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The influence of tobacco consumption on the relationship between schizotypy and hemispheric asymmetry

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ABSTRACT

Tobacco use is positively associated with severity of symptoms along the schizophrenia spectrum. Accordingly it could be argued that neuropsychological performance, formerly thought to be modulated by schizotypy, is actually modulated by drug use or an interaction of drug use and schizotypy. We tested whether habitual cigarette smokers as compared to non-smokers would show a neuropsychological profile similar to that observed along the schizophrenia spectrum and, if so, whether smoking status or nicotine dependence would be more significant modulators of behavior than schizotypy. Because hemispheric dominance has been found to be attenuated along the schizophrenia spectrum, 40 right-handed male students (20 non-smokers) performed lateralized left- (lexical decisions) and right- (facial decision task) hemisphere dominant tasks. All individuals completed self-report measures of schizotypy and nicotine dependence. Schizotypy predicted laterality in addition to smoking status: While positive schizotypy (Unusual Experiences) was unrelated to hemispheric performance, Cognitive Disorganization predicted reduced left hemisphere dominant language functions. These latter findings suggest that Cognitive Disorganization should be regarded separately as a potentially important mediator of thought disorganization and language processing. Additionally, increasing nicotine dependence among smokers predicted a right hemisphere shift of function in both tasks that supports the role of the right hemisphere in compulsive/impulsive behavior.

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1. Introduction

The concept of schizotypy, which was originally introduced by Meehl (1962) as a genetic diathesis-stress model for schizophrenia (see also Lenzenweger & Korfine, 1992), represents a mild and non-clinical thinking style in the general population reminiscent of the one reported by individuals with a clinical diagnosis of schizophrenia. Schizotypal symptoms in the general population are quantitatively less prominent yet qualitatively equivalent to those seen in schizophrenia (Gooding, Matts, & Rollmann, 2006; Rawlings, Williams, Haslam, & Claridge, 2008). However, while schizotypal symptoms are considered to lie at one extreme end of the schizophrenia spectrum (SSp) in the clinical population, in healthy people such symptoms are considered to express themselves in milder form along the SSp (Claridge & Broks, 1984; Van Os, et al., 1999). Schizotypy is typically assessed using self-report questionnaires (Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994; Mason, Claridge, & Jackson, 1995; Raine, 1991) and high scores might indicate enhanced proneness to psychosis (Chapman et al., 1994; Gooding, Tallent, & Matts, 2005). The notion that schizotypy and overt clinical psychosis are linked is also supported by observations that high-scoring, pre-selected schizotypal individuals from the general population demonstrate cognitive-attentional (Buchy, Woodward, & Liotti, 2007; Gooding, Kwapil, & Tallent, 1999; Sarkin, Dionisio, Hillix, & Granholm, 1998), sensory-motor-behavioral (Lenzenweger & Gold, 2000), physiological (Klein, Berg, Rockstroh, & Andresen, 1999; Pizzagalli et al., 2000) and neurochemical (Laruelle & Abi-Dargham, 1999; Murray, Lappin, & Di Forti, 2008) peculiarities comparable to those described in patients with schizophrenia.

Similarities between schizotypy and schizophrenia are not limited to pre-selected highly schizotypal individuals but present in randomly selected individuals from the general population (e.g. Mason & Claridge, 1999; Mohr, Bracha, & Brugger, 2003; Reed, et al., 2008; Shaw, Claridge, & Clark, 2001; Steel, Hemsley, & Pickering, 2002) that supports the notion that the SSp dimension extends across the general population. Indeed, there is an advantage in testing schizotypal individuals since basic brain mechanisms in psychosis can be studied in individuals free from confounding factors and illness-related phenomena seen in patients with schizophrenia,

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such as antipsychotic medication, hospitalization, or duration of illness (Esterberg, Jones, Compton, & Walker, 2007; Gooding et al., 1999).

Of particular interest to the present study is the enhanced consumption of readily available psychoactive substances as one moves along the SSp, such as i) tobacco in schizotypy (Esterberg, Goulding, McClure-Tone, & Compton, 2009; Williams, Wellman, Allan, et al., 1996) and schizophrenia patients (de Leon, Diaz, Rogers, Browne, & Dinsmore, 2002), ii) cannabis in schizotypy (Barkus, Stirling, Hopkins, & Lewis, 2006; Skosnik, Spatz-Glenn, & Park, 2001; Williams, Wellman, & Rawlins, 1996) and schizophrenia (Barnes, Mutsatsa, Hutton, Watt, & Joyce, 2006), and iii) caffeine in schizotypy (Jones & Fernyhough, 2009) and schizophrenia (Gurpegui, Aguilar, Martinez-Ortega, Diaz, & de Leon, 2004). While some authors have suggested that dopamine-enhancing drugs such as nicotine (Montgomery, Lingford-Hughes, Egerton, Nutt, & Grasby, 2007; Murphy et al., 2002) might be involved in the development of psychosis or some aspects of it (Abi-Dargham et al., 1998; Moore et al., 2007; Smith et al., 2009), others suggest that at-risk individuals may use nicotine as means of self medication (Adler, Hoffer, Wiser, & Freedman, 1993; Kumari & Postma, 2005; Zabala et al., 2009; Zammit et al., 2003). However, the reason for enhanced drug consumption along the SSp currently remains unexplained. Indeed, in the absence of unequivocal evidence that would fully support one or the other hypothesis (Adler et al., 1993; Smith et al., 2009) it could even be argued that behavior formerly associated with the SSp might rather result from drug consumption.

In line with this latter suggestion, in the current study we focus on hemispheric asymmetry of function since language dominance in the left hemisphere (LH) and visual face recognition dominance in the right hemisphere (RH) have been found to be attenuated in schizophrenia (Bleich-Cohen, Hendler, Kotler, & Strous, 2009; Kucharska-Pietura, David, Dropko, & Klimkowski, 2002; Loberg et al., 2006; Mitchell & Crow, 2005; Phillips & David, 1997; Sommer, Ramsey, & Kahn, 2001) and schizotypy (Broks, 1984; Brugger, Gamma, Muri, Schafer, & Taylor, 1993; Mason & Claridge, 1999; Mohr, Krummenacher, et al., 2005; Suzuki & Usher, 2009). While laterality studies in patients with schizophrenia frequently control for illegal drug use, this is less often the case for legal substances such as nicotine. In schizotypy research it does not seem to be common to screen for these substances; in fact, none of the above-mentioned schizotypy studies reported on controlling for both illegal and legal drug use. To lend further support to the importance of controlling for substance use in laterality research, functional hemispheric asymmetry might be modulated by nicotine (Gentry, Hammersley, Hale, Nuwer, & Meliska, 2000; McClernon, Gilbert, & Radtke, 2003) as well as dopamine, which is considered to be enhanced by drugs such as nicotine (Dawe, Gerada, Russell, & Grey, 1995; Montgomery et al., 2007; Murphy et al., 2002). For instance, decreased hemispheric asymmetry in patients with schizophrenia seems most prevalent in the unmedicated state (Mohr, Krummenacher, et al., 2005; Purdon, Woodward, & Flor-Henry, 2001 for overviews) and cognitive impairments in first episode patients with schizophrenia were more pronounced in non-smokers as compared to nicotine smokers (Zabala et al., 2009). In healthy individuals dopamine agonists (including nicotine) might enhance language functions (Gentry et al., 2000; Gilbert et al., 2008; Knecht et al., 2004; McClernon et al., 2003), which potentially stabilizes hemispheric asymmetry rather than attenuates it, particularly when reporting relatively elevated schizotypy (Mohr, Krummenacher, et al., 2005).

