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Categorical perception of familiarity: Evidence for a hyper-familiarity in schizophrenia

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ABSTRACT

Familiarity is a crucial aspect of recognition that may be perturbed in schizophrenia patients (SZP) and may lead to delusional disorders. However, there are no existing guidelines on how to assess and treat familiarity disorders in schizophrenia. Some experimental studies have investigated familiarity processing in SZP but have produced inconsistent results, which are likely a result of methodological issues. Moreover, these studies only assessed whether familiarity processing is preserved or impaired in SZP, but not the tendency of SZP to consider unfamiliar stimuli to be familiar. By using a familiarity continuum task based on the existence of the categorical perception effect, the objective of this study was to determine whether SZP present hyper- or hypo-familiarity.

To this purpose, 15 SZP and 15 healthy subjects (HS) were presented with facial stimuli, which consisted of picture morphs of unfamiliar faces and faces that were personally familiar to the participants. The percentage of the familiar face contained in the morph ranged from 5 to 95%. The participants were asked to press a button when they felt familiar with the face that was presented.

The main results revealed a higher percentage of familiarity responses for SZP compared with HS from the stimuli with low levels of familiarity in the morph and a lower familiarity threshold, suggesting a hyper-familiarity disorder in SZP. Moreover, the intensity of this "hyper-familiarity" was correlated with positive symptoms. This finding clearly suggests the need for a more systematic integration of an assessment of familiarity processing in schizophrenia symptoms assessments.

1. Introduction

Familiarity processing is a crucial aspect of recognition because it provides the experience that an item has been previously encountered (Yonelinas, 2001; Daselaar et al., 2006; Song et al., 2011). This ability is notably essential to establish appropriate social interactions (Antonius et al., 2013). Indeed, familiarity disorders have been described as a failure of affective judgment capable of strongly impacting social interactions (Ameller et al., 2015). They are notably present in some delusional disorders, such as Capgras syndrome (Capgras and Reboul-Lachaux, 1923) in which patients hold a delusion that an impostor has replaced a friend, spouse, parent, or other close family member, or in Fregoli syndrome (Courbon and Fail, 1927) which is the delusional belief that one or more familiar persons, usually persecutors following the patient, repeatedly change their appearances (Klein and Hirachan, 2014). While in Capgras syndrome, the patients display a loss of familiarity; in Fregoli syndrome they display "hyper-familiarity" (Klein and Hirachan, 2014). In schizophrenia, the existence of a familiarity disorder appears to place patients at risk for maladaptive behaviors and their medico-legal consequences, as suggested by links with violence and homicides (Bourget and Whitehurst, 2004; Carabellese et al., 2014). However, there are no existing guidelines on how to assess and treat familiarity disorders in schizophrenia (Klein and Hirachan, 2014). This is most likely because the nature of these impairments remains unaddressed by the commonly used experimental tasks. Thus, further experimental investigations are needed to better understand familiarity

Abbreviations: SZP, schizophrenia patients; HS, healthy subjects.

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processing in schizophrenia and may ultimately contribute to an improvement in the therapeutic care of those patients.

Recognition is supported by two kinds of memory, recollection and familiarity, that depend on distinct processes and different systems of brain structures (Yonelinas, 2001; Yonelinas et al., 2010). Until now, familiarity processing in SZP has primarily been examined using paradigms that estimate the relative contributions of familiarity (i.e., the feeling that a stimulus has been encountered before) and recollection (i.e., the retrieval of details associated with the initial exposure) during recognition tasks (Yonelinas et al., 2010). These paradigms are performed in two steps: 1) an encoding phase and 2) a test phase. Recognition is considered to be based on recollection if participants are able to recollect some specific aspects of the encoding conditions present when the stimulus was encountered.

Nevertheless, the studies that have employed these paradigms have produced inconsistent results. Indeed, a recent review that focused on familiarity and recollection suggested that recollection is consistently reduced in SZP, but the conclusions with regards to familiarity processing were less clear (Libby et al., 2013). Of the 19 identified studies that compared SZP with healthy controls, 7 reported that familiarity was reduced in SZP, 7 reported that familiarity was preserved, and 5 showed an increased reliance on familiarity processes, i.e., an increased proportion of items that were recognized based on familiarity in the absence of recollection for SZP compared with healthy subjects (HS) (Libby et al., 2013). Because familiarity is described as an automatic form of memory, one might assume that it should be preserved in SZP. Additionally, previous studies (Marie et al., 2001; Antonius et al., 2013) have demonstrated intact familiarity preference processing in SZP, suggesting that the feeling of familiarity is not impaired in SZP. Nevertheless, other studies shown that SZP suffer from a deficit in familiarity processing (Martin et al., 2005; Guillaume et al., 2007; Weiss et al., 2008). To explain this deficit, Weiss et al. (2008) postulated that SZP may present familiarity impairment because of an absence of rapid "novelty signal".

Beyond these inconsistencies, those studies had several methodological limitations. On the one hand, there are well-known difficulties with accurately distinguishing familiarity from recollection. Notably, it has been shown that source recognition may be supported by familiarity when the item and its context are unitized during encoding, which occurs when the contextual information is encoded as a feature of the item (Diana et al., 2008; Montaldi and Mayes, 2010; Migo et al., 2012). On the other hand, the use of an encoding phase to create familiar stimuli may be problematic because SZP are known to exhibit deficits in learning (Danion et al., 1999; Boyer et al., 2007). Moreover, a potential limitation of these methods is that they are procedurally complex and that the instructions for these tasks are most likely difficult to understand for patients with cognitive deficits (Ragland et al., 2012).

