### Journal of Nervous and Mental Disease

**Hypersensitivity to contingent behavior in paranoia: a new virtual reality paradigm**

---Manuscript Draft---

<table>
<thead>
<tr>
<th><strong>Manuscript Number:</strong></th>
<th>JNMD-D-15-00018R2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full Title:</strong></td>
<td>Hypersensitivity to contingent behavior in paranoia: a new virtual reality paradigm</td>
</tr>
<tr>
<td><strong>Article Type:</strong></td>
<td>Brief Report</td>
</tr>
<tr>
<td><strong>Keywords:</strong></td>
<td>attachment, trust; paranoia, contingency, social environment, virtual reality</td>
</tr>
<tr>
<td><strong>Corresponding Author:</strong></td>
<td>Miriam Fornells-Ambrojo, PhD, DCI rPsy, PGDip</td>
</tr>
<tr>
<td></td>
<td>UNITED KINGDOM</td>
</tr>
<tr>
<td><strong>Order of Authors:</strong></td>
<td>Miriam Fornells-Ambrojo, PhD, DCI rPsy, PGDip</td>
</tr>
<tr>
<td></td>
<td>Maike Elenbaas</td>
</tr>
<tr>
<td></td>
<td>Chris Barker</td>
</tr>
<tr>
<td></td>
<td>David Swapp</td>
</tr>
<tr>
<td></td>
<td>Xavier Navarro</td>
</tr>
<tr>
<td></td>
<td>Aitor Rovira</td>
</tr>
<tr>
<td></td>
<td>Josep Maria Tomas Sanahuja</td>
</tr>
<tr>
<td></td>
<td>Mel Slater</td>
</tr>
<tr>
<td><strong>Order of Authors Secondary Information:</strong></td>
<td>UNITED KINGDOM</td>
</tr>
<tr>
<td><strong>Manuscript Region of Origin:</strong></td>
<td>UNITED KINGDOM</td>
</tr>
</tbody>
</table>

**Abstract:**

Contingency in interpersonal relationships is associated with the development of secure attachment and trust, whereas paranoia arises from the over- attribution of negative intentions. We used a new virtual reality paradigm to experimentally investigate the impact of contingent behavior on trust along the paranoia continuum. Sixty-one healthy participants were randomly allocated to have a social interaction with a pleasant virtual human (avatar) programmed to be highly responsive or not (high/low contingency). Participants rated trustworthiness and trusting behavior were assessed alongside control variables attachment and anxiety. Higher paranoia and dismissive attachment were associated with larger interpersonal distances. Unexpectedly, extremely paranoid individuals experienced the highly contingent avatar as more trustworthy than his low contingency counterpart. Higher dismissive attachment was also associated with more subjective trust in both conditions. Extreme paranoia is associated with hypersensitivity to non-contingent behavior, which might explain experiences of mistrust when others are not highly responsive in everyday social situations.
**Full title:** Hypersensitivity to contingent behavior in paranoia: a new virtual reality paradigm

**Running title:** Contingent behavior and paranoia

**Authors:**

Miriam Fornells-Ambrojo, Ph. D.a #*, Maaike Elenga, D. Clin. Psy. a #, Chris Barker, Ph. D. a, David Swapp, Ph. D. b, Xavier Navarro, M. Sc. c, Aitor Rovira, M. Sc. b,c, Josep Maria Torres Sanahuja, M. Sc. c, Mel Slater, D. Sc. c, d

**Affiliations:**

a Research Dept of Clinical, Educational and Health Psychology, University College London, UK

b Department of Computer Science, University College London, UK

c Event Lab, Faculty of Psychology, University of Barcelona, Spain

d Institució Catalana de Recerca i Estudis Avarçats (ICREA), Spain

# These authors contributed equally to this work

*Requests for reprints should be addressed to: Dr Miriam Fornells-Ambrojo, Research Dept of Clinical, Educational and Health Psychology, University College London; 1-19 Torrington Place, London WC1E 7HB, United Kingdom; e-mail: miriam.fornells-ambrojo@ucl.ac.uk

**Acknowledgements:** We thank Sebastien Kuntz [http://www.imin-vr.com] for the extended licence for MiddleVR for Unity
Abstract:

Contingency in interpersonal relationships is associated with the development of secure attachment and trust, whereas paranoia arises from the over-attribute of negative intentions. We used a new virtual reality paradigm to experimentally investigate the impact of contingent behavior on trust along the paranoia continuum. Sixty-one healthy participants were randomly allocated to have a social interaction with a pleasant virtual human (avatar) programmed to be highly responsive or not [high/low contingency]. Perceived trustworthiness and trusting behavior were assessed alongside control variables attachment and anxiety. Higher paranoia and dismissive attachment were associated with larger interpersonal distances. Unexpectedly, extremely paranoid individuals perceived the highly contingent avatar as more trustworthy than his low contingency counterpart. Higher dismissive attachment was also associated with more subjective trust in both conditions. Extreme paranoia is associated with hypersensitivity to non-contingent behavior, which might explain experiences of mistrust when others are not highly responsive in everyday social situations.