Thus the present study aims to test the conjecture that neuropsychological performance formerly associated with schizotypy might actually be explained by elevated nicotine use. If decreased hemispheric asymmetry is a result of nicotine use rather than schizotypal symptoms, this might explain why studies on functional hemispheric asymmetry and schizotypy report findings that are heterogeneous (Liouta, Smith, & Mohr, 2008) since the smoking status of participants between studies might have differed. In line with this reasoning, we hypothesize that nicotine smokers as compared to non-smokers yield a reduced functional hemispheric asymmetry and might do so with increased nicotine consumption. This hypothesis does not rule out the possibility that nicotine consumption and schizotypy interact to produce reduced hemispheric asymmetry and might do so differently for separate schizotypy dimensions (Mohr, Krummenacher, et al., 2005; Mohr, Landis, Bracha, Fathi, & Brugger, 2005). We assume that any laterality-schizotypy relationship and its interaction with nicotine will be most pronounced for positive schizotypy because most studies reported on a decreased hemispheric asymmetry for positive schizotypy but less so for negative schizotypy (Liouta et al., 2008). The limited knowledge on the modulating influence of Cognitive Disorganization on hemispheric asymmetry would predict no influence on performance (Gruzelier & Richardson, 1994; Mason & Claridge, 1999). Finally, since previous studies have found more consistent findings in male as compared to mixed-sex or female study groups (Mason & Claridge, 1999; Mohr, Rohrenbach, Laska, & Brugger, 2001), the current study focused on male participants only.

2. Method

2.1. Participants

Forty male right-handed undergraduate students (20 smokers and 20 non-smokers) were recruited through public advertisement in and around the University of Bristol, and through personal contact. The smokers had a mean age (always in years, ±SD) of 22 (±2, range 19–28) and the non-smokers had a mean age of 21 (±1, range 18–23). The non-smokers were required never to have been regular, daily smokers or casual smokers of more than 100 cigarettes ($m = 27 \pm 33$, range 0–100) in their lifetime to qualify as a non-smoker (David et al., 2005). Right-handedness was determined with the Edinburgh Handedness Inventory (Oldfield, 1971) according to previously used scoring criteria (see also Kita, de Condappa, & Mohr, 2007).

All participants were Caucasian native English speakers and had normal or corrected to normal vision. As indicated by self-report, none of the participants reported drug abuse (either recreational or psychiatric) in the past three months, or a previous history of psychiatric or neurological illness (Mohr, Landis, & Brugger, 2006). The study was approved by the local Ethics committee.

2.2. Materials

2.2.1. Self-report questionnaires

2.2.1.1. The O-LIFE questionnaire. The O-LIFE questionnaire (Mason et al., 1995) is a validated 150-item self-report questionnaire assessing schizotypy in terms of four dimensions. Positive schizotypy is assessed by 30 items pertaining to Unusual Experiences (UnEx, maximum score 30, including items such as 'Are your thoughts sometimes so strong that you can almost hear them?'), negative schizotypy by 27 items assessing Introvertive Anhedonia (IntAn, maximum score 27, including items such as 'Have you had very little fun from physical activities like walking, swimming or sports?'), and Cognitive Disorganization is assessed by 24 items (CogDis, maximum score 24, including items such as 'Do you find it difficult to keep interested in the same thing for a long time?'). Finally, 23 items assessing Impulsive Nonconformity (maximum score 23), which does not represent a schizotypy dimension

(Mason et al., 1995), and 40 filler items and items measuring schizotypal personality (STA) and borderline personality (STB) (Claridge & Broks, 1984), which will not be considered further. For each item, participants have to indicate whether the statement is true or false. The number of positive responses (some items are reversely formulated) is summed so that higher scores indicate higher schizotypy. Normative values can be found in Mason et al. (1995) and Mason and Claridge (2006) and the scale has shown high test-retest reliability (Burch, Steel, & Hemsley, 1998). The questionnaire also includes six lie items (taken from Eysenck's Personality questionnaire (Eysenck & Eysenck, 1975). In line with a previous study (Krumm-Merabet & Meyer, 2005), we only included participants with a lie-score ≤ 5 (mean lie score was 1 ± 1).

2.2.1.2. Fagerström Test of Nicotine Dependence (FTND). The FTND is a widely used self-report questionnaire on nicotine dependence (Heatherton, Kozlowski, Frecker, & Fagerström, 1991). Participants have to rate their smoking behavior on six questions (e.g. "Do you find it difficult to refrain from smoking in places where it is forbidden?"). On questions where yes/no responses are provided positive (='Yes') responses are scored as 1, and negative (= 'No') responses are scored as 0. Otherwise the score is determined by a 4-point Likert scale (scores range from 0–3). A score of 10 indicates high nicotine dependence while a score of 0 indicates low nicotine dependence (Heatherton et al., 1991; Japuntich, Piper, Schlam, Bolt, & Baker, 2009).

2.2.2. Hemi-field studies

For both hemi-field tasks participants were sat centrally at a distance of 57 cm from the computer screen (eye-screen distance). The keyboard was centrally placed in front of the participant so that the response keys were to the right and left of the body midline. Stimuli were presented using the experimental software system E-Prime (Psychology Software Tools) with a monitor display refresh rate of 60 Hz.