Those methodological limitations can be overcome by using (1) simple categorization tasks through which the ability of participants to detect familiar stimuli among unfamiliar stimuli can be easily measured and (2) stimuli that are familiar to the participant and therefore do not require an initial encoding or familiarization task (Maddock et al., 2001; Qin et al., 2012). A range of studies has assessed face processing in SZP from categorization tasks based on familiar stimuli but only a few have systematically assessed familiarity processing per se (Darke et al., 2013; Joshua and Rossell, 2009). Moreover, several methodological limitations may still be noted. First, some of these studies have used faces of famous people as familiar stimuli (Pomarol-Clotet et al., 2010), which were generally iconic pictures of celebrities (such as Che Guevara or Marilyn Monroe); these iconic pictures may promote recollection processes (Ramon et al., 2011) and can be unknown to some participants (Trinkler et al., 2009), particularly those who may have a restricted general knowledge. Second, to assess whether familiarity processing is preserved or impaired in SZP, those studies were focused on the analysis of correct responses. However, an analysis of errors can also be very instructive: a high number of omissions can be associated with a "hypo-familiarity" disorder, i.e., an inability to detect familiar stimuli (or alternatively, with the tendency of SZP to not answer in favor of familiarity when they feel uncertain); a high number of false alarms can be considered to reveal a "hyper-familiarity" disorder, i.e., considering unfamiliar stimuli to be familiar (or alternatively, with the tendency of SZP to answer in favor of familiarity when they feel uncertain). In several studies that examined face recognition in SZP by comparing the rates of correct responses between SZP and HS, we observed that a frequent type of error made by SZP is a false alarm, suggesting a possible "hyper-familiarity" disorder (Irani et al., 2006; Caharel et al., 2007).

In the current study, we aimed to assess familiarity disorders in SZP by creating an original paradigm that was particularly suited to studying familiarity processing in SZP. Considering the previous reports, we decided to use a categorization task that was based on stimuli that were familiar for the participant. To avoid methodological issues linked to the use of pictures of celebrities, we chose to use personally familiar stimuli for each of the participants. Additionally, to test whether there is a hypo- or a hyper-familiarity disorder in SZP, we decided to use a familiarity continuum task. This type of task is based on the existence of the categorical perception effect, which occurs when the perception of differences between categories is enhanced at the expense of our perception of incremental changes in the stimulus within a category (Pollak and Kistler, 2002). This categorical perception effect can be evidenced using an imaging-morphing procedure which consists of creating stimuli that vary along continua between discrete categories: (Kiffel et al., 2005; Angeli et al., 2008; Armann and Bülthoff, 2012). Referring to studies on categorical perception, we chose to use an identification task in which participants had to press a button when they felt familiar with the face that was presented. We created facial stimuli specific to each participant by morphing photographs of faces from persons that were unknown and personally familiar to them. Thus, the use of personally familiar stimuli allowed the specific study of familiarity without the involvement of recollection because (1) the participants were naïve with regard to the familiar persons' faces that were presented and (2) no original pictures were displayed (the least familiar picture involved a 5% level of familiarity, and the most familiar one involved a 95% level of familiarity). Since facial stimuli were never seen by the participants before the task, we expected that participants could not "recollect" the stimulus and that stimulus recognition was only based on familiarity.

Two types of analyses were performed on the collected data. First, the individual percentage of "familiarity" responses were compared between groups. Second, based on the strategy used by Pollak and Kistler (2002) and D'Hondt et al. (2015), we fit separate psychometric function models for the familiarity continuum to the data from each individual participant, providing us with estimates of category boundaries and slope, which we used to compare familiarity processing between SZP and healthy controls. On the one hand, the categorical boundary corresponds to the level of the continuum where the probability of responding either that a face is familiar or unfamiliar is equal to 50%. Here, we use the term "familiarity threshold" to refer to this categorical boundary. We therefore hypothesized that SZP would demonstrate a shift in the familiarity threshold compared to HS. On the other hand, the slope of the logistic function allows us to estimate the abruptness of the response change (Kee et al., 2006).

2. Materials and methods

2.1. Participants

Fifteen (11 men) stabilized SZP (DSM-IV criteria) and 15 (11 men) healthy participants matched to the patients for gender and age (respectively, 33.1 ± 8.9 years and 30.3 ± 8.9 years, $t(28) = 0.880$, $p = 0.387$) were recruited. For SZP, the recruitment took place in a day hospital. For all participants, the exclusion criteria included the following: age less than 18 years or greater than 55 years, a history of neurological illness, substance abuse, and visual or intellectual difficulties precluding the test. For the SZP, the severity of their symptoms was rated using the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987). The local ethics committee approved this study, and all participants provided written informed consent.

