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When Pinocchio's nose does not grow: belief regarding lie-detectability modulates production of deception

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Does the brain activity underlying the production of deception differ depending on whether or not one believes their deception can be detected? To address this question, we had participants commit a mock theft in a laboratory setting, and then interrogated them while they underwent functional MRI (fMRI) scanning. Crucially, during some parts of the interrogation participants believed a lie-detector was activated, whereas in other parts they were told it was switched-off. We were thus able to examine the neural activity associated with the contrast between producing true vs. false claims, as well as the independent contrast between believing that deception could and could not be detected. We found increased activation in the right amygdala and inferior frontal gyrus (IFG), as well as the left posterior cingulate cortex (PCC), during the production of false (compared to true) claims. Importantly, there was a significant interaction between the effects of deception and belief in the left temporal pole and right hippocampus/parahippocampal gyrus, where activity increased during the production of deception when participants believed their false claims could be detected, but not when they believed the lie-detector was switched-off. As these regions are associated with binding socially complex perceptual input and memory retrieval, we conclude that producing deceptive behavior in a context in which one believes this deception can be detected is associated with a cognitively taxing effort to reconcile contradictions between one's actions and recollections.

Keywords: mock-crime, deception, beliefs, lie-detection, fMRI

INTRODUCTION

D . D

(S ., 2008). T , , . A (., A .,
2007; B ., 2009; K ., 2009; S ., 2010)
(G ., 2004, 2006)

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I (2007); S . (2008 ,) . S (. ., B ., 2008; G ., 2010, 2012) MRI (MRI) (. ., K ., 2005, 2009; M ., 2006) - - - . T , , . ' , - , - . P ' . A , , - , . C - , .

I - - , - . I , , , - . B - P ' , : P ' *believed* ?

S - (. ., F F , 2003). S , - , , (. ., P ., 2004; P ., 2005; D M ., 2006; M ., 2006; S ., 2010, 2012). D , , .

P - (A ., 2007; B ., 2009) - (G ., 2004, 2006). A , - , (IFG), (ACC, PCC,) (. ., S ., 2001; G ., 2003; L ., 2005; N ., 2005; G ., 2007; S ., 2012). T , , - - (G ., 2004, 2006; A ., 2007; B ., 2009). G . (2004, 2006) -

(2004), (2006). I ,04.1(1)-5.8( )410.952 (L ., 2005; G ., 2007). I S . (2012), IFG - . T , , , IFG - . I , , - .

