparisons were conducted across levels of relational complexity (using Bonferroni corrections). These analyses revealed that all participants were faster on simple than on reversed trial-types: simple I-YOU/reversed I-YOU, $t (59) = 8.38$, $P=.000$; simple HERE-THERE/reversed HERE-THERE, $t (29) = 13.61$, $P=.000$; simple NOW-THEN/reversed NOW-THEN, $t (29) = 11.66$, $P=.000$.

Response times on the perspective-taking task did not correlate with accuracy on any of the trial-types in the whole sample of participants, nor for each group when examined separately. These results indicate that the time taken to respond almost never affected accuracy in any direction and that, on almost all of the trial-types, better performance did not lead to faster responses.

In addition to response times, we calculated the time spent on screens presenting the first statement of each item (ex: "I have a red brick and you have a green brick. If I were you and you were me:") in order to examine if the two groups required a different amount of time to read this instruction. In line with the variation of the first statement length across the different trial-types, univariate analysis of these results revealed a significant main effect of trial-type ($F(7,406)=70.67$, $P=.000$), no significant effect of the type of group (Wilk's $F(1, 58)= 1.37$, $P=.25$) and no significant interaction between the type of group and trial-type ($F(7,406)=1.07$, $P=.38$), indicating that the two groups did not differ in the amount of time they spent reading the first statement of the trials.

SAS score / ToM, deictic relational responding

In order to determine whether individual SAS scores impacted on ToM and/or deictic relational responding performance, correlation analyses were conducted. Across the whole sample of participants, higher scores on the SAS combined significantly with lower accuracy on the ToM task ($r = -.59$, $P<.01$) and on the double reversed I-YOU/HERE-THERE trial-type of the perspective-taking task ($r = -.37$, $P<.05$). Response times in the perspective-taking task did not correlate with SAS scores. To summarize, the correlation analyses between participants' scores on the SAS and performance on the two experimental tasks were consistent with the analysis conducted earlier: a high level of social anhedonia was associated with poorer accuracy on ToM and on the higher level of relational complexity involving the interpersonal deictic frame.

Link between ToM and deictic relational responding performances

A series of correlation analyses were conducted between performances on ToM and perspective-

[4] Response latencies that exceeded two SD's above the mean were removed from statistical analyses. However, the exclusion of these data had no effect on the statistical analyses of response times.

taking tasks (using Bonferroni corrections) in order to examine the overlap between deictic relational responding and attribution of intentions. The results revealed that accuracy, but not response times, on deictic relational responding were associated with accuracy on ToM. Accuracy on the ToM task correlated significantly with the total score on the deictic relational responding task across the whole sample of participants ($r = .63$, $P<.01$). Performances on these two tasks were also significantly associated for the experimental group ($r = .62$, $P<.01$) and there was a similar tendency in the control group ($r = .47$, $P=.10$). In order to avoid multiple testing effects on Type I error, the trial-types were then regrouped as a function of relational complexity. In the whole sample of participants, the score on the ToM task was significantly associated with the score on reversed ($r = .4$, $P<.05$) and double reversed ($r = .54$, $P<.01$), but not on simple trial-types ($r = .15$, $P>.9$). In the experimental group, only the double reversed trial-types were significantly associated with ToM accuracy ($r = .48$, $P<.05$). In the control group, no correlation reached significance. In order to examine the prediction that reversing deictic relations is required to infer the intentions of others, a linear regression analysis was carried out with ToM performance as dependent variable and mean accuracy on all trial-types involving changing perspective (i.e., reversed and double reversed trial-types) as independent variables. The model was significant and explained 52% of the variance ($P=.000$), thus indicating that accuracy in reversing deictic relations was a strong predictor for ToM performance.