2.2. Stimuli

Stimuli were individually tailored for each subject and consisted of black and white images constructed from 3 photographs of familiar faces and 3 photographs of unfamiliar gender-matched faces. The necessity of homogenous pictures for the creation of morphed stimuli led us to use pictures of adults with neutral expressions and without distinctive features (such as glasses, mustaches or beards). Because the frequency of encounters may influence familiarity processing, strict temporal criteria were applied to select the familiar persons for each participant. For the HS, familiar persons were selected from colleagues or friends whom they encountered several days a week for at least 6 months. For the SZP, familiar persons were selected from among the medical staff using the same temporal criteria.

Pictures were standardized as followed: external features were removed, image sizes were adjusted (200 × 308 pixels) and all images were equalized with regard to brightness and contrast (mean grey value = 115 ± 5) using Adobe Photoshop®. For each participant, each familiar picture was associated with each unfamiliar picture to create 9 pairs of pictures. Then, for each picture pair, Morpheus Photo Animation® was used to generate 10 picture morphs, with different levels of familiarity (i.e., a percentage of the familiar face contained in the morph, which ranged from 5 to 95% in increments of 10%). The original pictures were not displayed. Ninety images were thus obtained for each subject, which were presented on a uniform grey background and viewed by each subject (size = 200 × 308 pixels; −6.37 × 9.80 degree of visual angle; mean grey value = 115 ± 5, Fig. 1).

2.3. Design and procedure

Stimuli were presented on a computer screen placed 60 cm from the subject in a dark room. E-Prime 1.1® was used to present the stimuli and record each subject's responses. The experimental session was divided into 3 sequences of 90 trials, separated by pauses. The first sequence was used as a training session; the data from the second and third sessions were used for our data analyses. During each sequence, the 90 morphed images generated for each participant were presented individually in a randomized order. Each trial included the presentation of a fixation cross for a variable and random duration (between 500 and 1500 ms), followed by one of the 90 morphs for 500 ms and then a 1500 ms inter-trial interval (Fig. 2). The duration of the entire experiment was 15 min. Participants were asked to press a button each time they felt familiar with the face that was presented, whereas they were asked not to give a response if the face did not look familiar; they could answer during the stimulus presentation time or the inter-trial interval. There were no instructions regarding their response times, and no feedback was given. After the completion of the task, the original pictures of the familiar and unfamiliar persons were presented and the subjects were asked to specify the identity of the persons they considered to be familiar.

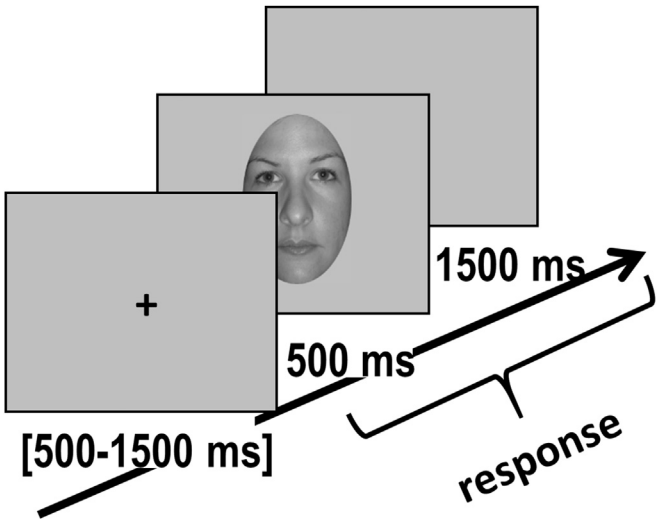

Fig. 2. Representation of a trial, including the presentation of a fixation cross for a variable and random duration (between 500 and 1500 ms), followed by one of the 90 morphs for 500 ms and then a 1500 ms inter-trial interval.

2.4. Data processing

First, the percentage of familiarity detection (number of responses divided by the number of trials) was calculated for each of the 10 conditions (i.e., each familiarity level). For 9 participants (6 SZP; 3 HS), 1 of the 3 familiar faces was not recognized at the end of the experiment. In these particular cases, data related to the stimuli that were derived from the non-identified face were removed from the analysis, and the data on the 120 remaining trials were analyzed. Second, a psychometric function (i.e., a sigmoid function with 4 parameters) that estimated the percentage of familiarity detection according to the familiarity level in the morph was adjusted for each participant's data. The sigmoid function equation

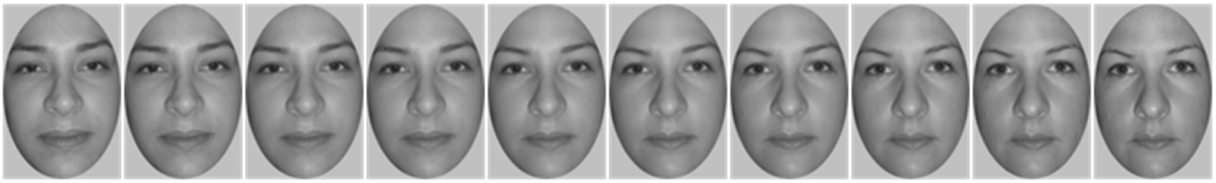

Fig. 1. Examples of stimuli for one participant for one among the 9 pairs of pictures: 10 morphs were generated for each picture pair from the familiar face to the unfamiliar face (from 5 to 95% in increments of 10%).

was calculated with SigmaPlot® by using the following formula:

$$y = a + \frac{b}{1 + e^{\frac{-(x-xc)}{d}}}$$

where y is the probability of a response and x is the familiarity level in the morph. The familiarity threshold and the abruptness of the sharp change of response were estimated for each sigmoid function by considering the categorical boundary (the familiarity level at which the participant considered a face to be familiar in half of the trials) and the curve slope from the parameters xc and d, respectively.

