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Validation of the French sensory gating inventory: A confirmatory factor analysis

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ABSTRACT

The Sensory Gating Inventory (SGI) is an instrument investigating daily experiences of sensory gating deficit developed for English speaking schizophrenia patients. The purpose of this study is to design and validate a French version of the SGI. A forward–backward translation of the SGI was performed. The psychometric properties of the French SGI version were analyzed. A confirmatory factor analysis (CFA) was carried out to determine whether factor structure of the French version is similar to the original English version. In a sample of 363 healthy subjects (mean age = 31.8 years, S.D. = 12.2 years) the validation process revealed satisfactory psychometric properties: the internal consistency reliability was confirmed for each dimension; each item achieved the 0.40 standard threshold for item-internal consistency; each item was more highly correlated with its contributive dimension than with the other dimensions; and based on a CFA, we found a 4-factor structure for the French version of the SGI similar to the original instrument. Test-retest reliability was not determined. The French version of the SGI is a psychometrically sound self-report for measuring phenomenological sensory gating experiences.

1. Introduction

Abnormal regulation and integration of sensory, perceptual and attentional processes and, in particular, sensory gating abnormalities are considered a core deficit among patients with schizophrenic disorder (Andreasen et al., 1994; Light and Braff, 2003; Micoulaud Franchi et al., 2013). In his early description of Dementia praecox, Bleuler (1911), p. 68 noted, "the selectivity which normal attention ordinarily exercises among the sensory impressions can be reduced to zero so that almost everything is recorded that reaches the senses. Thus, the facilitating as well as inhibiting properties of attention are equally disturbed" (cf. alsoLight and Braff, 2003, p. 47).

McGhie and Chapman (1961) confirmed Bleuler's (1911) results in patients with schizophrenia following a non-structured phenomenological interview. Through an analysis of verbatim accounts and an implementation of categorical structuring, the authors isolated two types of change in daily experience for patients with schizophrenia. The first change

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involved disturbances in the process of "perception", including abnormalities in the quality of sensory input (i.e. perceived increases in stimulus intensity and a heightening of sensory vividness) with greater prevalence in auditory and visual modalities. Patients reported anomalies that they described as follows: "I have noticed that noises all seem to be louder" or "It is as if someone has turned up the volume". The second type of change was disturbances in the process of "attention", including distractibility and an inability to focus attention. Patients reported anomalies as follows: "The sounds are coming through to me, but I feel my mind cannot cope with everything. It is difficult to concentrate on any one sound" and "I listen to sounds all the time. I let all the sounds come in that are there" (McGhie and Chapman, 1961, p. 105).

Inspired by McGhie and Chapman's work (1961), two perceptual scales emerged to study sensory gating deficits in schizophrenia (Micoulaud-Franchi and Vion-Dury, 2013): the Structured Interview for Assessing Perceptual Anomalies (SIAPA) (Bunney et al., 1999) and the Sensory Gating Inventory (SGI) (Hetrick et al., 2012). The SIAPA is a structured interview administered to the patient that allows the interviewer to score the frequency of perceptual anomalies for the five sensory modalities on the three following dimensions: hypersensitivity, inundation/flooding, and selective attention to common external stimuli. Using this scale, Bunney et al. (1999) reported a significantly greater prevalence of auditory and visual perceptual anomalies in patients with schizophrenia compared to healthy subjects and, in doing so, confirmed the seminal results obtained by McGhie and Chapman. The SGI is a self-report questionnaire composed of 36 items addressing a broad range of sensory gating-like subjective experiences that are rated by the patients on a 6-point Likert scale. The psychometric properties of the SGI indicate that it provides valuable information on 4 dimensions of sensory gating-like experiences: Perceptual Modulation (PM) (linked to 16 items, e.g., "My hearing is so sensitive that ordinary sounds become uncomfortable"), Over-inclusion (OI) (7 items, e.g., "I notice background noises more than other people"), Distractibility (D) (8 items, e.g., "There are times when I cannot concentrate with even the slightest sounds going on"), and Fatigue-Stress Modulation (FS) (5 items, e.g., "It seems that sounds are more intense when I'm stressed")

The advantages of the SGI compared to SIAPA are: i) it is a self-report questionnaire that could more accurately assess patients' experiences than interviewer scoring (Slevin et al., 1988), ii) it uses items mainly based on verbatim accounts of face-to-face interviews (in particularly from McGhie and Chapman, 1961) that are known to be an effective way of constructing a questionnaire to assess self-experience (McKenna, 1997), iii) it has been subjected to factor analysis to demonstrate its construct validity (whereas the SIAPA was not), which is an important empirical psychometric property for validating a scale (Nunnally and Bernstein, 1994).