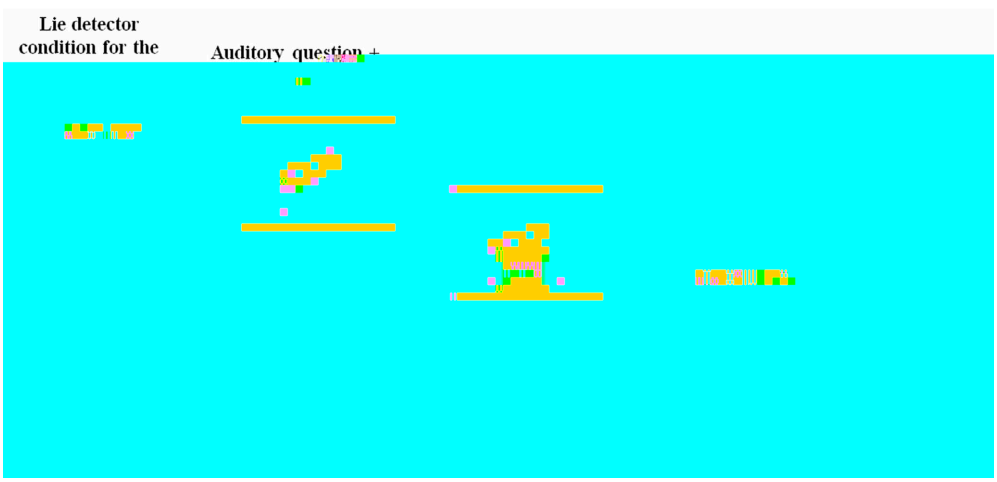

FIGURE 1 | A schematic example of the stimulus display. At the beginning of each block participants were told that the lie-detector (represented by the acronym GSR, for galvanic skin response) was either on or off. During the interrogation, pre-recorded auditory questions were read out over earphones, accompanied by appropriate visual presentations (question presentation took 2–4 s). After the question was completed, a response cue appeared on the screen for 2 s, during which participants had to provide a response. The response cue (0–2 s) was randomly assigned on each trial (Y/N or N/Y) to prevent participants from pressing only one button as a default response. Participants' response (which could be either "yes," "no," "no response" if no response was given within the allotted time or "wrong button" if a button without an assigned meaning was pressed) was displayed on the screen for the duration of the 5–8 s inter-trial interval (ITI).

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(. ., *I would delay giving a response when asked about the object I didn't steal to create confusion*).

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) (G ., 2003; L ., 2005; A ., 2007; B ., 2009; K ., 2009; S ., 2012): , IFG, PCC. O -

S Table 1. T BOLD IFG, PCC (Figure 3). T (>) (- > >).

I : / (Figures 4A,B) (Figures 4C,D), (O ., 2007), - (G ., 2003; M ., 2006). E

T BOLD . F / - , $t_{(16)} = 5.397$, $p < 0.001$. H - $t_{(16)} = 1.6$, $p = 0.14$. B . F

( ) - $t_{(16)} = 2.54$, $p < 0.05$. H - $t_{(16)} = 3.643$, $p < 0.01$.

DISCUSSION

W MRI . S - . O - / . T ( ) - . O , IFG, PCC - . R (S ., 2010, 2012), RT . T (., K ., 2005; L ., 2005; S ., 2008; S F , 2009). T . I . T H . T

Table 1 | Brain regions showing activation during response production.

Brain region	Hemisphere	x	y	z	t-value	Cluster size
MAIN EFFECT OF RESPONSE (FALSE > TRUE)						
Amygdala	R	30	0	−24	6.98	17
Inferior frontal gyrus (IFG)	R	44	26	10	6.24	25
Posterior cingulate cortex (PCC)	L	−2	−12	50	4.83	10
INTERACTION (ON FALSE-TRUE > OFF FALSE-TRUE)						
Hippocampus/parahippocampal gyrus	R	36	−18	−18	4.98	26
Temporal pole	L	−44	14	−22	4.89	17

Peak activation coordinates in standard MNI space and their associated t-scores. Regions shown were significantly activated at a threshold of p < 0.001 (uncorrected) with a cluster extent threshold of 10 voxels.

