What Neuroscience Can Tell about Intuitive Processes in the Context of Perceptual Discovery

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Abstract

■ According to the Oxford English dictionary, intuition is "the ability to understand or know something immediately, without conscious reasoning." Most people would agree that intuitive responses appear as ideas or feelings that subsequently guide our thoughts and behaviors. It is proposed that people continuously, without conscious attention, recognize patterns in the stream of sensations that impinge upon them. What exactly is being recognized is not clear yet, but we assume that people detect potential content based on only a few aspects of the input (i.e., the gist). The result is a vague perception of coherence which is not explicitly describable but instead embodied in a "gut feeling" or an initial guess, which subsequently biases thought and inquiry. To approach the nature of intuitive processes, we used functional magnetic resonance imaging when participants were working at a modified version of the Waterloo Gestalt Closure Task. Starting from our conceptualization that intuition involves an informed judgment in the context of discovery, we expected activation within the median orbito-frontal cortex (OFC), as this area receives input from all sensory modalities and has been shown to be crucially involved in emotionally driven decisions. Results from a direct contrast between intuitive and nonintuitive judgments, as well as from a parametric analysis, revealed the median OFC, the lateral portion of the amygdala, anterior insula, and ventral occipito-temporal regions to be activated. Based on these findings, we suggest our definition of intuition to be promising and a good starting point for future research on intuitive processes. ■

INTRODUCTION

In most everyday life decisions, we do not consciously go through steps of searching, weighing evidence, and carefully deciding which option to choose before we act. Rather, especially in situations where there is time pressure and/or uncertainty in terms of the probabilities and consequences of the options, we rely on instant responses that are distinguished by an affective valence or "gut feeling." These types of spontaneous judgment processes are defined collectively as intuition (e.g., Kahneman & Frederick, 2002; Hogarth, 2001).

Although almost everyone has an intuitive understanding of what intuition is, a generally accepted, scientific definition of intuition is still lacking. Definitions available highly depend on the individual research fields, which in turn differ in their meta-theoretical approaches and research methods. Hence, a specific definition of intuition is not correct or incorrect per se but can more or less adequately describe the constructs of intuitive processes one has in mind. Precisely because the term intuition has multiple connotations, it is important to specify its meaning in the context of this article: Following Bowers, Regehr, Balthazard, and Parker (1990), we define intuition as the "preliminary perception of coherence (pattern, meaning, structure) that is at first not consciously represented" (p. 74), but instead embodied in a "gut feeling" or an initial guess that subsequently biases our thought and inquiry. From an information processing perspective, it is suggested that specific situational cues automatically activate, probably by a process of spreading activation, a mnemonic network which integrates the entire stream of prior experiences that are all critically related to the crucial event. The result is a preliminary perception of coherence which the subject cannot yet describe explicitly. That is why intuition in everyday life is often referred to as "knowing something without knowing how you know it." Due to this dissociation between the ability to report on the cognitive processes and the intuitively guided behavior, which is often remarkably accurate, intuition has frequently been related to the unconscious. All in all, intuitive processes are assumed to capitalize on implicitly acquired knowledge but are not identical with implicit learning processes. Rather, stored mental representations provide the basis intuition capitalizes on. These representations are conceived of as nonverbal, concrete (e.g., images, feelings, physical sensations, metaphors), and its associations are suggested to tend to be context specific, although they are capable of generalization (Epstein, in press).

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As soon as the tacit or implicit perception of coherence becomes a plausible representation of coherence, which the subject can describe in explicit form, this transition in awareness is often experienced as a sudden and clear perception or insight. Yet, in our opinion, there is no implication that the implicit perception of coherence involves a fully formed but unconscious version of coherence which would regularly be represented consciously. Rather, we propose intuitive processes and insight processes to differ with regard to at least four aspects: (1) insight processes build on intuitive processes, and thus, follow the latter; (2) appear into consciousness; (3) consist in a solution; and (4) are bound to the problem-solving domain (cp. Bowden, Jung-Beeman, Fleck, & Kounios, 2005).

The conceptualization of intuition as an integration process of unconsciously represented information has to be specified in terms of information processing operations. One way to approach this issue may be to incorporate related neuropsychological results as well as experimental psychology with neuroscience. Neuropsychological research suggested the orbital region of the ventromedian prefrontal cortex (VMPFC) to be specifically implicated in affective or emotionally driven behavior, which is considered as one form of intuitive behavior (e.g., Davidson & Irwin, 1999; Rolls, 1999; Nauta, 1971). Damage to this area in humans has been shown to be associated with personality changes and gross impairments in everyday life decision making (Eslinger & Damasio, 1985; Damasio & van Hoesen, 1983). Specifically, patients with such damage have been shown to decide against their best interests and are unable to learn from previous mistakes despite intact intellectual abilities (Bechara, Tranel, & Damasio, 2002). The disadvantageous choice behavior was suggested to result from the patients' inability to integrate emotional and/or visceral signals into their decision-making process (Bechara et al., 2002; Damasio, 1996). It seemed as if those patients were unable to experience "gut feelings" or "initial guesses" that they can draw upon in the decision-making process. Supporting evidence for the assumption that the orbito-frontal cortex (OFC) may serve as detector and predictor of a potential content comes from studies that found OFC activity to be associated with hypothesis testing and guessing (Petrides et al., 2002; Elliott, Dolan, & Frith, 2000). From an anatomical point of view, the OFC may be dedicated to subserve the proposed integrative function, as this area receives input from all sensory modalities, including visceral ones, and so is probably the most polymodal region in the brain (with the exception of the rhinal regions; Kringelbach & Rolls, 2004).