The perceptual scales investigating daily experiences of sensory gating deficit were developed for English speaking schizophrenia patients (Bunney et al., 1999; Chapman et al., 1978; Hetrick et al., 2012). In order to better examine French patients' phenomenological sensory gating experiences (Micoulaud-Franchi and Vion-Dury, 2013), the purpose of this study was to design and validate a perceptual scale in French. Given the advantages of the SGI, we choose to adapt the SGI for use in French individuals. Translating questionnaires may be dependent on cultural background and, before using a translated questionnaire, it is necessary to perform a transcultural validation according to specific rules and methods. For the validation process, we analyzed the psychometric properties of the French SGI version. In particular, using confirmatory factor analysis (CFA), we determined whether this version behaves similarly to the original English version.

2. Methods and materials

2.1. Participants

A group of 580 people: undergraduate students (230 subjects) and graduate teachers and engineer researchers (350 subjects), from four neuroscience labs and one acoustic lab of the Aix-Marseille University (AMU)[1] were mailed a letter describing the purpose of the study and inviting them to self-administer a confidential web survey using a provided URL address.

2.2. Procedure

The mailed letter informed the recipients that they were entirely free to respond to the study or not and that, by agreeing to send the questionnaire back anonymously, they were giving their informed consent to participate. They were also informed that they would not be compensated for their participation. A research assistant could be reached by phone or by email to respond to any questions concerning the study.

Before carrying out the web survey, participants had to declare that they were native French speaking, between 18 and 65 years of age, and had no current or past substance abuse or dependency, no neurological illness, no brain injury and no auditory impairment. The web survey included in order of presentation: age and gender questions, the SGI (a 36 items questionnaire, answered using a balanced 6-point Likert scale ranging from 5 words descriptors: "never true", "almost never", "sometimes true", "almost always", to "always true"), the Perceptual Aberration Scale (PAS) (Chapman et al., 1978) (a 35 items questionnaire, answers by "true" or "false"), and the Trait Anxiety Inventory (TAI) (Spielberger, 1983) (a 20 items questionnaire, answers using a balanced 4-point Likert scale ranging from "almost never", "sometimes", "often", to "almost always"). The data were made automatically anonymous to ensure privacy.

A pre-test was conducted with 7 subjects of our team. We controlled that i) they well understood the survey, ii) they easily answered to the web survey by using the interface, and iii) data were recorded, correctly stored, and easy to export to statistical software. The mean duration of the 3 questionnaires was about 15 min, which was judged acceptable for our web survey.

This study was conducted in accordance with the Declaration of Helsinki and French Good Clinical Practices.

2.3. French translation of the SGI

Before carrying out the translation, the agreement of the authors of the original English SGI was obtained. A forward–backward translation was performed. The original version was translated into French by two French native speakers with a high level of fluency in both English and French and with a high level of acoustic expertise (graduate researchers in the field of acoustics). The back-translation into English was undertaken by an English native speaker with a high level of acoustic expertise and was made independently of the forward-translation. The divergences observed between the back-translation and the original English version were identified and discussed with the author (W.H.) of the original instrument. For the items where cross-language agreement could not be reached, French sentences were reworded. The final version of the French SGI is in Table 1.

2.4. Statistical analyses and hypotheses

Descriptive statistics of the obtained data included frequencies and percentages of categorical variables together with means and standard deviations of continuous variables. For the validation process, we analyzed the psychometric properties of

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Table 1
French version of the SGI.