Using SPSS, a repeated measures analysis of variance (ANOVA) with a Greenhouse–Geisser correction was performed on the percentage of familiarity detection, with the familiarity levels in the morph (i.e., 5%, 15%, 25%, 35%, 45%, 55%, 65%, 75%, 85%, 95%) as the within-subjects factor and the groups (i.e., SZP, HS) as the between-subjects factor. Student's t-tests were performed to localize the differences between the groups. The alpha level was set at 0.05. Then, familiarity thresholds and slopes were compared between groups with Student's t-test. Finally, to test the association between familiarity assessment and patients' clinical features, Bravais–Pearson correlation coefficients were calculated in the patient group between these values (thresholds and slopes), and the clinical features of SZP were rated using PANSS, duration of illness, age and medication.

3. Results

Repeated measures analyses of variance (ANOVA) with Greenhouse–Geisser corrections were conducted for the percentage of familiarity detection. A main effect of the level of familiarity in the morph ($F(9, 252) = 508.129$, $P < 0.001$) revealed that familiarity detection increased with the level of familiarity in the morph. An effect of the group ($F(1, 28) = 1121.852$, $P < 0.001$) indicated a higher rate of familiarity detection in SZP compared to HS. A significant interaction was found between the level of familiarity in the morph and the group. ($F(9, 252) = 3.811$, $P < 0.001$) revealing that the effect of the level of familiarity in the morph was not the same in both groups. A significant higher rate of "familiarity" responses was observed in SZP compared with HS for the following familiarity levels: 15% ($t(28) = -2.414$, $P = 0.029$), 25% ($t(28) = -2.560$, $P = 0.021$), 35% ($t(28) = -3.606$, $P = 0.002$), 45% ($t(28) = -2.847$, $P = 0.008$) and 55% ($t(28) = -2.436$, $P = 0.022$) (Table 1).

The sigmoid functions were fitted to each participant's data individually to obtain the slope and threshold values for each participant (Fig. 3). The psychometric function fit the participants' data very well ($R > 0.99$ for each of the participants). T-tests revealed a significantly lower familiarity threshold in the SZP group than in the HS (SZP: 50.73% ± 4.78; HS: 54.61% ± 4.57; $t(28) = 5.164$, $P = 0.031$), while the groups did not significantly differ in the slopes (SZP: 6.03; HS 5.02; $t(28) = -1.402$, $P = 0.172$).

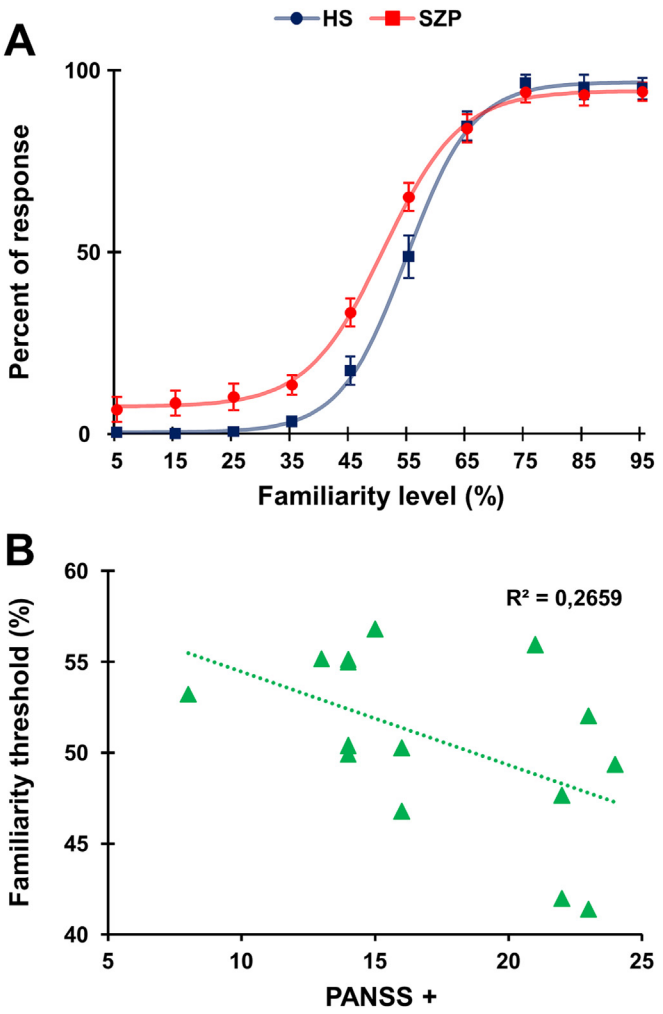

Fig. 3. Results of the experiment. A) Percentage of responses as a function of familiarity level in SZP (red) and HS (blue). For the analyses, the sigmoid functions were fitted to each participant's data individually to obtain the slope and threshold values for each participant, however for illustration, the sigmoid functions were fit to average group accuracy (SZP: $y = 0.07 + 0.87/(1 + e-(x-50.71)/6.56)$; HS: $y = 0.01 + 0.96/(1 + e-(x-54.57)/5.67)$. B) Correlation between familiarity thresholds and positive symptoms in schizophrenia patients. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3.1. Correlations with clinical features (Table 2)

A significant negative correlation was found between the familiarity threshold and positive symptoms, indicating that the more severe the positive symptoms were for a patient, the lower

Table 1
Percentage of familiarity detection (mean value ± standard deviation) according to the familiarity level in the morph for the SZP and HS groups.