Based on this evidence, we predict intuitive judgments that incorporate a preliminary perception of coherence would elicit activation within the median OFC as in contrast to judgments that do not involve such a perception. By using functional magnetic resonance imaging (fMRI) and a modified version of the Waterloo Gestalt Closure Task (Bowers et al., 1990), which was originally developed to measure intuitive responses, we wished to examine whether the neural substrates of intuitive judgments specifically activate the median OFC. Furthermore, to determine whether the observed activation was reliable, we additionally implemented a parametric design and investigated its effect on the hemodynamic response. Assuming that the median OFC would be activated, we wished to examine the functional connectivity of this area via a correlational analysis of the OFC's time course. Because the area of interest was the median OFC and this region has been known to be sensitive to susceptibility artifacts when employing gradient-echo echo-planar imaging (EPI) sequences, we used a spin-echo EPI sequence to eliminate signal voids. Spin-echo EPI is sufficiently sensitive to be used in cognitive studies, albeit with a reduction in Z scores of about a factor of three (Norris, Zysset, Mildner, & Wiggins, 2002).

All in all, we operationalized intuition as the preliminary perception of coherence in the context of (visual) discovery and investigate the phenomenon in its most simple form. Although this approach may leave some questions unanswered, we argue that it represents only the first stage in what will probably be a very complex research program.

METHODS

Participants

Fifteen (7 women, mean age 26.7, *SD* 2.9, range 20–32 years) right-handed, healthy volunteers participated in the fMRI experiment. Informed consent was obtained from each participant according to the Declaration of Helsinki. The experimental standards were approved by the local ethics committee of the University of Leipzig. Data were handled anonymously.

Materials

Stimuli, Task, and Experimental Session

Pictorial stimuli were centrally depicted on a black screen. Participants had their index fingers on a left and a right response button. Within each trial, a fixation cross was presented for 1 sec, followed by a cue of 500 msec, indicating that the next trial was about to start, which again was followed by a fixation cross of 500 msec, and then the stimulus was presented for 400 msec. Subsequently, a fixation cross was shown for 2 sec during which participants' response was recorded. No performance feedback was delivered whatsoever (see Figure 1). Overall, two conditions were employed:

In the object condition, participants were presented with fragmented black-and-white line drawings of

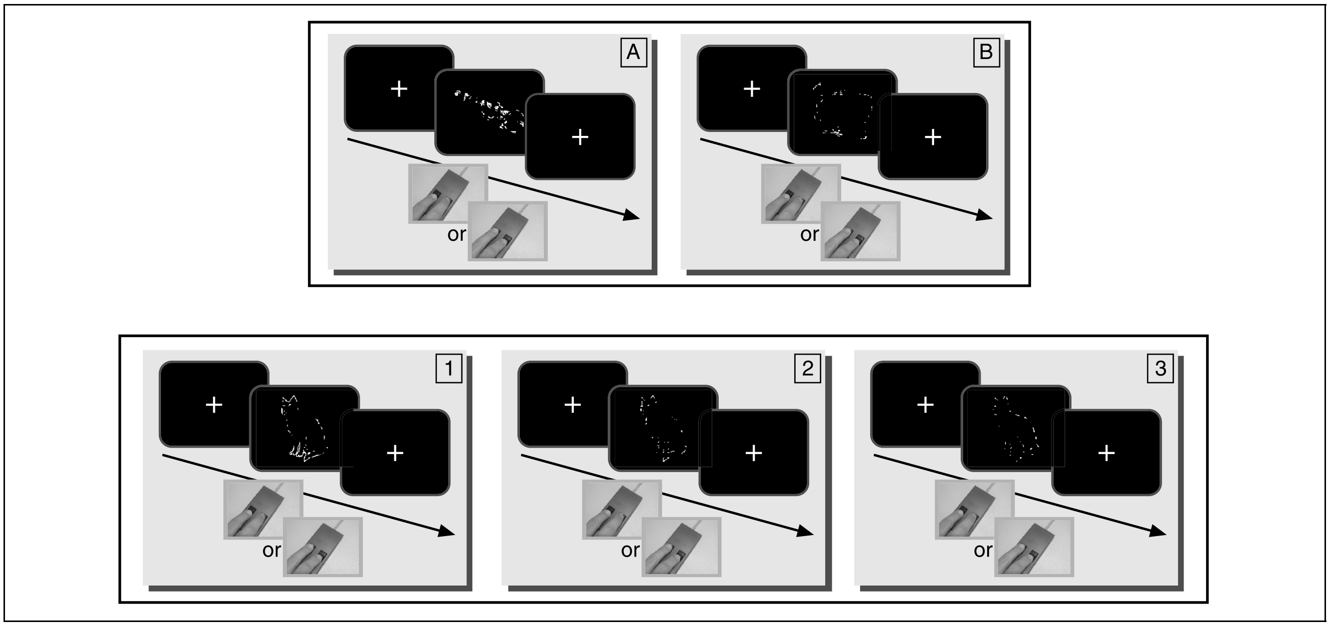

Figure 1. The upper left panel (A) shows an example of a coherent trial (violin), the upper right panel (B) an example of an incoherent trial. Stimuli were presented for 400 msec and participants had 2 sec to indicate whether the fragmented line drawing depicted a possible object (left response button) or an impossible object (right response button). In the lower panel, the three fragmentation levels are shown exemplary (cat). Note that stimuli were neither presented repeatedly nor were images concurrently presented in different levels of fragmentation within one individual session.