Keywords:

Attachment; trust; paranoia; contingency; social environment; virtual reality
1. Introduction

Contingency in interpersonal relationships plays an important role in early life, with parental responsiveness shown to be a predictor of secure attachment [Dunst et al., 2008]. In recent years, insecure attachment has been considered in pathways to persecutory delusions [Berry et al., 2006; MacBeth et al., 2008]. The caregiver’s accurate attribution of mental states facilitates the development of the infant’s mentalising capacity [Fonagy et al., 2007], but ‘over-mentalling’ [Versmissen et al., 2008] can lead to paranoia via external attributions [Rettig et al., 2001]. Accordingly, perceiving intentionality when there is none has been reported in people with persecutory delusions [Blakemore et al., 2003].

Paranoia has also been associated with safety behaviors, attempts to minimise perceived threat [Freeman et al., 2007]. We propose that interpersonal boundaries are a type of safety behavior that can be conceptualised as self-regulatory [Mikuła, 2007], acting to ‘deactivate’ the attachment system and protect from interpersonal threat. Increased interpersonal boundaries are indeed reported in psychos’s [Park et al., 2009] and are crucially associated with an external locus of control [Duke et al., 1973]. Accordingly, unfounded paranoia has been elicited in people with persecutory delusions, early psychos’s, at risk mental state and high trait non-clinical paranoia in ambiguous virtual environments [Fornells-Ambrojo et al., 2008; Freeman et al., 2010; Lysaker et al., 2010; Valmaggia et al., 2007].

We know that interactional synchrony influences trust [Kendon, 1970] but to date no research has investigated the role of contingent behavior in people with paranoia. Virtual characters programmed to give contingent nonverbal feedback (e.g., nods) in response to participants’ behavior elicit more rapport than non-contingent ones [Gratch et al., 2006]. Mimicry also increases perceived likability while it remains outside the perceiver’s awareness [Ballenson et al., 2008]. However, social anxiety reduces the impact of mimicry [Vrij et al., 2010].

This novel virtual reality study investigates interpersonal processes in paranoia by manipulating the contingency of virtual human (avatar) behavior. Perceptions of trustworthiness and interpersonal distance are evaluated. We hypothesise that a) The impact of contingent behavior on subjective trustworthiness and interpersonal distance will depend on trait paranoia. An interaction is predicted whereby higher contingent behavior results in higher trustworthiness and reduced interpersonal distance in individuals with low paranoia, whereas high trait paranoia participants will be immune to the contingency manipulation; b) Insecure attachment will be associated with lower levels of trust and larger interpersonal distance.
2. Method

2.1 Participants and procedure

Healthy male volunteers aged 18 and above were recruited from a London university. Exclusion criteria were a history of epilepsy or mental health problems, assessed with a question in the demographics section and a positive screen in the Psychosis Screening Questionnaire (PSQ; Bebbington et al. 1995). Ethical approval was obtained from the Division of Psychology and Language Sciences. Potential participants first completed a series of online screening questionnaires. Eligible participants were then invited by email to attend the Virtual Reality Lab at the Department of Computer Science. Written informed consent was obtained. Participants completed a series of post-virtual reality measures and received £10.

Virtual reality apparatus and scenario: The VR environment was displayed in an immersive projection system. High-resolution images, were projected in real-time onto three back-projected wall screens (3m x 2.2m) and a floor screen (3m x 3m). Stereo presentation was delivered via Lightweight CrystalEyes shutter-glasses. An inertial/ultrasonic head-tracking device was mounted on the glasses. Spatialised audio was delivered via four corner speakers. Intersense IS900 was used for 6 degrees of freedom head-tracking. The virtual reality scenario represented a student flat and was designed to be non-anxiety provoking. The virtual tenant, ‘Mark’, was a young male. The scenario had three stages. 1) The virtual tenant introduced himself to the participant and asked the participant their name. 2) Following the avatar’s cue that he was ready, participants asked the virtual flatmate set questions. 3) When participants asked their fourth and last question: ‘What’s the best thing about this flat?’, Mark walked towards the window and invited the participant to see the terrace. The scenario lasted two and a half minutes.