2.2.2.1. Lateralized lexical decision task (LDT). Participants were presented with an English version of the lateralized LDT used by Mohr, Krummenacher et al. (2005). The stimulus material consisted of 24 abstract nouns and 72 pronounceable non-words. The nouns consisted of four- and five-letter words, and were matched for word neighborhood and CELEX frequency. Each word was matched with a non-word of the same length. The remaining non-words were matched to result in an additional set of non-word pairs. The word pairs were displayed in black (33 point Courier New Bold font) against a grey background on the computer screen (see Fig. 1). Each letter string was presented with their centre 25 mm from central fixation (visual eccentricity: 2.5 degrees of visual angle per half-field). In each trial, we presented a fixation cross for 1000 ms before the word pair was shown for 150 ms, followed by a blank screen for 4000 ms, or until a response was given (Fig. 1). Participants were instructed to indicate whether they saw a meaningful English word on the left or right, or did not see a meaningful English word at all. To do so, participants had to press the shift key ipsilateral to the word with the index finger or space bar with both thumbs if they did not see a meaningful string of letters on the screen. Per block, there were 72 trials with three 24-trial conditions (word left/non-word right, non-word left/word right, non-word/non-word). The order of the stimuli was randomized within blocks and between participants. In addition, for the critical trials (in which a word was presented) each word stimulus appeared once in each visual field. Prior to the experimental task each participant undertook a practice block consisting of 10 trials with words not used in the experimental trial. We assessed the number of correct lexical decisions and the mean reaction times for correct lexical decisions for the left (LVF) and right (RVF) visual field separately. In the control condition, two non-words were displayed on either side of the screen (NoW).

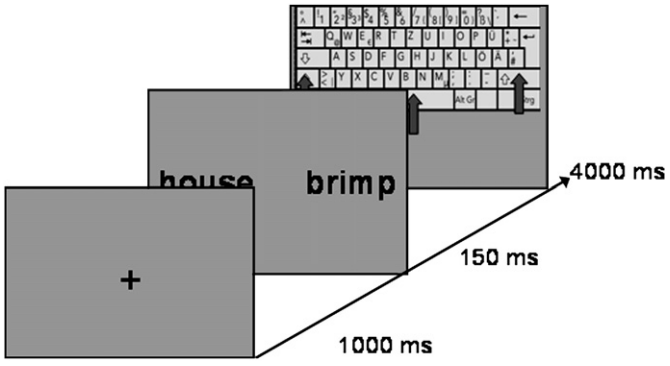

Fig. 1. Example of word stimuli and procedure used in the LDT.

2.2.2.2. Lateralized facial decision task (FDT). Participants were presented with facial stimuli against a grey background on the computer screen (see Fig. 2). Due to the potential effect of emotional faces on laterality (Workman, Peters, & Taylor, 2000), all faces had neutral expressions and were photographed straight on so that the faces appeared as symmetrical as possible with the central plane of the face in line with the centre of the screen. The eccentricity of each face picture was ~4 degrees of visual angle and the pictures were 335 × 400 pixels. This was to ensure that important facial information, such as eyes, nose and mouth, would fall in a similar visual angle as the words in the lexical decision task (~2.5°). The pictures consisted of 10 male and 10 female facial images (example in Fig. 2) that had been used in a previous study (Penton-Voak, Pound, Little, & Perrett, 2006). From these, 20 sexually-dimorphic composite faces were constructed (Fig. 2) with an equal amount of female and male half-faces appearing in each visual field. The same 20 composite faces were also presented mirror-reversed resulting in 40 composite faces. In each trial, a black central fixation point was presented on the screen for 1000 ms followed by the stimulus that was displayed for 150 ms. Following presentation of the stimulus, a blank screen was presented for a maximum of 4000 ms, or until a response was provided. In this task participants had to press the left shift key if the face appeared to be female and the right shift key if the face appeared to be male. Prior to the test trials participants were presented with a practice block of 10 trials consisting of two whole faces and eight composite faces that were not included in the experimental trials. We assessed the number and response time of facial decisions towards the left visual field (LF decisions) and right visual field (RF decisions). In the control condition, whole faces (WF) were presented (Fig. 2).

2.3. Data analysis

As in previous lateralized hemi-field studies (Allison, Puce, Spencer, & McCarthy, 1999; Ratcliff, Gomez, & McKoon, 2004), individual response latencies faster than 200 ms and slower than 2000 ms in both the LDT and FDT were excluded from further analysis. To test for differences in lateralized performance in smokers and non-smokers, we calculated 2 × 2 mixed sample ANOVAs with visual field (LVF, RVF) as the related samples factor and group (smokers vs. non-smokers) as the independent samples factor on mean reaction times (RT) of correct responses for the LDT. The same ANOVA was also calculated for percent correct responses

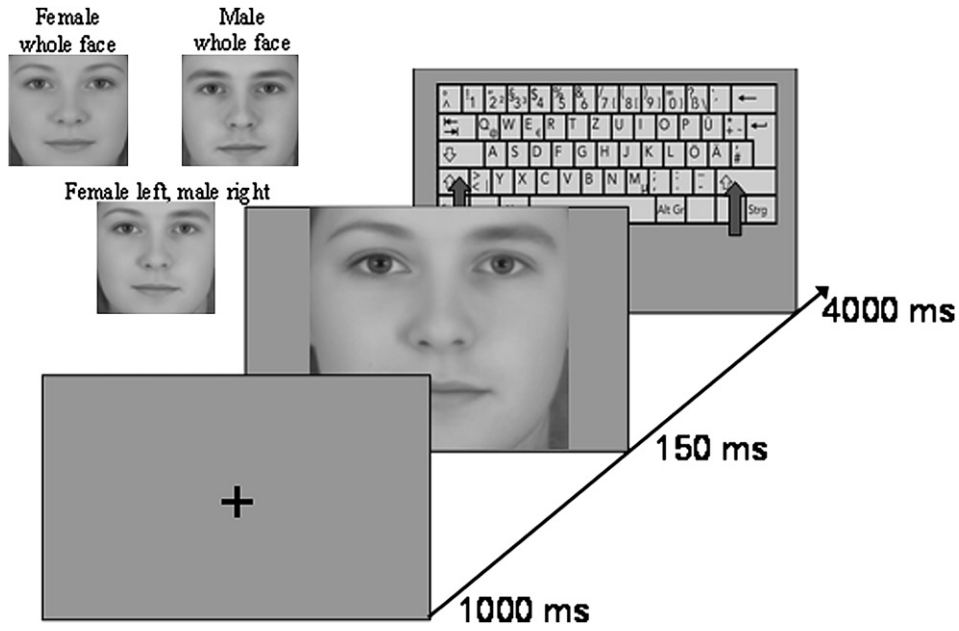

Fig. 2. Example of face stimuli and procedure used in the FDT.

in the LDT. For the FDT, to ascertain that participants could distinguish between male and female whole faces (WF), and that the percentage of correct sex decisions (WF) was higher than the percentage of sex decisions according to the left side of the composite face (LF decisions), we performed a repeated measures ANOVA on percent correct (WF) and percent LF decisions (composite faces) as repeated measure and group as between-subject measure. To also test whether there was an RT difference between WF and composite faces, and that LF decisions were potentially faster than those for RF decisions, we performed a repeated measures ANOVA on mean RT for sex decisions with face type (correct decisions for WF, LF decisions, RF decisions) as repeated measure and group as between-subject measure. Post-hoc tests correcting for multiple comparisons were performed using Tukey HSD tests or within-subjects contrasts. Effect sizes are reported for all ANOVA results.