common objects (visual angle: 2°). The figures were originally taken from the inventory of Snodgrass and Vanderwart (1980) inventory and were subsequently fragmented with a filter. In order to induce different levels of fragmentation, we used three different filters, which differed in their potential to mask the drawing. The task of the participants was to indicate whether the fragmented line drawing depicted a meaningful (left response button) or a meaningless object (right response button). Note that stimuli were not presented iterated, not even at different levels.

In the nonobject condition, participants were presented with meaningless fragmented black-and-white line drawings (visual angle: 2°). These types of stimuli were developed by dividing and randomly rotating the pixel information of the meaningful line drawings, so that the resulting stimulus contained the identical pixel information as the meaningful stimulus but was rearranged so that an aesthetically pleasing but meaningless form was depicted. In short, the meaningful stimuli were divided into eight parts; these parts were then randomly rearranged so that a stimulus resulted that was composed of eight parts that contained local collinearity but the overall picture distinguished the drawing as a physically impossible object. Like in the object condition, participants' task was to decide whether the line drawing represented a meaningful object.

In general, participants were instructed to rely on their feeling whether or not the stimulus depicted a coherent gestalt, that is, depicted a possible object. It was emphasized that participants need not be able to name the specific object in order to indicate that it was a meaningful object. We considered it essential to put participants into a regulatory focus that promoted creativity. This was because our participants are accustomed to reaction time experiments featured by explicit instructions about correct and incorrect responses, and thus, are unfamiliar with situations in which time pressure and incomplete information call for a more risky processing style. After the experimental session, participants were asked to fill out a short questionnaire concerning their strategies. Subsequently, they were thanked and debriefed.

An experimental session consisted of 200 experimental trials, namely, 50 trials for each of the three levels in the object condition (resulting in 150 object trials) and 50 trials for the nonobject condition. Additionally, we included 30 null events, in which no stimulus was presented and so the blood oxygenation level-dependent (BOLD) response was allowed to return to a baseline state. All trials lasted for 6 sec each (i.e., three scans of repetition time [TR] = 2 sec). To allow for measurements to be taken at numerous time points along the BOLD signal curve, the onset of each stimulus presentation relative to the beginning of the first of the three scans was varied randomly in four time steps (0, 500, 1000, and 1500 msec). The purpose of this procedure was to enhance the temporal resolution of the image acquisition (Birn, Cox, & Bandettini, 2002; Miezin, Maccotta, Ollinger, Petersen, & Buckner, 2000). Generally, so as not to contaminate participants' judgments in a functional session, no image used for an object trial was used for nonobject trials within the same session and vice versa. This procedure was possible as we produced 200 stimuli altogether, that is, 200 object and 200 nonobject stimuli. From this pool we draw for each individual session 150 object stimuli and 50 different nonobject stimuli.

MRI Scanning Procedure

Imaging

Imaging was performed using a 3-T scanner (Bruker Medspec 30/100, Bruker, Ettlingen, Germany). As we expected activation within the OFC, including the VMPFC, and this cortical area has been known to be affected by strong susceptibility gradients, we used a spin-echo (SE) sequence which has been shown to be less sensitive to susceptibility-related signal dropout as in contrast to gradient-echo (GE) sequences (Schmidt, Boesiger, & Ishai, 2005; Norris et al., 2002). Yet, the drawback of using SE-based instead of GE-based fMRI is a lower statistical power of the SE sequences. Seventeen axial slices (4 mm thickness, interslice gap 1 mm, field of view [FOV] 19.2 cm, data matrix of 64 × 64 voxels, and in-plane resolution of 3 × 3 mm) parallel to the bicommissural plane (AC–PC) were acquired using a spin-echo EPI sequence (TR 2 sec, echo time [TE] 75 msec). Due to the application of an SE sequence and a TR of 2 sec, it was possible to collect only 17 axial slices, hence, excluding posterior parietal areas, dorsal prefrontal areas, and the most ventral part of the cerebellum from the imaging volume. Prior to the functional runs, 17 anatomical T1-weighted modified driven equilibrium Fourier transform (MDEFT; Norris, 2000; Ugurbil et al., 1993) images (data matrix 256 × 256, TR 1.3 sec, TE 10 msec) were acquired as well as 17 T1-weighted EPI images with the same spatial orientation as the functional data. The latter were used to coregister the functional scans with previously acquired high-resolution full-brain 3-D brain scans.