Nos	Dimension[a]	Items	French version	Mean	(S.D.)	Floor (%)	Ceiling (%)	INFIT[b]
1.	PM	Every now and then colors seem more vivid to me than usual.	De temps en temps les couleurs me semblent plus vives que d'habitude.	1.14	(1.22)	40.5%	0.6%	1.30
2.	PM	Sometimes I find it difficult to focus on one visual sight to the exclusion of others.	Parfois, je trouve qu'il est difficile de se concentrer sur un détail visuel à l'exclusion des autres.	1.47	(1.27)	28.9%	0.6%	0.99
3.	D	I find it hard to concentrate on just one thing.	Je trouve qu'il est difficile de se concentrer sur une seule chose.	1.45	(1.24)	24.0%	1.1%	1.32
4.	OI	The silliest little things that are going on interest me.	Je suis intéressé(e) par les petites choses les plus bêtes qui peuvent survenir.	2.18	(1.44)	11.6%	5.5%	0.97
5.	PM	At times I have feelings of being flooded by sounds.	J'ai parfois le sentiment d'être submergé(e) par les sons.	1.75	(1.47)	27.8%	2.8%	0.89
6.	D	There are times when I can't concentrate with even the slightest sounds going on.	Il y a des moments où le moindre bruit qui passe m'empêche de me concentrer.	2.34	(1.36)	8.0%	5.0%	1.12
7.	PM	Sometimes it seems like someone has turned the volume up—things seem really loud.	Parfois, j'ai l'impression que quelqu'un a augmenté le volume; c'est comme si les choses devenaient vraiment très bruyantes.	1.39	(1.39)	37.2%	1.1%	0.99
8.	PM	There are days when indoor lights seem so bright that they bother my eyes.	Il y a des jours où les lumières d'intérieur semblent si lumineuses que cela gène mes yeux.	1.13	(1.34)	46.0%	1.7%	1.18
9.	OI	I notice background noises more than other people.	Je remarque les bruits de fond plus que les autres personnes.	1.60	(1.43)	26.2%	4.4%	1.30
10.	PM	I hear sounds but I can't make sense of them all because it's like trying to do 2 or 3 things at once.	J'entends les sons, mais je ne peux pas leur donner de sens à tous, parce que ce serait comme essayer de faire 2 ou 3 choses à la fois.	0.91	(1.17)	50.4%	0.6%	1.26
11.	PM	For several days at a time I have such heightened awareness of sights and sounds that I cannot shut them out.	Il y a des périodes de plusieurs jours consécutifs, où je suis tellement sensible à tous les éléments visuels et sonores que je ne peux pas les ignorer.	0.71	(1.19)	63.9%	1.7%	0.96
12.	PM	It seems like I hear everything at once.	J'ai l'impression d'entendre tout à la fois.	0.97	(1.22)	48.2%	1.4%	1.13
13.	D	I am easily distracted.	Je suis facilement distrait(e).	2.07	(1.29)	7.7%	5.0%	0.83
14.	PM	It seems like I take in too much.	Je me sens saturé(e) par trop de sensations.	1.12	(1.27)	42.1%	1.1%	0.96
15.	FS	When I am driving at night, I am bothered by the bright lights of oncoming traffic.	Quand je suis au volant la nuit, je suis gêné(e) par les lumières vives des voitures venant en sens inverse.	2.91	(1.54)	7.7%	18.5%	1.15
16.	D	It is hard to keep my mind on one thing when there's so much else going on.	Lorsqu'il se passe beaucoup de choses, j'ai des difficultés à rester concentré(e) sur une seule.	2.30	(1.34)	6.6%	5.2%	0.78
17.	D	When I am in a group of people I have trouble listening to one person.	Quand je suis avec un groupe de personnes, j'ai des difficultés à n'en écouter qu'une seule.	1.92	(1.52)	19.6%	6.1%	1.40
18.	PM	My hearing is so sensitive that ordinary sounds become uncomfortable.	Mon audition est si sensible que les sons du quotidien en deviennent pénibles.	0.77	(1.12)	56.7%	1.1%	1.02
19.	PM	It's not bad when just one person is speaking but if others join in, then I can't pick it up at all. I just can't get into tune with that conversation.	Lorsqu'une seule personne parle, je n'arrive pas trop mal à suivre, mais si d'autres s'y joignent, alors je n'arrive plus du tout à suivre. Je ne peux simplement plus entrer dans la conversation.	0.80	(1.14)	55.1%	0.3%	1.21