We also tested whether, within each group, the tasks resulted in lateralized performance at all (Mohr, Krummenacher, et al., 2005; Mohr et al., 2006) using conventional laterality indices (Marshall, Caplan, & Holmes, 1975). In general terms, this would mean that inferior performance is subtracted from superior performance, and that this difference is divided by its sum. Accordingly, positive values indicate an advantage of the normally dominant hemisphere (LDT: LH; FDT: RH), and negative values an advantage of the normally sub-dominant hemisphere. In order to obtain indices that would be comparable in this respect, the indices for i) accuracy in the LDT, and ii) reaction times in the FDT was $(RVF/RF - LVF/LF)/(LVF/LF + RVF/RF) \times 100$, while the indices for reaction times in the LDT was $(LVF/LF - RVF)/(LVF + RVF) \times 100$. For accuracy in the FDT, we determined only percent LF decisions (as LF and RF decisions added up to 100%, including RF decisions and was deemed redundant). These indices were subjected for each group separately to one sample t–tests against chance level.

Finally, in order to establish an effect of schizotypy over and above smoking status or nicotine dependence on hemispheric asymmetry, we performed multiple stepwise regressions as follows. Group status and nicotine dependence scores were entered in the first step, UnEx scores, CogDis scores and IntAn scores in the second step, and the interaction between the schizotypy subscales and smoking status or FTND scores, respectively, in the last step. Thus, three blocks of predictors were entered in nested blocks, meaning that each subsequent block contained all prior predictors and the additional predictors from the current block. Presentation of results however will only include the new predictors entered, for economy of presentation. Because all tolerance values were above .2 (Menard, 1995), and all independent variables were mean-centered, multi-collinearity between the independent variables was considered negligible. The dependent variables were i) percent index for the LDT and ii) RT-indices for the LDT and FDT separately. However, to account for a potentially different contribution of each hemisphere to decreased hemispheric asymmetry (Mohr, Krummenacher, et al., 2005; Sommer et al., 2001), additional separate stepwise regression analyses were conducted with iii) correct word recognition in the LVF and RVF, iv) RTs for correct lexical decisions in the LVF and RVF, v) percent LF decisions and percent correct sex decisions for WF, and vi) RTs for LF decisions, RTs for RF decisions, and RTs for correct WF decisions. Kolmogorov–Smirnov tests for the smokers and non-smokers separately revealed normal distribution for all behavioral measures and questionnaire scores. All p-values were two-tailed and the α-level was set at .05, unless otherwise stated.

3. Results

3.1. Participants

After removal of LDT data of one participant due to erroneous usage of the three response keys, unpaired t-tests showed that smokers and non-smokers did not differ for age, handedness scores, UnEx scores, CogDis scores, and IntAn scores (Table 1). Average schizotypy scores across groups were lower (UnEx: 6.15 ± 4.44, CogDis: 9.20 ± 4.68, IntAn: 4.80 ± 2.94) than those reported from a representative comparison sample (Mason & Claridge, 2006). In smokers and non-smokers, schizotypy scores were unrelated (all p-values $> .20$), apart from significant positive correlations between UnEx and CogDis scores (non-smokers: $r = .62$, $p < .01$; smokers: $r = .63$, $p < .01$). FTND scores were within normal ranges (Table 1) for an unselected group of smokers (Fagerström et al., 1996), and were unrelated with schizotypy scores (all p-values $> .20$).

Table 1
Demographic variables of the study population. Presented is age (in years), handedness scores (HS), schizotypy scores, and Fagerström Test for Nicotine Dependence scores for smokers ($n = 20$) and non-smokers ($n = 20$) separately. Results (t) of the unpaired t-tests (df = 37) are given together with the respective p-values (p).

	Mean ± SD (range)		t	p
	Smoker	Non-Smoker		
Age	22.09 ± 1.92 (19–28)	21.59 ± 1.09 (18–23)	1.03	.31
HS	11.08 ± .94 (9–12)	11.28 ± .72 (10–12)	−.76	.45
UnEx[a]	6.65 ± 5.08 (0–16)	5.65 ± 3.75 (0–14)	.71	.48
CogDis[b]	8.75 ± 4.93 (2–17)	9.65 ± 4.49 (1–19)	−.60	.55
IntAn[c]	3.95 ± 2.19 (0–9)	5.65 ± 3.38 (1–12)	−1.89	.07
FTND[d]	1.40 ± 1.57 (0–5)	n/a	n/a	n/a

[a] Unusual Experiences.
[b] Cognitive Disorganization.
[c] Introvertive Anhedonia.
[d] Fagerström Test for Nicotine Dependence.

3.2. Lateralized performance in smokers and non-smokers

3.2.1. LDT

The repeated measures ANOVA on percent accuracy showed a significant main effect for visual field (F [1, 37] = 2.16, $p < .001$; *partial* $\eta^2 = .35$) with performance being superior for the RVF than LVF (Table 2). The remaining comparisons (main effect for group: F [1, 37] = .46, $p = .50$, *partial* $\eta^2 = .01$; interaction between group and visual field: F [1, 37] = .67, $p = .42$, *partial* $\eta^2 = .02$, Table 2) were both not significant. The analogue ANOVA on mean RT revealed no significant main effects (visual field: F [1, 37] = 1.40, $p = .25$, *partial* $\eta^2 = .04$; smoking group: F [1, 37] = .80, $p = .38$, *partial* $\eta^2 = .02$), and no significant interaction between smoking group and visual field (F [1, 37] = 1.00, $p = .33$, *partial* $\eta^2 = .03$). Single t-tests against zero for the laterality indices were significant for percent accuracy, but not RT, for the whole sample (percent accuracy: t [38] = 4.65, $p < .001$; RT: t [38] = .88, $p = .38$, Table 2), smoker (percent accuracy: t [19] = 2.87, $p = .01$; RT: t [19] = .06, $p = .95$, Table 2), and non-smoker (percent accuracy: t [18] = 3.67, $p < .01$; RT: t [18] = 1.02, $p = .32$, Table 2), separately. The positive laterality indices point to an RVF advantage (and thus an LH advantage) in all instances.

Table 2
Mean (SD) lateralized task performance for the total sample (LDT[a]: $n = 39$, FDT[b]: $n = 40$), smoker (LDT: $n = 20$, FDT: $n = 20$) and non-smoker (LDT: $n = 19$; FDT: $n = 20$) separately.