Data Analysis

The MRI data were processed using the software package LIPSIA (Lohmann et al., 2001). Functional data were corrected for motion artifacts using a matching metric on the basis of linear correlation. To correct for the temporal offset between the slices acquired in one scan, a cubic-spline interpolation was applied. A temporal high-pass filter with a cutoff frequency of 1/160 Hz was used for baseline correction of the signal and a spatial Gaussian filter with 5.65 mm full-width half-maximum (FWHM) was applied. The anatomical slices were coregistered with the full brain scan that resided in the stereotactic coordinate system and then transformed by linear scaling to a standard size (Talairach & Tournoux, 1988). The transformation parameters obtained from this step were subsequently applied to the functional slices so that the functional slices were also registered into the stereotactic space. Slice gaps were scaled using a trilinear interpolation, generating output data with a spatial resolution of 3 × 3 × 5 mm (45 mm^3).

The statistical evaluation was based on a least-squares estimation using the general linear model (GLM) for serially autocorrelated observations (random effects model; Friston, Frith, Turner, & Frackowiak, 1995; Worsley & Friston, 1995; Friston, 1994). An event-related design was implemented, that is, the hemodynamic response function was modeled by means of the experimental conditions for each stimulus (event = onset of stimulus presentation). The design matrix was generated utilizing a synthetic hemodynamic response function and its first and second derivatives (Friston et al., 1998) and a response delay of 6 sec. The model equation, including the observation data, the design matrix, and the error term, was convolved with a Gaussian kernel of dispersion of 4 sec FWHM to deal with the temporal autocorrelation (Worsley & Friston, 1995). Contrast images (i.e., estimates of the raw-score differences between specified conditions) were generated for each subject. The single-subject contrast images entered into a second-level analysis on the basis of Bayesian statistics (Neumann & Lohmann, 2003). In the approach by Neumann and Lohmann (2003), posterior probability maps and maps of the effect size for the effects of interest in groups of subjects are calculated on the basis of the resulting least-squares estimates of parameters for the GLM. The output of the Bayesian second-level analysis is a probability map showing the probability for the contrast to be larger than zero. For visualization, a threshold of 99.5% was applied to the probability maps.

Reasons to use Bayesian second-level analysis for fMRI data are manifold: A comparison between the established analysis based on *t* statistics and Bayesian second-level analysis showed that the latter is more robust against outliers. Furthermore, the Bayesian approach overcomes some problems of null hypothesis significance testing, such as the need to correct for multiple comparisons, and this approach provides estimates for the size of an effect of interest as well as for the probability that the effect occurs in the population (Neumann & Lohmann, 2003).

RESULTS

Behavioral Results

A repeated-measures analysis of variance (ANOVA) revealed that participants were significantly slower on trials in which they judged the fragmented drawing to be meaningful (mean reaction time [RT in msec]/standard error [*SE*] = 1124/63) as compared to those trials in which they judged the drawing to be meaningless [RT/SE = 1028 (59); $F(1,14) = 4.73$; $p = .05$]. On average, participants judged only 33.3% ($SE = 2.8$) of the object trials to be meaningful, whereas they judged 83.5% ($SE = 5.4$) of the nonobject trials to be meaningless [$F(1,14) = 39.2$; $p = .0001$].

When conditions object and nonobject were split up per level, a repeated-measures ANOVA revealed a significant main effect (ME) for condition and level as well as a significant interaction regarding the rate of correct responses; for RT it revealed a significant ME for condition and a significant interaction [% correct: ME condition: $F(1,14) = 114.1$; $p = .0001$; ME level: $F(2,13) = 21.3$; $p = .0001$; interaction: $F(2,13) = 44.6$; $p = .0001$; RT: ME condition: $F(1,14) = 11.8$; $p = .004$; ME level: $F(2,13) = 2.2$; $p = .14$; interaction: $F(2,13) = 38.6$; $p = .0001$; see also Table 1].

Imaging Results

Direct Contrasts

To test for the specific neural correlates of intuitive judgments, we contrasted trials which participants judged to be coherent (i.e., depicting a common object), with trials which participants judged to be incoherent (i.e., depicting nonobjects). Because participants judged 33% of the overall 150 object trials to be coherent and 84% of the overall 50 nonobject trials to be incoherent, the contrast investigating intuitive processes was performed, on average, on an equal number of trials. The posterior probability maps of this comparison showed activation specific for intuitive judgments within the anterior and posterior median OFC, right anterior insula, within the right lateral portion of the amygdala complex, midbrain area, right thalamus, ventral occipito-temporal (VOT) regions bilaterally, and within the right cerebellum (see upper left panel in Figure 2 and Table 2 for Talairach coordinates). Note that we did not observe any activation within the right anterior portion of the superior temporal gyrus, an area which has been suggested to reflect insight processes (Bowden et al., 2005; Jung-Beeman et al., 2004).

To the extent that activation within the median OFC simply reflects the monitoring of the reward value of objects, either consciously or unconsciously (Davidson & Irwin, 1999), activation within this area should also be elicited when contrasting object trials with nonobject trials irrespective of participants' judgment. This is because object trials could be considered as rewarding as they depict familiar shapes in contrast to nonobject trials. The posterior probability map of the contrast object versus nonobject showed activation bilaterally within the anterior insula ($x = -31/31$, $y = 21/18$, $z = 8/-3$), VOT regions ($x = -46/37$, $y = -53/-47$, $z = -18/-18$), and cerebellum ($x = -16/19$, $y = -68/-77$, $z = -21/-21$). Yet, activation within the median OFC did not reveal.