Fam. level	5%	15%	25%	35%	45%	55%	65%	75%	85%	95%
SZP										
Mean	0.07	0.09	0.10	0.14	0.33	0.65	0.84	0.94	0.93	0.94
(±SD)	0.13	0.13	0.14	0.10	0.15	0.15	0.15	0.11	0.11	0.10
HS										
Mean	0.00	0.00	0.01	0.03	0.17	0.49	0.85	0.97	0.95	0.95
(±SD)	0.01	0.01	0.02	0.04	0.15	0.23	0.15	0.09	0.13	0.11
t-Test	−1.836	**−2.414**	**−2.560**	**−3.606**	**−2.847**	**−2.436**	0.039	0.684	0.535	0.833

Significant values ($P < 0.05$) **in bold**.

his/her familiarity threshold would be. Furthermore, we observed a statistical trend toward a correlation between the familiarity threshold and the duration of illness. No correlation was observed between familiarity thresholds and medications or age or between slopes and any of the clinical features.

4. Discussion

The current study aimed to assess familiarity processing in SZP using a familiarity continuum task. The main results revealed a hyper-familiarity disorder in SZP, as suggested by (1) higher percentage of familiarity responses for SZP compared with HS for stimuli with low levels of familiarity in the morph (15% of familiarity) and those with intermediate levels of familiarity (until 55% of familiarity); (2) a lower familiarity threshold for SZP. Moreover, the individual familiarity thresholds were positively correlated with the positive symptoms as assessed by PANSS, suggesting a significant association between the hyper-familiarity disorder and the positive dimension of the symptomatology.

First, SZP considered stimuli to be familiar significantly more often than HS did. This result suggests therefore the possibility of a hyper-familiarity disorder, i.e., the tendency to consider stimuli to be familiar when they are not. In line with this, there was also a significant interaction between the familiarity level and the group. Indeed, the propensity for SZP to feel familiar with stimuli was significantly higher than that observed for HS for low-level familiarity morphs (from 15% to 35%) and ambiguous ones (between 45% and 55% of familiarity in the morph). These findings confirm a hyper-familiarity disorder in SZP, who, more often than healthy controls, consider stimuli that are predominantly unfamiliar or ambiguous to nevertheless be familiar. Thus, SZP required less visual information about familiarity to consider a face familiar than did the HS. These results also confirm recent findings showing that under conditions of uncertainty, SZP appear to reach decisions with little evidence (Krug et al., 2014).

Second, the data from all participants demonstrated the expected sigmoidal curve with familiarity detection approaching 100% for stimuli near the endpoint of the continuum, which is characteristic of the typical pattern of categorical perception. This confirms previous results showing that familiar faces are perceived categorically (Beale and Keil, 1995). In HS, the mean familiarity threshold was equal to 54.61%, which signifies, quite logically, that familiarity responses begin to predominate when there is a superior proportion of familiarity information within the morph (Stretch and Wixted, 1998). A significantly lower familiarity threshold was found in SZP, suggesting that familiarity responses of SCZ began to predominate for stimuli that included a lower familiarity level than for HS. The familiarity threshold of 50.73% observed in SZP also suggests that their "familiarity" responses begin to predominate for highly ambiguous stimuli, i.e., when there is almost as much familiarity information as unfamiliar information. This finding appears to corroborate the hypothesis that the higher number of false alarms made by SZP compared with HS observed in several studies (Irani et al., 2006; Caharel et al., 2007) may reflect a "hyper-familiarity" disorder. Because familiarity is assumed to reflect a signal detection process (Yonelinas et al., 2010), it would have been particularly relevant to report hits and false alarms. Unfortunately, all the stimuli used in this study contain a certain percentage of familiarity (from 5 to 95%) and cannot be classified by the experimenter as familiar or unfamiliar, which did not allow us to estimate these data.

Of note, the comparison of sigmoid functions between SZP and HS revealed that the curve slopes were not significantly different between the two groups. Thus, familiarity processing could be comparable between SZP and HS, and the difference in familiarity processing between the groups could be primarily caused by a response bias. Previous behavioral studies have shown a reduced global visual processing in favor of a local one in SZP (Shin et al., 2008; Joshua and Rossell, 2009). Stimulus recognition in SZP would consist of matching salient features of faces individually and independently by a feature-based strategy (Fakra et al., 2008). By using this cognitive and feature-based strategy, SZP would not be able to display a rapid and intuitive processing of the emotion that is generated by a configuration-based strategy. Thus, the processing of familiar stimuli in SZP would not be based on the emotional responses that are usually associated with specific familiar stimuli (Maddock et al., 2001; Qin et al., 2012) but would instead be supported by a cognitive strategy. In summary, the prevailing processing of details would lead SZP to focus their attention on different parts of the stimulus, and as soon as they feel familiar with a particular detail, they would conclude that the stimulus is familiar. This tendency to ascribe relevance (familiarity) to unrelated (unfamiliar) events has previously been proposed to reflect an inability to assess the correct salience of events, which is assumed to constitute a key component of the illness (Irani et al., 2006).