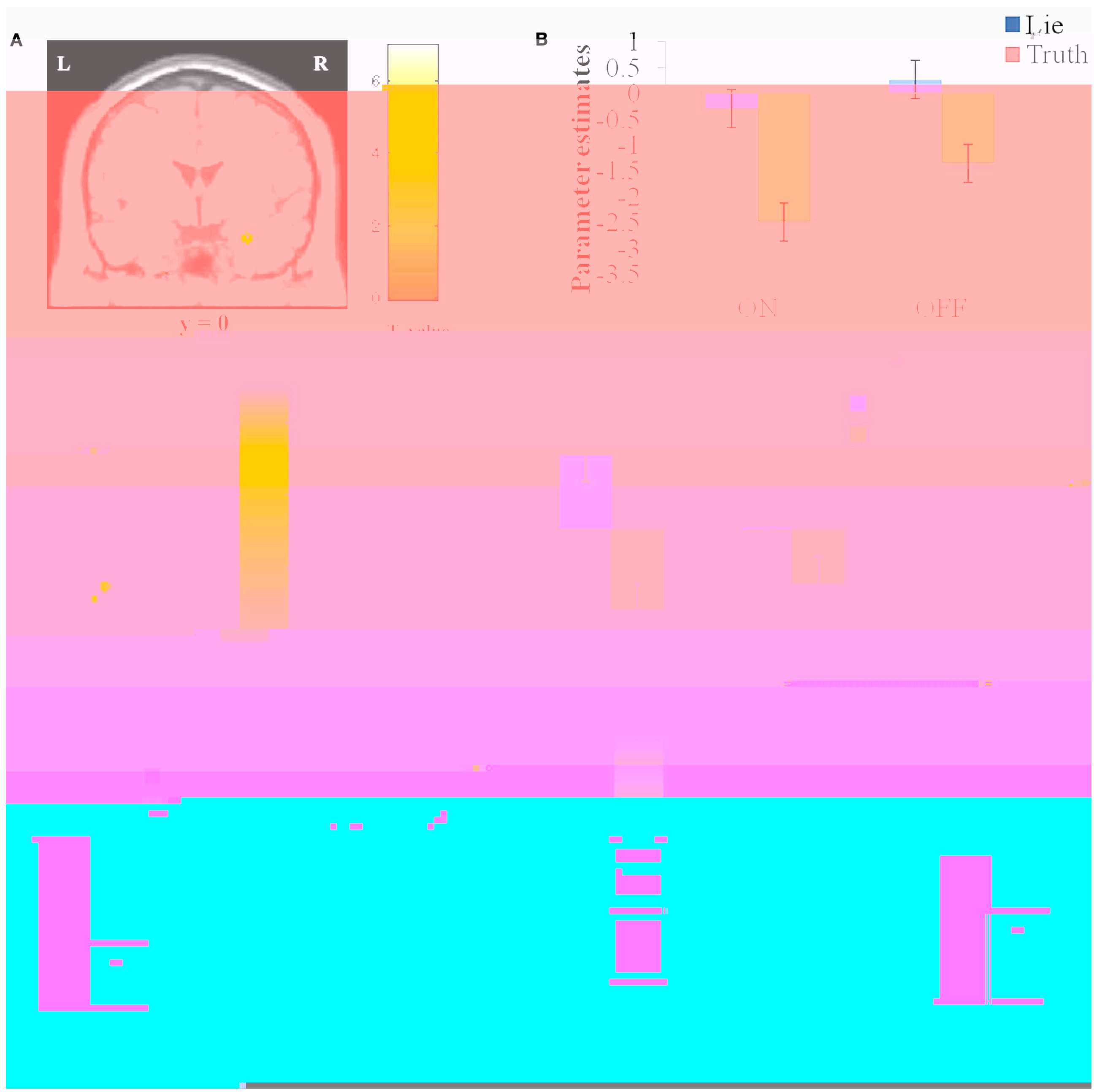

FIGURE 3 | The main effect of response (false > true). Panels on the left show the activation cluster and panels on the right show mean parameter estimates in the activation cluster in the right amygdala (**A** and **B**), right IFG (**C** and **D**), and left PCC (**E** and **F**). Deceptive responses in these regions yielded higher BOLD activation than truthful ones, and this difference was not significantly modulated by belief about whether the lie detector was on or off.

. H , RT , - . T - RT .