Parametric Analysis

To model the effects of an increasing possibility to experience a preliminary perception of coherence, we implemented a parametric design. As outlined above, we generated three levels of fragmentation, that is, drawings differed in their amount of pixel information presented. Accordingly, a Level 3 drawing contained less pixel information than a Level 1 drawing, and thus, the possibility to experience a preliminary perception of coherence decreased with the decreasing amount of pixel information. As a stimulus-dependent parameter assuming equidistance between the levels (e.g., 1, 2, 3) is much inferior to a performance-dependent parameter using the percentage of correct answers per level, we implemented a parameter of the latter type. The posterior probability map shows the median OFC, anterior insula bilaterally, left ventral tegmental area, right hypothalamus, the left lateral portion of the amygdala complex, the right midportion of the parahippocampal gyrus, and VOT regions bilaterally to be more engaged the higher the possibility to experience a preliminary perception of coherence (see lower panel in Figure 2 and Table 2 for coordinates).

Functional Connectivity of the Median OFC Investigated by Temporal Correlations

The way in which the variations in one region relate to those in other regions may provide insight into neuronal connectivity independent of any specific task or

Table 1. The Rate of Correct Responses and Reaction Times (RT in msec; with Standard Errors in Parentheses) for the Three Levels of Stimulus Fragmentation for the Conditions Object and Nonobject

	% Correct			*RT*		
Condition	*Level 1*	*Level 2*	*Level 3*	*Level 1*	*Level 2*	*Level 3*
Object	53.2 (3.4)	27.6 (3.4)	23.3 (2.6)	1015.5 (55.1)	1163.1 (62.5)	1107.8 (61.8)
Nonobject	81.3 (3.7)	91.5 (2.7)	88.1 (2.8)	1093.1 (63.9)	958.0 (65.1)	954.3 (54.8)

In the object condition, 50 trials were presented for each level (i.e., 150 trials altogether), whereas 50 trials were presented for all levels in the nonobject condition.