DISCUSSION

ToM in social anhedonia

In line with the prediction that there is a link between social anhedonia and ToM deficits, it was expected that participants with high SAS scores would demonstrate low accuracy on tasks that involve inferring the intentions behind direct speech. This prediction was supported by the data; participants with a high social anhedonic profile were not as accurate as controls when they were required to say what the characters of the short stories really intended. Though the difference between the two groups was very small and participants with a high social anhedonic profile appeared to answer correctly the majority of the questions, these slight difficulties are in line with the subtle impairments reported in the literature on ToM in non-clinical population presenting similarities with schizophrenia (Langdon & Coltheart, 1999; Platek et al., 2003; Irani et al., 2006). Consistent with studies that have shown poor ToM to be associated with negative symptoms of schizophrenia (Corcoran et al., 1995; Langdon et al., 1997; Mazza, De-Risio, Surian, Roncone, & Casacchia, 2001), the results of the present study underline the social anhedonia dimension (i.e., one of the negative symptoms of schizophrenia) for the understanding of ToM impairments in schizophrenia. However, whether impairment in inferring mental states results from or is the cause of social anhedonia remains uncertain (also, other factors could influence these two variables). For example, one could argue that difficulties in understanding others lead to a low interest for social contact. Actually it is likely that both factors interact especially when the impairment in ToM becomes severe, as in schizophrenia. That is, if a person who lacks interest for social contact presents important difficulties in understanding others, his/her attempts to communicate might be ineffective and as a consequence his/her level of pleasure provided by social interactions will decrease even more.

Because we did not assess other dimensions of schizotypy in our sample of participants, it is possible that these presented other similarities with schizotypal people (for example, magical ideation) that could be also factors influencing the differences observed between the two groups. Nevertheless, as discussed earlier, recent studies demonstrated that a high level of social anhedonia, even when it is associated with a low level of magical ideation, constitutes a strong predictor for the development of schizophrenic symptoms (Horan et al., 2007). These promising results suggest that future studies should not focus only on schizotypy to understand the development of schizophrenia and the deterioration of ToM abilities from sub-clinical to clinical condition. A greater consideration to the implications of the social dimension should rather be given, even in populations who do not present the other characteristics of schizotypy.

Deictic relational responding in social anhedonia
As discussed earlier, RFT suggests that ToM abilities are underpinned by perspective-taking skills conceptualized in terms of deictic relational

framing (Barnes-Holmes et al., 2001). Thus, if participants scoring high on the SAS were impaired in ToM (which was demonstrated by the current results), according to RFT it should follow that they would also demonstrate poorer performances than controls on a deictic framing task. The results confirmed this prediction, revealing that experimental participants were significantly less accurate than controls on the most difficult level of deictic relational complexity (i.e. double reversed trial-types). Though a level of variability was observed in the two groups for double reversed trial-types, the majority of the experimental participants were unable to score at better than chance level responding on the two double reversed trial-types, whereas this proportion was only 0.2 in the control group. In addition, performance on these two double reversed trial-types correlated significantly with SAS score. No difference was expected on simple perspective-taking since no modification of perspective is needed at that level, which was confirmed by the results. Experimental participants were as accurate as control group participants in judging reversed perspective-taking questions, suggesting that impairment on perspective-taking skills appears only at a relatively high level of complexity5. Thus, in high social anhedonic individuals the three deictic frames seem to be in place but not the flexible repertoires in responding to them. In contrast to our prediction, the type of participant group did not affect differentially the response times. One possible explanation for this result is that response time is not an appropriate way to discriminate between non-clinical adults. However, it is interesting to note that, as experimental participants did not respond faster than controls, impulsivity cannot account for their poorer performance.

One could argue that the poorer performance of experimental participants is due to the length of the sentences in the double reversed perspective-taking. Indeed, memory impairment observed in the schizophrenic spectrum (Heinrichs & Zakzanis, 1998; Jashan & Sergi, 2007) could alter the ability to respond to longer items (a similar prediction was also discussed in McHugh et al., 2004b, as poorer performance on double reversing was observed in the youngest participants). But the introduction of the items remained on screen when participants were responding, allowing participants to read it as many times as they needed. In addition, no difference was found between the two groups on the time spent to read the introduction.

RFT predicted that accuracy would be lower as a function of relational complexity for the whole sample of participants, because reversed, but not simple, levels require changing perspective. The results (accuracy and responses times) were consistent with that prediction; all participants performed better on simple than on reversed perspective-taking, except controls, who were as accurate on reversed I-YOU as on simple I-YOU. This last point is interesting because, even if there was no significant difference between experimental and control participants on reversed I-YOU trial-types, it suggests that people with a high social anhedonia profile found it more difficult to take the perspective of another whereas controls did not. In addition, the difference between the two groups appeared significant only on the higher level of relational complexity involving the frame of I-YOU6. Thus, the findings from the current study indicate some abnormalities in high social anhedonic participants when responding in accordance with the interpersonal deictic frames. Such difficulties in interpersonal perspective-taking are highly compatible with studies by Langdon and Coltheart (2001) and Langdon, Coltheart, Ward, and Catts (2001) showing that schizotypal people and people with schizophrenia have impairments in