		All		Non-smoker		Smoker	
		Mean	SD	Mean	SD	Mean	SD
LDT	LDT LVF %[c,d]	54.06	19.57	51.21	19.91	56.77	19.35
	LDT RVF %[e]	69.02	12.99	68.97	12.75	69.06	13.56
	LDT NoW %[f]	43.70	20.58	48.03	21.16	39.58	19.66
	LDT index %[g]	14.01	18.81	16.95	20.15	11.22	17.50
	LDT LVF RT	680.33	182.55	714.04	198.50	648.30	164.65
	LDT RVF RT	654.83	149.30	665.98	146.05	644.23	155.34
	LDT NoW RT	936.55	209.41	945.00	229.60	928.51	193.97
	LDT index RT	1.47	10.44	2.91	12.38	.11	8.30
FDT	FDT LF %[h]	54.38	9.72	53.00	8.54	55.75	10.81
	FDT WF %[i]	86.94	11.27	84.50	9.95	89.38	12.22
	FDT LF RT	702.04	167.42	716.64	157.29	687.45	179.84
	FDT RF[j] RT	724.13	182.22	732.36	174.59	715.91	193.73
	FDT WF RT	582.80	110.03	606.15	107.75	559.46	109.97
	FDT index RT	1.40	5.95	.84	4.83	1.96	6.98

[a] Lexical decision task.
[b] Facial decision task.
[c] Left visual field.
[d] Percentage correct.
[e] Right visual field.
[f] Two non-words displayed on either side of the screen.
[g] Laterality index.
[h] Left face decisions.
[i] Whole face decisions.
[j] Right face decisions.

3.2.2. FDT

The repeated measures ANOVA on percentage accuracy showed a main effect for face type (WF, LF decisions) indicating that percent correct sex decisions for WF was higher than the proportion of LF decisions (F [1,38] = 222.45, $p < .001$, *partial* $\eta^2 = .85$, Table 2). The interaction between face type and group (F [1, 38] = .24, $p = .63$, *partial* $\eta^2 = .01$) and the main effect for group (F [1, 38] = 2.35, $p = .13$, *partial* $\eta^2 = .06$) were not significant. The repeated measures ANOVA on mean RT for sex decisions with face type (correct decisions for WF decisions, LF decisions, RF decisions) as repeated measure (see also data analysis section) showed a significant main effect for face type (F [2,37] = 41.85, $p < .001$, *partial* $\eta^2 = .52$). Post-hoc within-subjects contrasts showed comparable RTs for LF and RF decisions (F [1, 38] = 2.29, $p = .14$, *partial* $\eta^2 = .06$), but faster responses for WF as compared to both LF (F [1, 38] = 48.42, $p < .001$, *partial* $\eta^2 = .56$) and RF (F [1, 38] = 62.12, $p < .001$, *partial* $\eta^2 = .62$) decisions (Table 2). The main effect for smoking group (F [1, 38] = .45, $p = .51$, *partial* $\eta^2 = .01$), and the interaction were both not significant (F [2, 37] = .42, $p = .65$, *partial* $\eta^2 = .01$). For the whole sample, a single t-test against chance level (50%) for percent LF decisions was significant (t [39] = 2.85, $p < .01$), but not for a single t-test against chance level (0) for the RT laterality index (t [39] = 1.49, $p = .14$, Table 2). Analogue t-tests for the groups separately showed no significant bias for non-smokers (percent LF decisions: t [19] = 1.57, $p = .13$; RT index: t [19] = .78, $p = .45$, Table 2), but a significant LF decision bias in smokers for percent LF decisions (t [19] = 2.38, $p = .03$; RT index: t [19] = 1.26, $p = .22$, Table 2). Percent LF decisions above 50% represent an LF bias (and by inference point to an RH dominance in the FDT).

3.3. Multiple regression analyses using smoking status as a predictor variable

Hierarchical multiple regression analyses with group (smokers, non-smokers) entered in the first block (Step 1), schizotypy subscales in the second block (Step 2) and the interaction between group and schizotypy subscales in the third block (Step 3, see also Section 2.3) were conducted to evaluate the variance contributions of schizotypy as a predictor of hemispheric asymmetry on top of smoking status. Since multiple comparisons were run, we focus on significant R^2-changes (all other results see Tables 3–6), and for economy of presentation of nested block multiple regression analyses we present only the final block added in each model. The results for all tasks and parameters are presented in Tables 3–6.

3.3.1. LDT

Results showed that group status alone (Step 1) did not significantly predict variance in any of the outcome variables. Adding schizotypy subscale scores (Step 2) improved the model for the RT index, and RVF RT (Table 3). In both cases, increasing CogDis scores predicted a decrease in the RT index, likely resulting from a significant increase in RVF RTs (Table 3). Adding the interaction terms in the third block (Step 3) did not improve the regression model significantly (Table 3).

3.3.2. FDT

The comparable hierarchical multiple regression analyses for the FDT (see also 2.3) showed that group status alone (Step 1) did not predict variance in any of the outcome variables (Table 4). Adding schizotypy subscale scores (Step 2) did not improve the model (Table 4). Adding the interaction terms in the third block (Step 3) improved the overall model for WF percent correct. This

Table 3
Beta-weights and ΔR^2 for the LDT[a] outcome variables for the whole sample accounting for smoking status.

	Independent variables	Percentage correct			RT		
		LVF[f]	RVF[g]	Index[h]	LVF	RVF	Index
Step 1:	Group (SM, nSM[b])	.14	.00	−.15	−.18	−.07	−.14
Smoking status	ΔR^2	.02	.00	.02	.03	.01	.02
Step 2:	UnEx[c]	.17	.18	−.07	−.05	−.13	.12
Schizotypy	CogDis[d]	.16	−.38†	−.33	.09	.55**	−.51*
	IntAn[e]	−.11	.13	.18	−.02	−.12	.13
	ΔR^2	.09	.10	.15	.00	.23*	.20*
Step 3:	Group × UnEx	−.05	.19	.21	−.04	.01	−.05
Interaction smoking status and schizotypy	Group × CogDis	.02	−.10	−.10	.18	.05	.20
	Group × IntAn	−.04	−.06	−.01	.27	.13	.26
	ΔR^2	.00	.02	.03	.10	.02	.09
	R^2 total	.11	.12	.20	.13	.25	.31†
	Adjusted R^2 total	−.09	−.08	.02	−.06	.08	.16†

† $p \leq .10$; * significant at $p \leq .05$; ** significant at $p \leq .01$.
[a] Lexical decision task.
[b] SM = smoker, nSM = non-smoker.
[c] Unusual Experiences.
[d] Cognitive Disorganization.
[e] Introvertive Anhedonia.
[f] Left visual field.
[g] Right visual field.
[h] Laterality index.

improvement resulted from a significant interaction between group and IntAn scores (Table 4). Post-hoc regressions for each group separately including only IntAn as a predictor variable revealed that increasing IntAn scores predicted a decrease in WF percent correct in non-smokers only (non-smokers: $R^2 = .47$, $\beta = -.69$, $p < .001$; smokers: $R^2 = .04$, $\beta = .21$, $p = .37$).