FPO

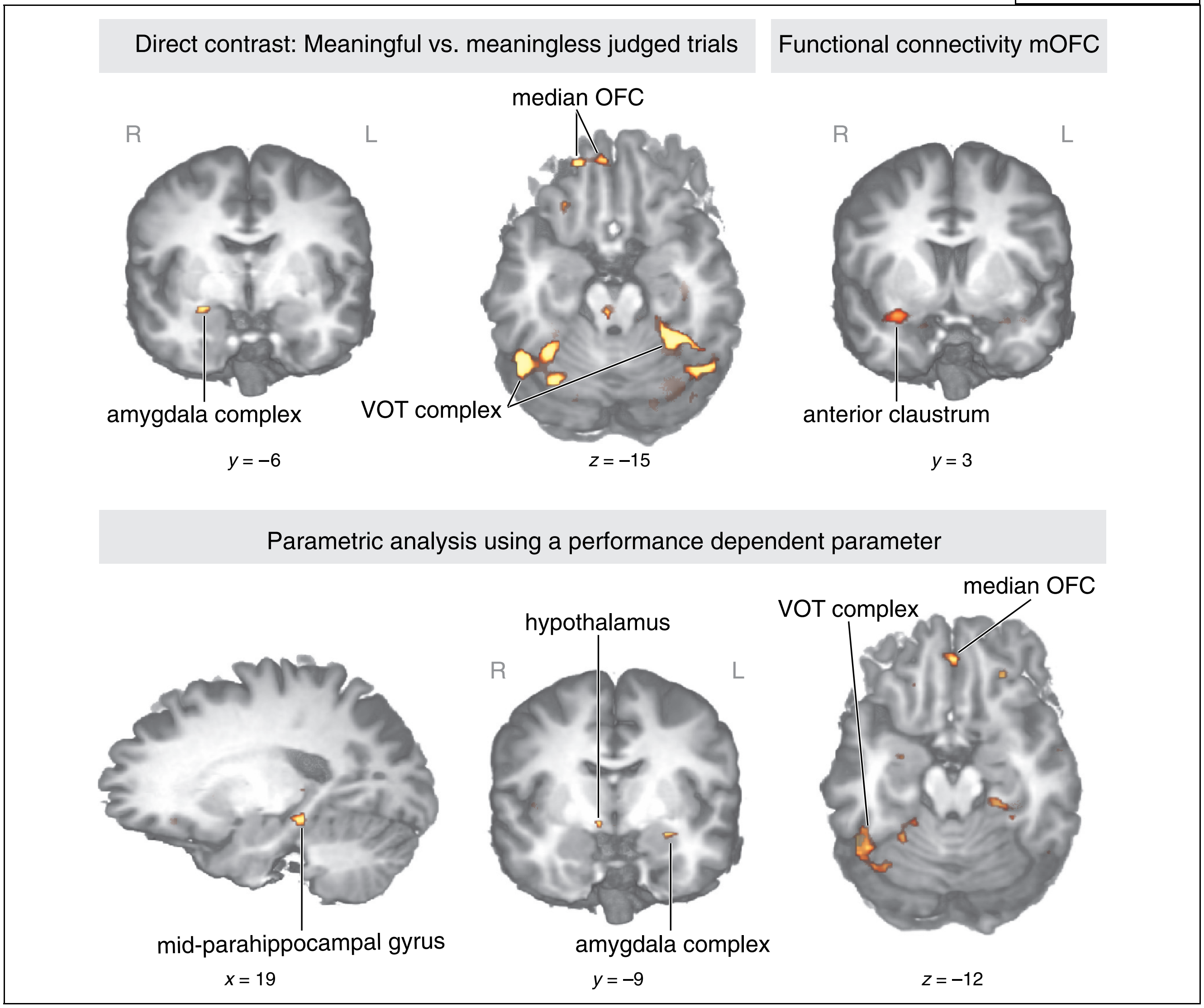

Figure 2. Group-averaged activations are shown on coronal, sagittal, and axial slices of an individual brain normalized and aligned to the Talairach stereotactic space. The upper left panel shows the imaging results of the direct contrast between trials that participants judged to be meaningful with trials that participants judged to be meaningless. The upper right panel shows the imaging results from the correlational analysis of the median OFC's (mOFC) time course. In the lower panel, imaging results from the parametric analysis are shown that used a performance-dependent regressor (i.e., the percentage of correct answers per level).

contrast. Hence, to examine the functional connectivity among brain regions, analyses of correlations between regional signal fluctuations must have been approved (e.g., Hampson, Peterson, Skudlarski, Gatenby, & Gore, 2002). In general, the unique activity time course is considered to act like a temporal fingerprint, which can then be used to segregate cortical subdivisions (Bartels & Zeki, 2005). To examine the functional connectivity of the median OFC in the present study ($x = -1$, $y = 39, z = -12$), a correlational analysis was performed using the area's time course as a regressor. As a result, functional interactions were revealed between the median OFC and the right anterior claustrum ($x = 28, y = 3$, $z = -12$), anterior insula ($x = 40$, $y = 9$, $z = -6$), and the median portion of the amygdala complex ($x = 19$, $y = -8, z = -18$; threshold was assigned to $Z = 3.4$; see upper right panel in Figure 2).

DISCUSSION

In the present fMRI study, we attempted to examine the neural substrates of intuitive judgment processes in the context of perceptual discovery. Following Bowers et al. (1990), we conceived of intuitive processes as the preliminary perception of coherence in terms of pattern, meaning, or structure, embodied in an affective valence or ''gut feeling,'' which subsequently guides prospective behavior. Specifically, we propose that clues of coherence may activate a relevant mnemonic network, which

Table 2. Laterality, Anatomical Specification, Talairach Coordinates (x, y, z), and Posterior Probabilities for Activation According to Bayesian Analysis are Shown for the Direct Contrast and the Parametric Contrast

Area	*x*	*y*	*z*	*Bayesian (%)*
Intuitive > nonintuitive judgments				
L. median orbitofrontal cortex (OFC)	−5	45	−15	99.9
	−20	42	−15	99.9
L. posterior median orbitofrontal gyrus	−26	18	−9	99.9
R. anterior insula	40	12	−6	99.9
R. lateral portion of the amygdala complex	22	−6	−9	99.9
L. midbrain area	−5	−30	−15	99.9
R. thalamus	7	−15	11	99.9
L. ventral occipito-temporal gyrus/fusiform gyrus	−32	−48	−12	99.9
	−50	−54	−15	99.9
R. ventral occipito-temporal gyrus/fusiform gyrus	28	−45	−12	99.9
R. cerebellum	25	−69	−18	99.9
Parametric analysis				
L. median OFC	−2	39	−12	99.9
R. median OFC	25	33	−9	99.9
L. anterior insula	−35	15	−3	99.9
R. anterior insula	37	15	−3	99.8
L. ventral tegmental area	−5	−18	−6	99.9
R. hypothalamus	7	−8	−3	99.9
L. lateral portion of the amygdala complex	−26	−9	−9	99.9
R. midportion of the parahippocampal gyrus	19	−30	−9	99.9
L. ventral occipito-temporal gyrus/fusiform gyrus	−26	−48	−9	99.9
	−35	−66	−6	99.9
	−49	−50	−15	99.9
R. ventral occipito-temporal gyrus/fusiform gyrus	31	−36	−18	99.9

integrates the entire stream of prior experiences making up the gist of the entity. In the present forced-choice paradigm, participants were briefly (400 msec) presented with fragmented line drawings depicting common objects, and such line drawings that were identical in pixel information but did not depict a real object. The participants' task was to decide whether or not the drawing was coherent (i.e., represented a possible object). Given the difficulty of the task, participants were encouraged to base their decision on an "initial guess" whether or not the drawing was coherent.