O (M ., 2006) . N ACC, DLPFC, IFG, (. ., K ., 2005; B ., 2009; G P , 2009; S ., 2010, 2012; G ., 2012) . T

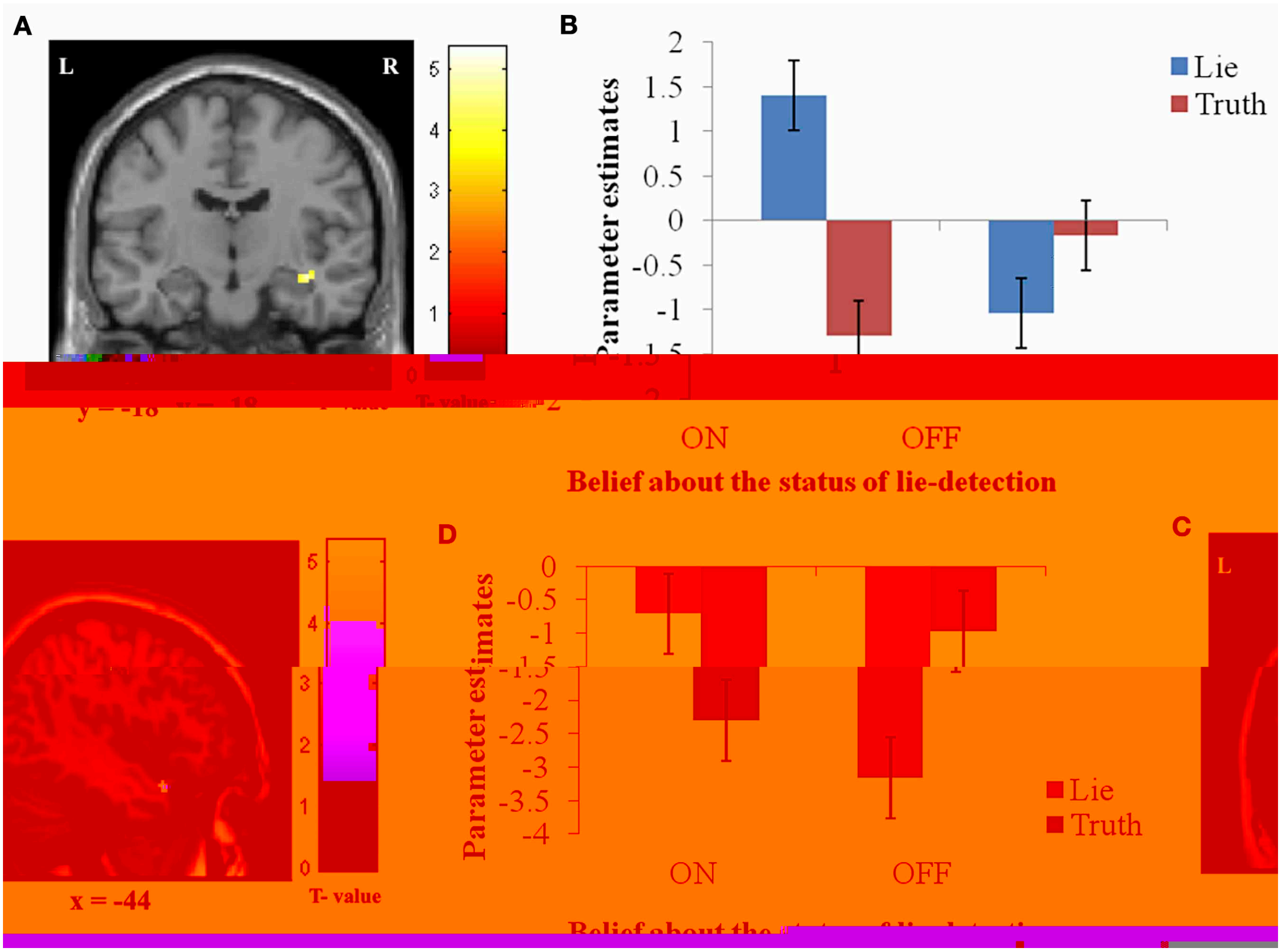

FIGURE 4 | The interaction between response type (true or false) and belief about the lie-detector (on or off). Panels on the left show the activation cluster and panels on the right show parameter estimates in the activation cluster in the right hippocampus/parahippocampal gyrus (**A** and **B**) and left temporal pole (**C** and **D**). In these loci, the difference between the BOLD activation caused by false vs. true responses was abolished (and for the hippocampus/parahippocampal gyrus, reversed) when participants believed the lie detector was off.

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MAIN EFFECTS: DECEPTIVE vs. TRUTHFUL RESPONSES

D BOLD IFG, PCC. T IFG (A ., 2007; B ., 2009; S ., 2012). H D (2007); O . (2007) . A . (2007)

. T , , . I , B . (2009)

per se.

I , PCC (M ., 2006). H . , . T , - , . P IFG (G ., 2007; S ., 2012) (A ., 2004) (C ., 2009). I , IFG , (S ., 2012). T IFG , - .

INTERACTION OF DECEPTIVE/TRUTHFUL RESPONSE AND BELIEF ABOUT LIE-DETECTABILITY

W , / , BOLD - , . T - (C ., 2003; F F , 2003; V ., 2006), (M ., 2002; H ., 2003), (G ., 2004, 2006). O . (2007) . I , - . T , - , (; D , 2007; O ., 2007). T - , . T

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T (. ., B ., 2002) ., B (2010) . A (S ., 2006)

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CONCLUSIONS

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ACKNOWLEDGMENTS

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N R F ' C F

I N W T .

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