3.4. Multiple regression analyses using nicotine dependence scores as a predictor variable

3.4.1. LDT

The hierarchical multiple regression analysis with nicotine dependence scores (FTND) entered in the first block (Step 1), schizotypy subscales scores in the second block (Step 2) and the interaction between group and schizotypy subscales scores in the third block (Step 3, see also Section 2.3) were conducted to determine the effect of schizotypy on top of nicotine dependence within smokers. Again, since multiple comparisons were run, we will only focus on the significant R^2-changes (all other results see Table 5). Results showed that FTND scores predicted 23.5% of the variance in RVF percent correct (higher FTND scores predicted decreasing RVF percent correct, Table 5). The addition of schizotypy subscale scores (Step 2) and the addition of the interaction terms (Step 3) did not improve the model (Table 5).

3.4.2. FDT

The comparable hierarchical multiple regression analyses for the FDT (see also 2.3) showed that FTND scores explained 26% of the variance in LF percent correct (Model 1, Table 6); increasing FTND scores predicted an increase in LF percent correct. The

Table 4
Beta-weights and ΔR^2 for the FDT[a] outcome variables for the whole sample accounting for smoking status.

	Independent variables	Percentage correct		RT			
		LF[f]	WF[g]	LF	RF[h]	WF	Index[i]
Step 1:	Group (SM, nSM[b])	.14	.22	−.09	−.05	−.22	.10
Smoking status	ΔR^2	.02	.05	.01	.00	.05	.01
Step 2:	UnEx[c]	−.16	−.20	−.17	−.23	−.02	−.24
Schizotypy	CogDis[d]	−.06	.18	.44*	.49*	.41*	.18
	IntAn[e]	−.30	−.28†	.06	.00	.05	−.15
	ΔR^2	.13	.10	.14	.15	.16†	.06
Step 3:	Group × UnEx	−.18	−.26	.01	.11	.14	.19
Interaction smoking status and schizotypy	Group × CogDis	.28	.25	−.11	−.10	−.07	−.02
	Group × IntAn	−.03	.41*	.44*	.39*	.18	−.04
	ΔR^2	.05	.19*	.15†	.13	.04	.03
	R^2 total	.20	.33*	.30†	.28	.25	.10
	Adjusted R^2 total	.03	.19*	.15†	.13	.08	−.10

† $p \leq .10$; * significant at $p \leq .05$.
[a] Facial decision task.
[b] SM = smoker, nSM = non-smoker.
[c] Unusual Experiences.
[d] Cognitive Disorganization.
[e] Introvertive Anhedonia.
[f] Left face decisions.
[g] Whole face decisions.
[h] Right face decisions.
[i] Laterality index.

Table 5
Beta-weights and ΔR^2 for the LDT[a] outcome variables for smokers only accounting for nicotine dependence.

	Independent variables	Percentage correct			RT		
		LVF[f]	RVF[g]	Index[h]	LVF	RVF	Index
Step 1:	FTND[b]	−.10	−.48*	−.20	.17	.01	.21
Nicotine dependence	ΔR^2	.01	.23*	.04	.03	.00	.04
Step 2:	UnEx[c]	.13	.14	.00	−.08	−.18	.17
Schizotypy	CogDis[d]	.21	−.33	−.40	.22	.59†	−.53†
	IntAn[e]	−.13	.01	.12	.30	.05	.46*
	ΔR^2	.09	.07	.14	.15	.26	.30
Step 3:	FTND × UnEx	−.69*	−.27	.47	.48	.32	.26
Interaction nicotine dependence and schizotypy	FTND × CogDis	.05	−.23	−.16	−.15	−.15	.06
	FTND × IntAn	−.26	−.30	.05	.46	.07	.67*
	ΔR^2	.35	.15	.13	.26	.07	.27†
	R^2 total	.44	.45	.31	.44	.33	.61†
	Adjusted R^2 total	.12	.13	−.09	.12	−.07	.38†

† $p \leq .10$; * significant at $p \leq .05$; * significant at $p \leq .01$.
[a] Lexical decision task.
[b] Fagerström Test for Nicotine Dependence.
[c] Unusual Experiences.
[d] Cognitive Disorganization.
[e] Introvertive Anhedonia.
[f] Left visual field.
[g] Right visual field.
[h] Laterality index.

addition of schizotypy subscale scores (Step 2) did not improve the model. The interaction terms showed that the interaction between FTND scores and CogDis scores explained additional variance in WF RTs. Median-splits were performed on FTND scores and post-hoc regressions were conducted on WF RT and CogDis scores for the high- and low-scoring FTND groups separately. Increasing CogDis scores predicted slowed responding for WF in the low-FTND group only (Low FTND: $R^2 = .65$, $\beta = .81$, $p < .01$; high FTND: $R^2 = .07$, $\beta = -.27$, $p = .52$).

4. Discussion

A varying degree of illegal and legal drug consumption along the SSp might explain heterogeneous findings when investigating the link between schizotypy and neuropsychological performance (Archie et al., 2007; Barnes et al., 2006; Esterberg et al., 2009; Gurpegui et al., 2004; Jones & Fernyhough, 2009; de Leon et al., 2002; Williams, Wellman, Allan, et al., 1996). In particular, it could be conjectured that neuropsychological impairments formerly associated with symptom dimensions are actually the result of drug use. We therefore investigated whether a reduced hemispheric asymmetry for function (language in the LH, visual face recognition in the RH) in schizotypy might result from nicotine consumption or an interaction between schizotypy and nicotine consumption. Irrespective of schizotypy and smoking status, we replicated the commonly observed RVF over LVF advantage for lexical decisions (e.g. Bourne, 2006; Mohr, Krummenacher, et al., 2005) reflecting the LH's dominance for language processing. We also replicated the LF bias for composite faces (Butler & Harvey, 2006; Mason & Claridge, 1999) that reflects the RH dominance for visual face processing.

Table 6
Beta-weights and ΔR^2 for the FDT[a] outcome variables for smokers only accounting for nicotine dependence.

	Independent variables	Percentage correct		RT			
		LF[f]	WF[g]	LF	RF[h]	WF	Index[i]
Step 1:	FTND[b]	.51*	.36	−.04	.11	.08	.21
Nicotine dependence	ΔR^2	.26*	.13	.00	.01	.01	.05
Step 2:	UnEx[c]	−.09	−.33	−.25	−.16	.13	−.01
Schizotypy	CogDis[d]	.06	.27	.31	.34	.31	.11
	IntAn[e]	−.23	.22	.50*	.41†	.24	−.14
	ΔR^2	.06	.11	.34†	.28	.28	.02
Step 3:	FTND × UnEx	−.44	.09	.27	.02	.09	−.45
Interaction nicotine dependence and schizotypy	FTND × CogDis	.45	.10	−.60*	−.50†	−.72**	.18
	FTND × IntAn	.42	−.14	−.06	.22	.24	.49
	ΔR^2	.19	.03	.21	.21	.40*	.19
	R^2 total	.51	.27	.55	.51	.69*	.26
	Adjusted R^2 total	.22	−.15	.28	.23	.50*	−.17

† $p \leq .10$; * significant at $p \leq .05$.
[a] Facial decision task.
[b] Fagerström Test for Nicotine Dependence.
[c] Unusual Experiences.
[d] Cognitive Disorganization.
[e] Introvertive Anhedonia.
[f] Left face decisions.
[g] Whole face decisions.
[h] Right face decisions.
[i] Laterality index.