Activation within Median Orbito-frontal Cortex Reflects Intuitive Processing

In the present study, activation within the medial OFC specifically revealed when participants judged the fragmented drawings to be coherent, and this activation showed to depend on the possibility to perceive a coherent gestalt in terms of visual information. Activation within the median OFC during visual recognition has been recently suggested to provide an initial guess "facilitating recognition by substantially limiting the number of object representations that need to be considered" (Bar et al., 2006, p. 449). Similarly to the presently employed task, Bar et al. (2006) presented participants with blurry images of common, everyday objects (i.e., either masked or spatially filtered images), and asked their participants to indicate whether or not the image they saw depicted a normal everyday object. The results of their elegant fMRI and magnetoencephalography (MEG) study revealed (a) that OFC activation unique to successful recognition developed 50 msec *before* activation was observed within the fusiform region, which has been shown to be involved in object recognition (Grill-Spector & Malach, 2004), and (b) that the early recognition-related OFC activation depended on the spatial frequencies in the image, that is, low spatial frequency (LSF) filtered object images elicited higher fMRI signals within the OFC compared to high spatial frequency (HSF) filtered object images. These findings highly support our hypothesis about intuitive processes, which proposes that in situations with time pressure and/or insufficient information, specific situational cues of a fuzzy input-representation activate a mnemonic network signaling the most likely interpretation of the input, which is then used by downstream areas. Based on the results of the present study, we propose the median OFC to reflect intuitive processes, that is, to serve as a detector of potential content which is derived from the critical aspects of the input. This gist information is supposed to consist of the most representative attributes of the respective category, namely, the prototypical aspects. The resulting preliminary perception of coherence, supposed to be embodied in a "gut feeling" or an initial guess, is then assumed to bias our thought and inquiry accordingly. The MEG study by Bar et al. has provided important temporal information regarding this process during object recognition: Information from early visual areas is transferred to the OFC and then back-projected to ventral occipito-temporal (VOT) areas. We propose the information delivered from the OFC to continuously add color to the ongoing processing. But only in situations were there is time pressure and/or shortcomings regarding the input information, the biasing signals from the OFC are suggested to be taken into account. Support for this assumption was again provided by Bar and colleagues, who showed that the functional connectivity between early visual areas, the OFC, and the fusiform gyrus is stronger for blurry images (LSF images) compared to nonblurry images (HSF images).

To more closely examine the nature of the proposed integration process taking place within the OFC, it might be helpful to determine the kind of information being delivered to the OFC. By incorporating the literature on basic visual processing, we offer a preliminary hypothesis about the kind of information being projected from early visual areas to the prefrontal cortex, possibly by using the inferior fronto-occipital tract: Previous work showed that normal visual object identification (''what'') depended on occipito-temporal cortices, whereas object location (''where'') required parietal cortical areas (Ungerleider & Mishkin, 1982). The dual visual system view was then combined with physiological data: Information about form and color delivered by so-called P-cells (within the lateral geniculate nucleus [LGN]) was considered to project ultimately to the ''what'' hierarchy of visual areas ending in the temporal lobe, whereas information about motion delivered by the M-cells (within the LGN) was considered to project to the ''where'' hierarchy of visual areas ending in the parietal lobe. The pathway providing information from the K-cells (within the LGN) was ignored, as it did not fit well with the two visual system models and are only recently an object of interest (Xu et al., 2001; Hendry & Reid, 2000; Ding & Casagrande, 1998). K-cells have been found to share many achromatic spatial and temporal properties in common with both M- and P-cells but are limited in the message they send, which makes it hard to shoehorn them into one of the two categories (Casagrande & Royal, 2004). One possibility may be that K-cells process *the* critical information important both for motion and object identification in parallel to the processing within the P- and M-cells. Information provided by the K-cells is proposed to be mainly relied on in uncertain situations, especially when information from the P- and M-pathway is not available. Specifically, K-cells are the only cell group that projects directly to the extrastriate cortex (V2, V4) and particularly to inferotemporal cortex (Hernandez-Gonzalaz, Cavada, & Reinoso-Suarez, 1994). Hence, K-cells are suggested to sustain some visual behavior in the absence of the visual cortex (V1), and thus, are assigned a crucial role in ''blindsight'' (Vakalopoulos, 2005; Hendry & Reid, 2000). In turn, the object-processed visual information the OFC receives stems from the inferior temporal cortex (Kringelbach & Rolls, 2004). Accordingly, the inferotemporal cortex might serve as an interface mediating the processing of unconscious visual information conveyed by the K-cells.

Bar et al. (2006) describe the function of the OFC as a ''top-down facilitation of object recognition,'' yet, as we think that the term ''top-down facilitation'' may set on a somewhat wrong track, we suggest to broaden this interpretation. Usually, top-down guidance means ''based on the observer's knowledge'' in contrast to bottom-up guidance which means that the stimulus itself provides the guidance largely independent of that knowledge (e.g., Wolfe, Butcher, Lee, & Hyle, 2003). As outlined in the Introduction, intuition can be circumscribed as ''knowing something without knowing how you know it,'' hence, it might be promising to distinguish the facilitation process subject to the sort of knowledge that is relied on: The gist information is realized on the basis of the observer's implicit knowledge rather than being consciously extracted on the basis of the observer's explicit knowledge.