[5] These results suggest that social anhedonic people are able to reverse one relation but begin to have difficulties when the complexity increases. Interestingly, Rehfeldt et al. (2007) observed that children with ASD performed poorer on reversed than on double reversed trials, The authors argued that children might not have responded relationally on the highest level of complexity and just repeated the first sentence of the statement. In contrast, the lower rate of accuracy of our experimental participants on double reversed suggests they did respond relationally.

[6] We observed consistent results with the same participants in a deictic relational responding task that involved attribution of beliefs. The participants with high social anhedonia were less accurate in belief attribution to another than in self attribution whereas no difference was found as a function of attribution-type in controls (in preparation).

allocentric simulation, a capacity to imagine the appearance of an object under a rotation of the viewer (as opposed to egocentric simulation which refers to the capacity to imagine the appearance of an object under a rotation of the object). In our perspective-taking task, trial-types involving I-YOU can be considered as requiring allocentric simulation (because, as Langdon and Coltheart wrote, the participant needs to reconstruct another first-person experience of an object that remains fixed within a world-centered frame of reference) whereas egocentric simulation might be needed in HERE-THERE and NOW-THEN trial-types (because the participant needs to reconstruct another first-person experience of an object that changes relative to the fixed self-referential view-point). This set of findings lead us to suggest that social anhedonia might be specifically responsible for the development of difficulties in adopting the perspective of another. Because individuals presenting this profile engage in fewer social interactions, they lack training in taking the perspective of others. In line with this assumption, data from developmental studies showed that ToM skills of children are linked to the number of social interactions and role-plays they engage with (Bartsch, 2002; Taylor & Carlson, 1997; Taylor, Carlson, Maring, Gerow, & Charley, 2004). Though the current study was designed only in the purpose of assessing performance without any manipulation of the environment, the data support the idea that a history of exposition to social interactions is critical to the development of interpersonal deictic framing. This might have considerable implications for the remediation of ToM deficits in schizophrenia. That is, role-plays included in rehabilitation programs for patients with schizophrenia might be refined by targeting deictic relational responses more precisely and by taking into account the level of social anhedonia of those patients.

ToM and deictic relational responding

The results of the current study supported the RFT assumption that one's ability to infer the intentions of others is linked to relational responding under the control of deictic relational frames. Indeed, we observed a significant correlation between performances on the ToM task and on the RFT perspective-taking task in the whole sample of participants, which suggests a strong and consistent association between the abilities assessed by these two tasks. More precisely, it appeared that the reversed and the double reversed, but not the simple, trial-types were significantly correlated with the ToM task. From an RFT view, it is not surprising that simple perspective-taking was not associated with ToM performance, since our task consisted of inferring the intentions of others, which always requires adopting a different perspective. Furthermore, in line with RFT conceptualization of ToM abilities according to which deictic framing underpins inferring intentions of others, accuracy in reversing deictic relations appeared to be a strong predictor for performance on the Hinting Task. These findings lead us to suggest that training in deictic framing might improve performance on this traditional ToM Tasks, as Weil (unpublished) demonstrated with false-beliefs tasks.

CONCLUSION

The findings of this study corroborate recent studies in the field of RFT by showing that social anhedonic people are impaired in ToM and also perform poorly on deictic relational tasks. Furthermore, people's ability to infer mental states was strongly predicted by performance on deictic relational responding across the whole sample of participants. In addition, this study underscores the role of the social dimension in the ability to respond in accordance with deictic relational frames. Further research must be conducted to examine if it is the lack of social experience linked to this dimension that is more specifically responsible for the development of difficulties in attribution of mental states. One way to test this prediction is to assess deictic framing in individuals presenting social withdrawal in spite of their interest for social contact, such as people with severe social anxiety.

Appendix: Full perspective taking protocol

SIMPLE TRIALS

Simple I-YOU:

I have a red brick and you have a green brick.
Which brick do I have? Which brick do YOU have?
I have a green brick and you have a red brick.
Which brick do YOU have? Which brick do I have?