- Please insert Figure 1 about here -

Contingency manipulation: Some of the virtual flatmate’s non-verbal responses were programmed to have contingent/non-contingent relationship to participant’s head movements. In the high contingency (HC) condition, the virtual flatmate tilted his head every time the participant moved the head from side to side, with a 1.5 second delay. When participants moved their head in any other way, the virtual flatmate swayed side to side. Additionally, the researcher triggered avatar nodding each time the participant spoke. In the low contingency (L.C) condition, avatar responses were programmed to occur but with a 20 second delay.

Virtual reality procedure: Participants were divided into two groups based on a median split in paranoia scores and they were randomly allocated to the high or the low contingent (HC/LC) condition by
permuted blocks method. Participants were informed that the study aimed to understand how people respond to virtual environments. They were instructed to enter the scenario, and to interview the virtual tenant by asking him four pre-set questions in order (e.g. Q1: ‘What do you like about flat sharing?’). They were given a prompt sheet.

2.2. Measures

The pre-virtual reality measures were: [1] the Paranoia Scale (PS) (Fenigstein et al., 1992), [2] the Trait Anxiety Inventory (STAI) (Spiegelberg, 1983), [3] the Relationship Questionnaire (RQ) (Bartholomew et al., 1991). Virtual reality measures included [4] interpersonal distance, a behavioral measure of trusting behavior was proximity to the virtual tenant, measured as the mean distance kept by the participant from the tenant during the last scene. The distance automatically recorded (in metres) using horizontal Pythagorean distance. Baseline distance used as control was measured in the same way from the start of the scenario. Post-virtual reality measures were [5] Subjective avatar trustworthiness was assessed by asking participants to rate how trustworthy the virtual tenant had come across to them on a 7-point Likert scale and [6] the Sense of presence questionnaire (Slater et al., 1998).

2.3 Statistical analyses

Data was analysed using SPSS for Windows (v.21). Hierarchical regression analyses were conducted to predict the two dependent variables: trustworthiness and interpersonal distance. In step 1, individual key predictor variables (paranoia, contingency condition) and control variables (anxiety, avatar movement, attachment) were included using Enter Method. When mean interpersonal distance from the virtual tenant was the dependent variable, mean baseline distance was also entered as a covariate in step 1. In step 2, the interaction term (paranoia x contingency condition) was added also using forward selection method. Step 1 was included to investigate the main effects of paranoia and the contingency condition on the dependent variables, since the inclusion of the interaction term in step 2 prevents interpretation of coefficients for these variables as they reflect conditional relationships (Jaccard et al., 1990). Regression residuals plots confirmed approximation to a normal distribution. The Johnson- Neymann technique was used to follow up significant interactions.

3. Results

Two hundred and eighty-one potential participants accessed the online pre-virtual reality survey. 93 of which did not complete the survey, and 46 were excluded because of a history of mental illness. Of the 142 contacted to participate, 54 did not reply and 25 were not available to meet within the study timeframe. Of the 63 participants who took part in the study, 2 were excluded due to unexpected technical
faults during the running of the virtual scenario. Sixty-one male participants. Their mean age was 25.3 (SD= 7.3), 47.77% were from a White ethnic background and 55.90% had student status. The mean paranoia score (PS) [Fenigstein et al. 1992] was 35.57 (SD = 10.96; range = 22-63), and trait anxiety (STAI) [Speilberger, 1983] had a mean of 38.08 (SD=8.91). PS and STAI were significantly correlated (Pearson’s r = .48, p<.001). About half of the sample (n=30, 49%) had a secure attachment as indicated by the RQ [Bartholomew et al. 1991]. Continuous scores for individual attachment categories were: secure (Mean = 4.87, SD = 1.56), insecure fearful (Mean = 3.16, SD = 1.82), insecure preoccupied (Mean = 2.72, SD = 1.85), insecure dismissive (Mean = 3.86, SD = 1.26). Paranoia was significantly associated with secure (Pearson’s r = - .28, p = .029), insecure fearful (Pearson’s r = .38, p = .002) and insecure preoccupied (Pearson’s r = .38, p = .052) but not with dismissive attachment (Pearson’s r = .12, p = .35). Interpersonal distance between the participant and the avatar at the last stage of the virtual interaction (Figure 1a) had a mean of 1.43 metres (SD=0.26, range = 0.93-2.20), which compares to a mean baseline distance (Figure 1a) of 2.02 metres (SD=0.26, range = 1.37-2.60). These values are in line with implicit rules about social distance [Hall, 1966]. Participants reported a mean level of subjective avatar trustworthiness of 4.87 (SD = 1.07, range =2-7). Subjective trust and interpersonal distance were not significantly associated (Pearson’s r = - .03, p = .833). The HC (n= 30) and LC groups (n=31) did not differ on subjective trust (t = .76, df = 58, p = .452) or interpersonal distance (F (1,58) = .67, p = .417). The mean total number of contingent avatar movements significantly differed between the high (M =23.1 (SD = 7.3) and low (M = 7.0 (SD = 1.1) contingency conditions (t =11.86, df = 59, p <.001). Participants felt as if they were in the virtual flat, as shown by a mean sense of presence [Slater et al. 1998] score of 25.47 (SD=6.52, range= 11-38).