When nicotine consumption and schizotypy were accounted for, we observed that i) nicotine consumption *per se* was unrelated to lateralized performance, ii) increasing nicotine dependence (FTND scores) seemed to predict an RH bias in both the LDT and FDT, and iii) CogDis seemed the only schizotypy dimension related to lateralized performance (increasing CogDis predicted a decreased LH language dominance and slowed responding for the sex of whole faces in individuals with low FTND scores). UnEx scores, on the other hand, were unrelated to lateralized task performance and elevated IntAn scores were related to a potentially more general visual face processing deficit.

4.1. Nicotine and lateralized performance

The finding that general smoking status was unrelated to lateralized performance is in line with previous studies showing no difference in LDT performance between a group who received a DA agonist (Levodopa) and a group who received a placebo (Mohr, Krummenacher, et al., 2005; Mohr et al., 2006). However, studies investigating the role of nicotine on task performance more directly found that transdermal nicotine patches (slow, constant nicotine application) provided to abstinent smokers stabilized LH language functions (Gentry et al., 2000; McClernon et al., 2003), and smoking a nicotine cigarette (fast, acute nicotine application) impaired lexical decisions for centrally presented words (Gentry et al., 2000). McClernon et al. (2003) additionally observed that increasing nicotine dependence was related to improved performance in both hemispheres in a language memory task; unfortunately the authors did not test an RH-dominant task. In the present study we observed that increasing nicotine dependence (FTND scores) in smokers predicted decreasing word recognition performance in the RVF and an increasing LF decision bias (irrespective of schizotypy). This RH shift in hemispheric dominance as a function of nicotine dependence would support findings from previous electroencephalography (Norton, Brown, & Howard, 1992) and positron emission tomography (Ernst et al., 2001; Rose et al., 2007) studies. Also, such an RH shift might reflect a general bias towards RH functioning with increasing drug dependence since higher consumption of one drug commonly predicts higher consumption of other drugs (Degenhardt, Hall, & Lynskey, 2001; Martinez-Ortega, Jurado, Martinez-Gonzalez, & Gurpegui, 2006). In support of this possibility, the RH has been implicated in other forms of compulsive behaviors such as over-eating (Regard & Landis, 1997; Uher & Treasure, 2005), gambling (Cilia et al., 2008; Regard, Knoch, Gutling, & Landis, 2003), and violent or antisocial behavior (Mychack, Kramer, Boone, & Miller, 2001; Narayan et al., 2007). Given the structural and neurochemical dependence of the brain, it is not unreasonable to argue that transient short-term (Bachtold et al., 2001; Mohr, Michel, et al., 2005; Regard, Cook, Wieser, & Landis, 1994) or longer-term (Crinion & Leff, 2007; Raboyeau et al., 2008) inter-hemispheric asymmetries might be modulated by neurochemical processes (e.g. Fink et al., 2008; Hausmann & Gunturkun, 2000; Mohr, Landis, et al., 2005). Accordingly we would predict even stronger relationships between hemispheric asymmetry and nicotine (or other forms of substance and non-substance) dependence when testing hemispheric asymmetry as a function of more severe dependencies. Nicotine dependence scores were relatively low in the current sample and several of our smokers had scores of zero that would classify them as "least dependent smokers" (Etter, Duc, & Perneger, 1999).

4.2. Schizotypy, nicotine and lateralized performance

While our findings on nicotine dependence were promising, those relating to schizotypy subscales did not support our predictions. Firstly, we found no relationship between UnEx scores and both hemispheric asymmetry (Kravetz, Faust, & Edelman, 1998; Mason & Claridge, 1999) and nicotine dependence (Lopez, Maldonado, & Pueyo, 2001). A possible reason might be our relatively low UnEx and CogDis scores (Table 1) when compared to those of a normative sample (Mason & Claridge, 2006); however, our nicotine dependence (Lopez et al., 2001; Stavem, Røgeberg, Olsen, & Boe, 2008) and schizotypy scores (Nunn & Peters, 2001; Rawlings & Goldberg, 2001; Suzuki & Usher, 2009) were comparable to previous studies. For instance, Lopez et al. (2001) reported elevated UnEx scores in smoking undergraduate psychology students compared to non-smoking ones. In the current study schizotypy scores were comparable in the two smoking groups and were unrelated to nicotine dependence scores (Esterberg et al., 2007), although most authors report this link (Allan et al., 1995; Esterberg et al., 2009).

Secondly, we found that increasing CogDis scores were related to an RH shift of function, i.e., a decreasing LH dominance for language and an increasing LF preference (together with slowed WF decisions). This might indicate that CogDis relates to impaired face recognition performance more generally and to impaired LH-language functions in particular. In line with our findings, a reduced LH language dominance as a function of CogDis has been reported previously (Claridge et al., 1992; Kravetz et al., 1998; Suzuki & Usher, 2009) although independent studies would have also predicted a similar result for UnEx scores (Brugger et al., 1993; Kravetz et al., 1998; Mohr, Krummenacher, et al., 2005; Pizzagalli et al., 2000; Suzuki & Usher, 2009). Questionnaires in several of these previous studies did not distinguish between positive schizotypy and CogDis (Brugger et al., 1993; Mohr, Krummenacher, et al., 2005) and when schizotypy dimensions were separated, both scales related to a reduced LH language dominance (Kravetz et al., 1998; Mason et al., 1995; Suzuki & Usher, 2009). CogDis is frequently considered to be a distinct dimension of positive schizotypy, but it is not yet known whether it has a stronger overlap with positive or negative symptoms (Kitamura, Okazaki, Fujinawa, Takayanagi, & Kasahara, 1998; McGorry, Bell, Dudgeon, & Jackson, 1995; Spitzer, Braun, Hermle, & Maier, 1993; Weinstein & Graves, 2001). A stronger positive correlation between CogDis and UnEx scores than between CogDis and IntAn scores seems common (Kravetz et al., 1998; Mason et al., 1995; Nunn & Peters, 2001; Rawlings & Goldberg, 2001; Tsakanikos & Reed, 2003). Moreover, a stronger relationship of CogDis compared to positive schizotypy, with language "impairments" has also been reported (Johnston, Rossell, & Gleeson, 2008; Moritz et al., 1999; Stefanis et al., 2006). Therefore, future studies will be required to disentangle the specific or combined role of CogDis on hemispheric asymmetry.