Simple HERE-THERE:

I am sitting here on the blue chair and you are sitting there on the black chair.
Where am I sitting? Where are YOU sitting?
I am sitting here on the black chair and you are sitting there on the blue chair.
Where are YOU sitting? Where am I sitting?

Simple NOW-THEN:

Yesterday I was watching television, today I am reading.

What am I doing now? What was I doing then?
Yesterday I was reading, today I am watching television.
What was I doing then? What am I doing now?
Yesterday you were reading, today you are watching television.
What are YOU doing now? What were YOU doing then?
Yesterday you were watching television, today you are reading.
What were YOU doing then? What are YOU doing now?

REVERSED RELATIONS

Reversed I-YOU:
I have a red brick and you have a green brick. If I was you and you were me.
Which brick would I have? Which brick would YOU have?
I have a green brick and you have a red brick. If I was you and you were me
Which brick would YOU have? Which brick would I have?
I have a red brick and you have a green brick. If I was you and you were me.
Which brick would YOU have? Which brick would I have?
I have a green brick and you have a red brick. If I was you and you were me
Which brick would I have? Which brick would YOU have?
I am sitting here on the black chair and you are sitting there on the blue chair. If I was you and you were me.
Where would YOU be sitting? Where would I be sitting?
I am sitting here on the black chair and you are sitting there on the blue chair. If I was you and you were me.
Where would I be sitting? Where would YOU be sitting?
I am sitting here on the blue chair and you are sitting there on the black chair. If I was you and you were me.
Where would I be sitting? Where would YOU be sitting?
I am sitting here on the blue chair and you are sitting there on the black chair. If I was you and you were me.
Where would YOU be sitting? Where would I be sitting?

Reversed HERE-THERE:
I am sitting here on the blue chair and you are sitting there on the black chair. If here was there and there was here.
Where would YOU be sitting? Where would I be sitting?
I am sitting here on the black chair and you are sitting there on the blue chair. If here was there and there was here.
Where would I be sitting? Where would YOU be sitting?
I am sitting here on the blue chair and you are sitting there on the black chair. If here was there and there was here.
Where would I be sitting? Where would YOU be sitting?
I am sitting here on the black chair and you are sitting there on the blue chair. If here was there and there was here.
Where would YOU be sitting? Where would I be sitting?
Yesterday I was sitting there on the blue chair, today I am sitting here on the black chair. If here was there and there was here.
Where would I be sitting now? Where would I be sitting then?
Yesterday I was sitting there on the black chair, today I am sitting here on the blue chair. If here was there and there was here.
Where would I be sitting then? Where would I be sitting now?
Yesterday I was sitting there on the blue chair, today I am sitting here on the black chair. If here was there and there was here.
Where would I be sitting then? Where would I be sitting now?
Yesterday I was sitting there on the black chair, today I am sitting here on the blue chair. If here was there and there was here.
Where would I be sitting now? Where would I be sitting then?
Yesterday you were sitting there on the blue chair, today you are sitting here on the black chair. If here was there and there was here.
Where would you be sitting now? Where would you be sitting then?
Yesterday you were sitting there on the blue chair, today you are sitting here on the black chair. If here was there and there was here.
Where were you sitting then? Where would you sitting now?
Yesterday you were sitting there on the black chair, today you are sitting here on the blue chair. If here was there and there was here.
Where would you be sitting now? Where would you be sitting then?
Yesterday you were sitting there on the black chair, today you are sitting here on the blue chair. If here was there and there was here.
Where would you be sitting then? Where would you be sitting now?