In addition, the individual familiarity thresholds of the SZP were negatively correlated with the positive symptoms, suggesting that the ability of SZP to consider a face as being familiar is related to the productive dimension of their symptoms. A correlation between positive symptoms and excess of recognition (reflected by false alarms when patients were presented with unfamiliar faces) has previously been observed in a study based on the discrimination between familiarity and recollection (Guillaume et al., 2007). In this study, the authors postulated that the greater facility to accept a stimulus as familiar reflects the loosening of associations that characterize the disorganization of SZP (Guillaume et al., 2007). However, familiarity disorders are delusional disorders that are not specific to SZP but may occur in affective or organic illnesses (Klein and Hirachan, 2014) that are not characterized by a disorganization. Accordingly, we suggest that the "hyper-familiarity" observed in SZP is related to the delusion rather than the disorganization. This is in agreement with our statement in the introduction pointing out

Table 2
Pearson's correlation coefficients (ρ) between familiarity thresholds and slopes values and clinical features in schizophrenia patients.

	Age	DOI (y)	AP (CPZ)	PANSS positive	PANSS negative	PANSS general	PANSS total
Mean	33.1	8.1	621.0	17.26	20.0	38.6	75.26
(±SD)	±8.9	±6.0	±452.0	±4.81	±6.18	±10.6	±18.61
Thresholds							
ρ	0.100	*−0.506*	0.353	**−0.516**	0.139	−0.340	−0.316
(P)	(0.722)	(*0.055*)	(0.198)	(**0.049**)	(0.621)	(0.215)	(0.251)
Slopes							
ρ	0.129	−0.039	0.003	0.465	0.203	0.081	0.214
(P)	(0.646)	0.890	0.991	0.080	0.469	0.774	0.444

DOI: duration of illness (in years); AP (CPZ): average antipsychotic dose in chlorpromazine equivalents. Statistically significant correlation values ($P < 0.05$) are shown **in bold**; statistical correlation trends ($P < 0.08$) are shown *in italics*.

the necessity to not limit familiarity assessments to the correct identification of familiar stimuli but to consider the familiarity disorder in terms of hyper-familiarity. Moreover, we observed a statistical trend toward a correlation between the familiarity threshold and the duration of illness. This finding suggests that "hyper-familiarity" is related to the productive dimension of SZP symptoms and that it may progress during the development of mental illnesses. Finally, the heterogeneous nature of schizophrenia over its longitudinal course may explain the inconsistent outcomes of previous studies and the previous difficulty of concluding that there is a familiarity disorder in SZP.

The study nevertheless had a number of limitations. First, for some participants, 1 of the 3 familiar faces was not recognized, and the associated data were not included in the analysis. It is likely that the use of pictures with faces without external features and the adjustment and equalization (in terms of size, brightness and contrast) of each picture contributed to this difficulty in identification. However, this standardization was necessary to make the stimuli comparable and create morphs between pictures. Furthermore, for the participants who did not identify 1 of the 3 stimuli, 120 trials remained available, which allowed us to conduct analyses and obtain a threshold value for each of the included participants. Second, because we chose to use strict criteria to create our stimuli (for each participant, 3 familiar persons, gender-matched, without distinctive features and encountered several days a week for at least 6 months), this study was limited in sample size. However, even if based on a small sample of participants, our results show a significant interaction between familiarity level and group, a significant lower familiarity threshold in patients and a significant negative correlation between the familiarity threshold and positive symptoms in the patient group. Nevertheless, further research is required to confirm our results.

Despite the limitations, the results from the current study have important methodological and clinical implications for the understanding of familiarity processing in individuals with schizophrenia. From a methodological point of view, this study confirms the usefulness of (1) using an imaging-morphing procedure for the determination of subjective boundaries between familiarity and unfamiliarity to compare familiarity processing between SZP and HS and (2) using personally familiar stimuli for SZP to avoid complex procedures and metacognitive demands (Libby et al., 2013). Thus, this paradigm allowed us to account for the hyper-familiarity effect and its correlation with positive symptoms. From a clinical point of view, our results suggest that SZP are able to detect a familiar stimulus when it is depicted at a low familiarity level. This ability would be associated with the intensity of SZP positive symptoms. In the context of a recollection deficit, hyper-familiarity might be considered a compensatory process to improve memory performance (Libby et al., 2013). Nevertheless, it has been suggested that when the recognition system is only supported by familiarity, the failure to reinstate the appropriate context evoked by the stimulus would result in the retrieval of false information (Edelstyn et al., 2003). Then, the false information might lead to delusional syndromes and, in the context of face processing, to delusional misidentification. Accordingly, even if our results tend to show a better performance for SZP in the familiarity detection, this apparent positive effect might eventually result in maladaptive behaviors and the formation of delusions.