3.1 Predictors of trusting behavior and subjective trustworthiness

Table 1 shows the results of a multiple regression predicting interpersonal distance from the virtual tenant.

A greater distance from the avatar (less trusting behavior) was predicted by higher paranoid and dismissive attachment2, as well as by greater distance at the start of the conversation and less avatar movements.

--- Please insert Table 1 about here ---

--- Covarying for baseline distance

---

2 Dismissive attachment was entered in step 1 out of the four attachment categories because of its association with the dependent variables: Dismissive attachment was found to be the only attachment type that was either significantly associated with subjective trust (r = .31, p = .016) or approached significance for interpersonal distance, r = .23, p = .063.
Greater trustworthiness was predicted by higher levels of dismissive attachment and by the interaction between paranoia and contingency (please see Table 1, Step 2). The Johnson-Neymann technique was used to characterise the interaction. The conditional effect of Contingency condition on Trust transitioned to significance at Paranoia score of 49.89, b = -1.24, SE = .15, t = .05, p = .05, 95% CIs [-2.49, 0.00] at the 90th percentile of the distribution in the sample (n=8), with the relation between Trust and Contingency condition being significant at Paranoia scores above this point. In sum, individuals with high trait paranoia reported significantly higher levels of trust towards a highly responsive avatar (+C) than to an avatar that was less responsive (-C).

4. Discussion

4.1. Self-regulatory attachment behavior
A novel virtual reality paradigm was used to investigate the impact of interpersonal contingency on trust. Trusting behavior, operationalised as the interpersonal distance, was predicted by higher paranoia, dismissive attachment, baseline interpersonal distance and avatar movement, but not by the degree of avatar contingent behavior. This is in line with evidence from experience data sampling in people with high paranoia who reported social threat irrespective of degree of familiarity (Collip et al., 2011) and failure to adjust behavior in response to evidence of another agent’s trustworthy behavior in economic exchange paradigms (Fett et al., 2012).

High subjective trust was not reflected behaviorally in closer proximity with the avatar. Dismissive attachment was also associated with both higher subjective trust and larger interpersonal distances. Why would individuals who are experiencing another as trustworthy behave in a way that might signal mistrust? Anomalous trust behavior with discrepancies between observed trusting behavior in the presence of subjective trust, can be rooted in insecure attachment (Fonagy et al., 2007). Indeed, children with externalising behavior, who, like individuals with paranoia (Combs et al., 2007), have been found to have hostile attribution style (Orobio de Castro et al., 2005) are trusting of others, but appear less trustworthy. Experiencing another as trustworthy in the context of a history of disrupted attachments can be threatening and give rise to over-arousal (Horowitz et al., 1964). Distancing is therefore conceptualised as a ‘deactivating strategy’, a self-regulatory attachment behavior (Mikulincer et al., 2007).

4.2. Hypersensitivity to contingency in extreme paranoia?
Tasks used to investigate intentionality in paranoia (Blakemore et al., 2003) have been criticised for their third person perspective (Chan et al., 2011) and questionable generalizability (Montag et al., 2011). In contrast, the current paradigm manipulated used a first person perspective. Under these circumstances,
people with extreme non-clinical paranoia, against our predictions, showed a heightened perceptiveness to contingent behavior instead of over-attributing intentionality. Heightened sensitivity to threat could emerge from adverse childhood experiences (MacBeth et al. 2008). Indeed attachment-disrupting events, such as being brought up in an institution, have been implicated paranoia (Bentall et al. 2014) and, in at risk of psychosis populations, interpersonal sensitivity, an excessive awareness of the behavior of others, has been associated with paranoia (Maslila et al. 2012; Valmaggia et al. 2007). The current study suggests that particularly high levels of interpersonal contingency might be necessary for highly paranoid individuals to develop trust, and therefore the absence of high responsiveness from others is experienced as a sign of mistrust. As argued in Trower et al. (1995)’s interpersonal theory of poor me paranoia, threats to the self can arise from the lack of objectifying other and the defence involves transforming indifference into persecution.