In the beginning, we emphasized the integrative function of the OFC with regard to experiential information. That is, to which degree does the actual input match with previously rewarded input. Associative information in this respect may be delivered by the amygdala complex to which the OFC has direct neuroanatomical connections (Fuster, 2000). Electrophysiological studies in rats and monkeys, conducted to dissociate the role of the OFC and the amygdala complex, showed that activation within the amygdala complex, but not within the median OFC, correlated with the magnitude of the incentive value, whereas median OFC activation, but not amygdala activation, increased with the difficulty of the choice being made. Based on these findings, activation within the amygdala complex in the present study may reflect the magnitude of the incentive value of the predictive cues (i.e., the current visual input predictive of possible objects).

To further elucidate the functional role of the OFC during intuitive processing, it is highly suggested to replicate this study in the auditory domain.

Activation within Ventral Occipito-temporal Regions Reflects Object Recognition Processes

A great deal of evidence showed a set of regions in the ventral (''what'') stream that respond more strongly when participants view images of objects, faces, and places than of textures or visual noise (for a comprehensive review, see Grill-Spector & Malach, 2004). A central complex of these object-selective regions constitutes a stretch of cortex bounded by the fusiform gyrus laterally and the parahippocampal gyrus medially, which has been termed the VOT cortex. The object-selective regions showed a wide range of perceptual invariances to visual cues and object modifications (Grill-Spector & Malach, 2004). Furthermore, it has been found that object-selective cortices do not represent local contours or local image features but rather correlate with the *percept* of an object or face (Grill-Spector, 2003; Andrews, Schluppeck, Homfray, Matthews, &

Blakemore, 2002; Hasson, Hendler, Bashat, & Malach, 2001). That is, activation did not correlate with the physical presence of an object or face but with the participants' perceptual reports. Importantly, activation within object-selective regions even correlated with false identification (Grill-Spector, 2003).

In the present experiment, activation within VOT regions showed to correlate with the (individual) successful object perception (direct contrast) as well as to increase with participants' identification performance (parametric contrast). Accordingly, VOT activation is suggested to correlate with participants' percepts of common objects rather than with the physical data. Hence, VOT regions in the present study are suggested to reflect holistic object perception processes—biased by OFC input—rather than the processing of low-level visual features. We conclude that whenever participants indicated the fragmented drawing to be coherent, they truly perceived an object regardless of the actual physical stimulus.

Implications of Unexpected Behavioral Findings

A limitation of the present study is participants' poor performance in the object condition as compared to their superior performance in the nonobject condition. Given these data, one could of course argue for a response bias, that is, participants' inclination for responding "no, the stimulus did not depict a meaningful object." One explanation may be that we failed to put participants into a motivational orientation that involves a relatively risky processing style in which novel alternatives are eagerly and actively sought. Higgins (1997) termed this motivational orientation "promotion focus" in contrast to a "prevention focus" that involves a relatively risk-averse and vigilant processing style in which repetition is preferred to novelty and alternatives are carefully eliminated. Crowe and Higgins (1997) could demonstrate that participants with a promotion focus adopted a relatively risky processing style that led to a lower response threshold, which in turn was represented in a tendency to insure hits (successful recognition) at the cost of increased false alarms (failure to reject). In contrast, participants with a prevention focus adopted a relatively risk-averse processing style that led to a higher response threshold, which again was represented in a tendency to insure correct rejections (successful rejecting distractor stimuli) at the costs of increased misses (failing to recognize target stimuli).

In the present study, participants clearly showed a high response threshold (83.5% correct rejections, 66.7% misses), which may be seen as an indicator of a conservative or risk-averse processing style in terms of a prevention focus. This instance may be caused by our participants' habituation with reaction time experiments conducted at the present laboratory. This type of experiments is characterized by a clear indication of what is considered a correct or an incorrect response, and creative thoughts are needless if not unwanted. As a result, participants' habitual regulatory focus may have acted as the primary force impelling the cognitive tuning of their processing style.

Does Activation within the Claustrum Represent the Temporal Synchronization Process during Intuitive Judgment Processes?

Results from the functional connectivity analysis revealed activation within the right anterior claustrum, right anterior insula, and the median portion of the right amygdala complex. Accordingly, these regions, including the median OFC, are assumed to resemble each other with respect to their specific time course.

As outlined above, holistic processing is assumed to involve some form of cooperative activity between regions each coding for a different aspect of the same, critical event. Accordingly, not only an integration process has to be implemented but also a synchronization process in the temporal domain. Examining neurophysiological data, the claustrum may be suggested to be especially important for the timing of cortical activity (Crick & Koch, 2005). This finding has been supported by those showing the anterior claustrum to be implicated in the kindling of generalized seizures (Zhang et al., 2001). Based on this evidence and the claustrum's neuroanatomical connections and composition, the claustrum has been suggested to play a specific role "in binding disparate events into a single percept, experienced at one point in time" (Crick & Koch, 2005, p. 1273). The authors came up with the analogy of the claustrum as a "conductor coordinating a group of players in the orchestra [...]. Without the conductor the players can still play but they fall increasingly out of synchrony with each other" (Crick & Koch, 2005, p. 1276). Continuing with this speculation, activation within the claustrum may reflect the synchronization processes which is needed in order to experience an affective valence of "gut feeling" for a specific (behavioral) option. Yet, it remains for future studies to test for the specific functional role of the claustrum.

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