5. Conclusion

To the best of our knowledge, this work constitutes the first study of familiarity in SZP that relies on an identification task based on morph stimuli and reveals a hyper-familiarity effect whose intensity is correlated with positive symptoms in SZP. Thus, an increased familiarity, rather than a deficit in familiarity processing, could be proposed to support the difference of familiarity processing in SZP relative to HS. Nevertheless, this apparent performance could have important clinical consequences. This study clearly suggests the necessity of assessing the familiarity processing and a more systematic integration in the assessment of schizophrenia symptoms.

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Contributors

MH, FDH and DP designed the study and wrote the protocols. MH collected the data. DP and PT performed the literature review and analyses. GV contributed to the subject recruitment. MH and FDH completed the statistical analysis. All authors contributed to and approved the final manuscript.

Conflicts of interest

All other authors declare that they have no conflicts of interest.

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References

Ameller, A., Dereux, A., Dubertret, C., Vaiva, G., Thomas, P., Pins, D., 2015. What is more familiar than I? Self, other and familiarity in schizophrenia. Schizophr. Res. 161 (2–3), 501–505.
Angeli, A., Davidoff, J., Valentine, T., 2008. Face familiarity, distinctiveness, and categorical perception. Q. J. Exp. Psychol. Hove 61 (5), 690–707.
Antonius, D., Bruce, K.L., Moisa, B., Sinclair, S.J., Malaspina, D., Trémeau, F., 2013. Familiarity preference in schizophrenia is associated with ambivalent attitudes towards others. Schizophr. Res. 150 (1), 229–234.
Armann, R., Bülthoff, I., 2012. Male and female faces are only perceived categorically when linked to familiar identities—and when in doubt, he is a male. Vis. Res. 63, 69–80.
Beale, J.M., Keil, F.C., 1995. Categorical effects in the perception of faces. Cognition 57 (3), 217–239.
Bourget, D., Whitehurst, L., 2004. Capgras syndrome: a review of the neurophysiological correlates and presenting clinical features in cases involving physical violence. Can. J. Psychiatry 49 (11), 719–725.
Boyer, P., Phillips, J.L., Rousseau, F.L., Ilivitsky, S., 2007. Hippocampal abnormalities and memory deficits: new evidence of a strong pathophysiological link in schizophrenia. Brain Res. Rev. 54 (1), 92–112.
Caharel, S., Bernard, C., Thibaut, F., Haouzir, S., Di Maggio-Clozel, C., Allio, G., et al., 2007. The effects of familiarity and emotional expression on face processing examined by ERPs in patients with schizophrenia. Schizophr. Res. 95 (1–3), 186–196.
Capgras, J., Reboul-Lachaux, J., 1923. L'illusion des sosies dans un délire systématisé chronique. Bull. Soc. Clin. Med. Ment. 6–16.
Carabellese, F., Rocca, G., Candelli, C., Catanesi, R., 2014. Mental illness, violence and delusional misidentifications: the role of Capgras' syndrome in matricide. J. Forensic Leg. Med. 21, 9–13.
Courbon, P., Fail, G., 1927. Syndrome d'Illusion de Frégoli et schizophrenie. Bull. Soc. Clin. Med. Ment. 15, 121–124.
Danion, J.M., Rizzo, L., Bruant, A., 1999. Functional mechanisms underlying impaired recognition memory and conscious awareness in patients with schizophrenia. Arch. Gen. Psychiatry 56 (7), 639–644.
Darke, H., Peterman, J.S., Park, S., Sundram, S., Carter, O., 2013. Are patients with schizophrenia impaired in processing non-emotional features of human faces? Front. Psychol. 4, 529.
Daselaar, S.M., Fleck, M.S., Cabeza, R., 2006. Triple dissociation in the medial temporal lobes: recollection, familiarity, and novelty. J. Neurophysiol. 96 (4), 1902–1911.
D'Hondt, F., de Timary, P., Bruneau, Y., Maurage, P., 2015. Categorical perception of