Reversed NOW-THEN:
Yesterday I was watching television, today I am reading. If now was then and then was now.
What would I be doing then? What would I be doing now?
Yesterday I was reading, today I am watching television. If now was then and then was now.
What would I be doing now? What would I be doing then?
Yesterday I was watching television, today I am reading. If now was then and then was now.
What would I be doing now? What would I be doing then?
Yesterday I was reading, today I am watching television. If now was then and then was now.
What would I be doing then? What would I be doing now?
Yesterday you were watching television, today you are reading. If now was then and then was now.
What would you be doing then? What would you be doing now?
Yesterday you were reading, today you are watching television. If now was then and then was now.
What would you be doing then? What would you be doing now?
Yesterday you were watching television, today you are reading. If now was then and then was now.
What would you be doing now? What would you be doing then?
Yesterday you were reading, today you are watching television. If now was then and then was now.
What would you be doing now? What would you be doing then?
Yesterday I was sitting there on the blue chair, today I am sitting here on the black chair. If now was then and then was now.
Where would I be sitting now? Where would I be sitting then?
Yesterday I was sitting there on the blue chair, today I am sitting here on the black chair. If now was then and then was now.
Where would I be sitting then? Where would I be sitting now?
Yesterday I was sitting there on the black chair, today I am sitting here on the blue chair. If now was then and then was now.
Where would I be sitting now? Where would I be sitting then?
Yesterday I was sitting there on the black chair, today I am sitting here on the blue chair. If now was then and then was now.
Where would I be sitting then? Where would I be sitting now?
Yesterday you were sitting there on the blue chair, today you are sitting here on the black chair. If now was then and then was now.
Where would you be sitting then? Where would you be sitting now?
Yesterday you were sitting there on the blue chair, today you are sitting here on the black chair. If now was then and then was now.
Where would you be sitting now? Where would you be sitting then?
Yesterday you were sitting there on the black chair, today you are sitting here on the blue chair. If now was then and then was now.
Where would you be sitting then? Where would you be sitting now?
Yesterday you were sitting there on the black chair, today you are sitting here on the blue chair. If now was then and then was now.
Where would you be sitting now? Where would you be sitting then?

DOUBLE REVERSED RELATIONS

I-YOU/HERE-THERE:
I am sitting here on the blue chair and you are sitting there on the black chair. If I was you and you were me and if here was there and there was here.
Where would I be sitting? Where would YOU be sitting?
I am sitting here on the blue chair and you are sitting there on the black chair. If I was you and you were me and if here was there and there was here.
Where would I be sitting? Where would YOU be sitting?

I am sitting here on the black chair and you are sitting there on the blue chair. If I was you and you were me and if here was there and there was here.
Where would I be sitting? Where would YOU be sitting?
I am sitting here on the blue chair and you are sitting there on the black chair. If I was you and you were me and if here was there and there was here.
Where would YOU be sitting? Where would I be sitting?
I am sitting here on the black chair and you are sitting there on the blue chair. If I was you and you were me and if here was there and there was here.
Where would YOU be sitting? Where would I be sitting?
I am sitting here on the black chair and you are sitting there on the blue chair. If I was you and you were me and if here was there and there was here.
Where would YOU be sitting? Where would I be sitting?
HERE-THERE/NOW-THEN:
Yesterday I was sitting there on the blue chair, today I am sitting here on the black chair. If here was there and there was here and if now was then and then was now.
Where would I be sitting then? Where would I be sitting now?
Yesterday I was sitting there on the blue chair, today I am sitting here on the black chair. If here was there and there was here and if now was then and then was now.
Where would I be sitting then? Where would I be sitting now?
Yesterday I was sitting there on the blue chair, today I am sitting here on the black chair. If here was there and there was here and if now was then and then was now.
Where would I be sitting now? Where would I be sitting then?
Yesterday I was sitting there on the black chair, today I am sitting here on the blue chair. If here was there and there was here and if now was then and then was now.
Where would I be sitting then? Where would I be sitting now?
Yesterday I was sitting there on the black chair, today I am sitting here on the blue chair. If here was there and there was here and if now was then and then was now.
Where would I be sitting now? Where would I be sitting then?
Yesterday you were sitting there on the blue chair, today you are sitting here on the black chair. If here was there and there was here and if now was then and then was now.
Where would you be sitting then? Where would you be sitting now?
Yesterday you were sitting there on the blue chair, today you are sitting here on the black chair. If here was there and there was here and if now was then and then was now.
Where would you be sitting then? Where would you be sitting now?
Yesterday you were sitting there on the blue chair, today you are sitting here on the black chair. If here was there and there was here and if now was then and then was now.
Where would be you sitting now? Where would you be sitting then?
Yesterday you were sitting there on the black chair, today you are sitting here on the blue chair. If here was there and there was here and if now was then and then was now.
Where would you be sitting then? Where would you be sitting now?
Yesterday you were sitting there on the black chair, today you are sitting here on the blue chair. If here was there and there was here and if now was then and then was now.
Where would be you sitting now? Where would you be sitting then?
Yesterday you were sitting there on the black chair, today you are sitting here on the blue chair. If here was there and there was here and if now was then and then was now.
Where would be you sitting now? Where would you be sitting then?

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