The findings should be interpreted with caution given the small sample size, with only 8 participants in the 90th percentile of high paranoia showing sensitivity to the contingency manipulation. However, data in the current study replicates continuum research with extreme subclinical paranoia such as (Combs et al. 2004) reports that those on the 85th percentile of paranoia, with paranoia scores of PS > 53 (n=29) prefer larger interpersonal distances than people with low paranoia in an in vivo social task. Further research should focus on the role of paranoid beliefs characteristics such as intentionality to cause harm, that differ between those at the top and the bottom of the paranoia hierarchy (Freeman et al. 2003) as well as investigating contingency manipulations in more ambiguous scenarios that increase anxiety (Lysaker et al. 2010). The current findings also need to be replicated with clinical and non-clinical populations, including females. The analogue nature of the study is also a limitation, and further work could use naturalistic designs to capture the richness of real life social encounters. However, the use of virtual reality allowed us to control for confounds and focus on the aspects under investigation. Moreover, participants reported a sense of presence, a subjective feeling of ‘being in the virtual scenario’ and their interpersonal behavior followed proxemics rules (Hall, 1966), supporting the validity of the paradigm.

Paranoia of the therapist has been linked to lack of progress in cognitive therapy for psychosis (Lawlor et al. 2014). The current study suggests that when working clinically with individuals with high trait paranoia, awareness of potential interpersonal sensitivity, and therapist own contingent behavior may be particularly important, as careful attunement to the client and contingent responsiveness might be crucial for the development of a trusting therapeutic relationship.

Disclosures: The authors declare no conflicts of interest.
References


Table 1

<table>
<thead>
<tr>
<th>Experimental Variable</th>
<th>Interpersonal distance (at window in metres)</th>
<th>Avatar trustworthiness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>SE (b)</td>
</tr>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline distance</td>
<td>.31</td>
<td>.11</td>
</tr>
<tr>
<td>Avatar movement</td>
<td>- .02</td>
<td>.01</td>
</tr>
<tr>
<td>Trait Anxiety</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Dismissive attachment</td>
<td>.04</td>
<td>.02</td>
</tr>
<tr>
<td>Paranoia</td>
<td>.01</td>
<td>.00</td>
</tr>
<tr>
<td>Contingency</td>
<td>.9</td>
<td>1</td>
</tr>
<tr>
<td>F (6, 85) = 4.61; p &lt; .001**; Adj. R² = .26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Step 2**            |     |        |       |      |     |        |       |      |
| Avatar movement       | - .02 | .12 | - .20 | - .86 | .392 |
| Trait Anxiety         | - .02 | .12 | 1  | - 99 | .325 |
| Dismissive attachment | .23 | .18 | 35 | 2.72 | .009* |
| Paranoia              | .03 | .02 | 35 | 2.04 | .047* |
| Contingency           | - .29 | .45 | - .14 | - .59 | .58 |
| Paranoia*Contingency  | - .07 | .34 | 44 | - .75 | .008* |
| F (6, 51) = 7.65; p = .001**; Adj. R² = .42; ΔR² = .310 |

Note: * p < .05; ** p < .01; *** p < .001. Step 1 predictors: Method (1): Baseline distance in metres for interpersonal distance regression on y; Avatar movements; Trait Anxiety; Dispositional traits (trait anxiety, sociability, agreeableness, and openness); Dismissive attachment assessed by the Multidimensional Attributional Style Questionnaire (MASH). Step 2 predictors: Avatar movement; Trait Anxiety; Dispositional traits (trait anxiety, sociability, agreeableness, and openness); Dismissive attachment assessed by the Multidimensional Attributional Style Questionnaire (MASH). Contingency was entered in step 2 using Forward selection. The interaction term was not significant and was not kept in the final model. *Values for Trait anxiety and Contingency entered in step 2 regression analyses are not interpretable because of the presence of the interaction term. **Values for Trait anxiety and Contingency entered in step 2 regression analyses are not interpretable because of the presence of the interaction term. ***Values for Trait anxiety and Contingency entered in step 2 regression analyses are not interpretable because of the presence of the interaction term. ΔR² = .310.
Figure 1: Virtual reality images of interaction with virtual tenant: sequence of events

a) Initial greeting (stages 1 & 2)

b) Virtual tenant invites participant to look at the terrace “Come and have a look!” (stage 3)

c) Virtual tenant and participant walk towards window (stage 3)

d) Virtual tenant and participant have moved across the room to look at the terrace (stage 3)