emotional facial expressions in alcohol-dependence. Drug Alcohol Depend. (in press).
Diana, R.A., Yonelinas, A.P., Ranganath, C., 2008. The effects of unitization on familiarity-based source memory: testing a behavioral prediction derived from neuroimaging data. J. Exp. Psychol. Learn. Mem. Cogn. 34 (4), 730–740.
Edelstyn, N.M.J., Drakeford, J., Oyebode, F., Findlay, C., 2003. Investigation of conscious recollection, false recognition and delusional misidentification in patients with schizophrenia. Psychopathology 36 (6), 312–319.
Fakra, E., Salgado-Pineda, P., Delaveau, P., Hariri, A.R., Blin, O., 2008. Neural bases of different cognitive strategies for facial affect processing in schizophrenia. Schizophr. Res. 100 (1–3), 191–205.
Guillaume, F., Guillem, F., Tiberghien, G., Martin, F., Ganeva, E., Germain, M., et al., 2007. Use of the process dissociation procedure to study the contextual effects on face recognition in schizophrenia: familiarity, associative recollection and discriminative recollection. Psychiatry Res. 149 (1–3), 105–119.
Irani, F., Platek, S.M., Panyavin, I.S., Calkins, M.E., Kohler, C., Siegel, S.J., et al., 2006. Self-face recognition and theory of mind in patients with schizophrenia and first-degree relatives. Schizophr. Res. 88 (1–3), 151–160.
Joshua, N., Rossell, S., 2009. Configural face processing in schizophrenia. Schizophr. Res. 112 (1–3), 99–103.
Kay, S.R., Fiszbein, A., Opler, L.A., 1987. The positive and negative syndrome scale (PANSS) for schizophrenia. Schizophr. Bull. 13 (2), 261–276.
Kee, K.S., Horan, W.P., Wynn, J.K., Mintz, J., Green, M.F., 2006. An analysis of categorical perception of facial emotion in schizophrenia. Schizophr. Res. 87 (1–3), 228–237.
Kiffel, C., Campanella, S., Bruyer, R., 2005. Categorical perception of faces and facial expressions: the age factor. Exp. Aging Res. 31 (2), 119–147.
Klein, C.A., Hirachan, S., 2014. The masks of identities: who's who? Delusional misidentification syndromes. J. Am. Acad. Psychiatry Law 42 (3), 369–378.
Krug, A., Cabanis, M., Pyka, M., Pauly, K., Kellermann, T., Walter, H., et al., 2014. Attenuated prefrontal activation during decision-making under uncertainty in schizophrenia: a multi-center fMRI study. Schizophr. Res. 152 (1), 176–183.
Libby, L.A., Yonelinas, A.P., Ranganath, C., Ragland, J.D., 2013. Recollection and familiarity in schizophrenia: a quantitative review. Biol. Psychiatry 73 (10), 944–950.
Maddock, R., Garrett, A., Buonocore, M., 2001. Remembering familiar people: the posterior cingulate cortex and autobiographical memory retrieval. Neuroscience 104 (3), 667–676.
Marie, A., Gabrieli, J.D., Vaidya, C., Brown, B., Pratto, F., Zajonc, R.B., Shaw, R.J., 2001. The mere exposure effect in patients with schizophrenia. Schizophr. Bull. 27 (2), 297–303.
Martin, F., Baudouin, J.Y., Tiberghien, G., Franck, N., 2005. Processing emotional expression and facial identity in schizophrenia. Psychiatry Res. 134 (1), 43–53.
Migo, E.M., Mayes, A.R., Montaldi, D., 2012. Measuring recollection and familiarity: improving the remember/know procedure. Conscious. Cogn. 21 (3), 1435–1455.
Montaldi, D., Mayes, A.R., 2010. The role of recollection and familiarity in the functional differentiation of the medial temporal lobes. Hippocampus 20 (11), 1291–1314.
Pollak, S.D., Kistler, D.J., 2002. Early experience is associated with the development of categorical representations for facial expressions of emotion. Proc. Natl. Acad. Sci. U. S. A. 99 (13), 9072–9076.
Pomarol-Clotet, E., Hynes, F., Ashwin, C., Bullmore, E.T., McKenna, P.J., Laws, K.R., 2010. Facial emotion processing in schizophrenia: a non-specific neuropsychological deficit? Psychol. Med. 40 (6), 911–919.
Qin, P., Liu, Y., Shi, J., Wang, Y., Duncan, N., Gong, Q., et al., 2012. Dissociation between anterior and posterior cortical regions during self-specificity and familiarity: a combined fMRI-meta-analytic study. Hum. Brain Mapp. 33 (1), 154–164.
Ragland, J.D., Blumenfeld, R.S., Ramsay, I.S., Yonelinas, A., Yoon, J., Solomon, M., et al., 2012. Neural correlates of relational and item-specific encoding during working and long-term memory in schizophrenia. Neuroimage 59 (2), 1719–1726.
Ramon, M., Caharel, S., Rossion, B., 2011. The speed of recognition of personally familiar faces. Perception 40 (4), 437–449.
Shin, Y.-W., Na, M.H., Ha, T.H., Kang, D.-H., Yoo, S.-Y., Kwon, J.S., 2008. Dysfunction in configural face processing in patients with schizophrenia. Schizophr. Bull. 34 (3), 538–543.
Song, Z., Jeneson, A., Squire, L.R., 2011. Medial temporal lobe function and recognition memory: a novel approach to separating the contribution of recollection and familiarity. J. Neurosci. 31 (44), 16026–16032.
Stretch, V., Wixted, J.T., 1998. Decision rules for recognition memory confidence judgments. J. Exp. Psychol. Learn. Mem. Cogn. 24 (6), 1397–1410.
Trinkler, I., King, J.A., Doeller, C.F., Rugg, M.D., Burgess, N., 2009. Neural bases of autobiographical support for episodic recollection of faces. Hippocampus 19 (8), 718–730.
Weiss, A.P., Goff, D.C., Duff, M., Roffman, J.L., Schacter, D.L., 2008. Distinguishing familiarity-based from source-based memory performance in patients with schizophrenia. Schizophr. Res. 99 (1–3), 208–217.
Yonelinas, A.P., 2001. Components of episodic memory: the contribution of recollection and familiarity. Philos. Trans. R. Soc. B Biol. Sci. 356 (1413), 1363–1374.
Yonelinas, A.P., Aly, M., Wang, W.-C., Koen, J.D., 2010. Recollection and familiarity: examining controversial assumptions and new directions. Hippocampus 20 (11), 1178–1194.