With regards to face processing, the effect of CogDis in the present study seemed rather general than hemisphere-specific. In past studies, positive schizotypy was related to either an increased LF bias (Leonards & Mohr, 2009; Luh & Gooding, 1999) or a decreased LF bias (Mason & Claridge, 1999). Whether this might reflect a more general pattern of face processing deficits with increasing positive schizotypy has to be investigated further, but the consistent direction of regression coefficients (Table 4 and 5) and other reported forms of face processing difficulties in schizotypy (Laroi, D'Argembeau, Bredart, & van der Linden, 2007) would support a more general face processing deficit with enhanced CogDis. Interestingly, the decrease in WF-processing seemed particularly relevant to individuals with low nicotine dependence who might suffer from generally slowed visual face processing abilities. If this were the case, enhanced nicotine dependence should attenuate a relationship between CogDis and face processing. Studies investigating nicotine use in relation to schizotypy subscales are few. Esterberg et al. (2007) found that smoking related

to enhanced SPQ scores (Raine, 1991) in relatives of patients with schizophrenia but not in controls. Further, Esterberg et al. (2009) reported that enhanced cognitive disorganization (again SPQ) were predictive of cigarette use in a sample of healthy controls. Since increasing nicotine dependence scores in our sample were predictive of an RH shift of function (Ernst et al., 2001; McClernon et al., 2003; Norton et al., 1992; Rose et al., 2007) it is possible to argue that increasing nicotine consumption might stabilize RH-functions, particularly in individuals with high CogDis scores. In order to test this prediction individuals with higher nicotine dependence would have to be tested.

The findings relating to IntAn, a negative schizotypal feature, were unexpected since negative schizotypy has previously been a largely insensitive marker for hemispheric asymmetry (see Liouta et al., 2008; Suzuki & Usher, 2009 for recent accounts). Performance in the LDT (none of the dependent LDT measures were related to IntAn scores), but not in the FDT, would support this notion. In our non-smoking sample, increasing IntAn scores were predictive of a decrease in WF processing. Luh and Gooding (1999) observed that participants endorsing high positive schizotypal features were left-biased for faces, but those with high social anhedonia scores lacked this LF bias, which suggests a bimodal distribution (i.e., either showing a strong LF or RF bias; Leonards & Mohr, 2009). In two different samples, UnEx scores, but not CogDis scores, predicted a decreased LF bias for emotional composite faces (Mason & Claridge, 1999). In one of these studies, IntAn scores in women predicted a decreased LF bias. Importantly, none of the studies reported on WF performance (Luh & Gooding, 1999; Mason & Claridge, 1999) and our own findings would indicate that impaired performance in the FDT with increasing IntAn scores reflects a more general social and/or facial processing impairment in non-smokers (Haxby, Hoffman, & Gobbini, 2000; Kanwisher, McDermott, & Chun, 1997; Onitsuka et al., 2006; Pinkham, Hopfinger, Ruparel, & Penn, 2008), particularly given that non-smokers tended to score higher on IntAn as compared to smokers.

4.3. Limitations to the study

While we pre-selected participants for their right-handedness, right-handedness seems reduced in schizophrenia (Dragovic & Hammond, 2005) and schizotypy (Somers, Sommer, Boks, & Kahn, 2009) and, as such, this pre-selection might have compromised our ability to investigate a population that is truly psychosis-prone. While valid as a potential limitation of the current study, this pre-selection procedure is common practice in the study of hemispheric asymmetry in schizotypy (e.g. Mason & Claridge, 1999; Mohr, Krummenacher, et al., 2005; Suzuki & Usher, 2009) and generally in the study of hemispheric asymmetry (Bourne, 2006) since the testing of only right-handed participants reduces the number of potential "confounds", i.e., that of a reduced hemispheric asymmetry due to handedness. However, because of the important role of reduced right-handedness to both enhanced schizotypy and reduced hemispheric asymmetry, it only seems reasonable to suggest that future studies should investigate a more representative sample that is unselected for handedness (or actually select a wider range of hand preferences (e.g. Shaw et al., 2001; Somers et al., 2009).

Another limitation was our control of nicotine consumption. For instance, our smoking group consisted of a group of relatively light smokers rather than heavy smokers for whom nicotine influences on behavior might have been more pronounced (Myers, Taylor, Moolchan, & Heishman, 2008). Some previous studies directly challenged nicotine availability by providing nicotine patches/nicotine cigarettes (Gentry et al., 2000; McClernon et al., 2003). Nicotine exerts differential cognitive effects depending on whether administration is acute or chronic (Ernst et al., 2001; Jacobsen et al., 2005; McClernon et al., 2003; Rose et al., 2007). Additionally, nicotine activates receptors in different brain regions depending on the amount of nicotine exposure (e.g. Kumari & Postma, 2005); for instance, in an EEG study higher nicotine doses seemed to result in an LH shift of EEG power (i.e., decreased LH α-power and increased RH β-power) (Norton et al., 1992). Nicotine dependence was relatively low in our study (Esterberg et al., 2007; Etter et al., 1999), yet within normal ranges for an unselected group of smokers (Heatherton et al., 1991). Future research would certainly benefit from comparing chronic and acute nicotine exposure as well as administering varying amounts of nicotine directly.

4.4. Summary

In sum, we tested whether nicotine consumption might be a better predictor of hemispheric asymmetry than schizotypy in 40 right-handed men. We were particularly interested in whether attenuated hemispheric asymmetry would be more evident as a function of smoking status and nicotine dependence than (positive) schizotypy, or its interaction. Our findings partially support this idea. Increasing nicotine dependence (but not smoking status *per se*) was related to an RH shift in hemispheric function for both a LH and RH dominant task. These results indicate that nicotine use is relevant to the study of laterality and schizotypy, and might also be pertinent to the study of compulsive/impulsive behavior generally. With regards to schizotypy, CogDis seemed to be a more promising schizotypal dimension than UnEx in predicting attenuated language dominance (irrespective of smoking status). IntAn seemed to relate to face processing impairments more generally, particularly in non-smokers. Given our smokers' relatively low nicotine dependence and schizotypy scores, future studies should test individuals consuming higher doses of nicotine, and control more directly how much (e.g. nicotine dosage), in which form (slow: patches, fast: inhalation) and when (time before testing) nicotine is consumed with regards to testing. Such future studies might help to further elucidate the role of drug use on links between behavior and schizotypal symptoms as potential indicators of psychosis risk or psychosis protection. As a final note, most previous studies in the area reported on *either* an LH or RH-dominant task (but not both). If we had only used the LDT, we would have found "evidence" for a reduction in LH language functions with increasing FTND scores, but no overall RH shift in function.

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