20.	PM	Sometimes I notice background noises more than usual.	Parfois, je remarque les bruits de fond plus que d'habitude.	1.63	(1.32)	21.8%	1.9%	0.84
21.	OI	Not only the color of things fascinates me but all sorts of little things, like markings in the surface, attract my attention, too.	Non seulement la couleur des choses me fascine, mais toutes sortes de petites choses attirent aussi mon attention, comme les marquages sur les surfaces.	1.29	(1.41)	39.7%	2.2%	1.05
22.	D	I find it difficult to shut out background noise and that makes it difficult for me to concentrate.	J'ai des difficultés à ignorer les bruits de fond, ce qui m'empêche de me concentrer.	1.44	(1.22)	21.2%	1.9%	0.97
23.	OI	I seem to always notice when automatic appliances turn on and off (like the refrigerator or the heating & cooling system).	J'ai l'impression que je remarque toujours le moment où les appareils automatiques se mettent en marche ou en veille (comme le réfrigérateur ou le système de chauffage et de refroidissement).	1.77	(1.53)	25.1%	6.3%	1.13
24.	PM	I have feelings of being flooded by visual experiences, sights, or colors.	J'ai le sentiment d'être inondé(e) par des expériences visuelles, des images ou des couleurs.	0.66	(1.03)	61.7%	0.3%	0.84
25.	FS	When I am tired, the brightness of lights bothers me.	Quand je suis fatigué(e), la luminosité des éclairages me dérange.	2.18	(1.53)	14.0%	8.3%	1.00
26.	PM	There have been times when it seems that sounds and sights are coming in too fast.	Il y a des moments où j'ai l'impression de recevoir les sons et les images trop vite.	0.95	(1.24)	51.8%	0.6%	0.99
27.	PM	I can't focus on one sound or voice to the exclusion of others.	Je n'arrive pas à me concentrer sur un son ou une voix à l'exclusion des autres.	0.97	(1.10)	41.9%	0.3%	1.03
28.	D	At times I have trouble focusing because I am easily distracted.	Parfois, j'ai du mal à me concentrer parce que je suis facilement distrait(e).	1.87	(1.32)	13.8%	3.3%	0.73
29.	PM	Background noises are just as loud or louder than the main noises.	Les bruits de fond sont tout aussi forts ou plus forts que les bruits principaux.	0.84	(1.05)	49.9%	0.3%	0.76
30.	FS	I cannot focus on visual images when I am tired or stressed.	Quand je suis fatigué(e) ou stressé(e), je n'arrive pas à me concentrer sur les images visuelles.	1.68	(1.34)	20.7%	2.8%	1.24
31.	D	I have more trouble concentrating than others seem to have.	J'ai plus de difficultés de concentration que les autres personnes.	1.08	(1.22)	41.3%	1.4%	1.03
32.	OI	Maybe it's because I notice so much more about things that I find myself looking at them for a longer time.	Peut-être que c'est parce que je remarque beaucoup plus de détails sur les choses que je me retrouve à les regarder pendant plus longtemps.	1.26	(1.38)	39.7%	3.3%	0.94
33.	OI	Everything grips my attention even though I am not particularly interested in any of it.	De nombreuses choses attirent mon attention même si je ne m'y intéresse pas particulièrement.	1.88	(1.47)	19.6%	5.0%	0.77
34.	OI	I seem to hear the smallest details of sound.	J'ai l'impression d'entendre les moindres détails des sons.	1.07	(1.32)	46.0%	2.2%	0.93
35.	FS	When I'm tired sounds seem amplified.	Quand je suis fatigué(e), les sons me semblent amplifiés.	1.77	(1.53)	26.4%	5.5%	0.71
36.	FS	It seems that sounds are more intense when I'm stressed.	J'ai l'impression que les bruits sont plus intenses quand je suis stressé(e).	1.75	(1.55)	27.0%	6.6%	0.85

[a] Perceptual Modulation (PM), Over-Inclusion (OI), Distractibility (D) and Fatigue-Stress Modulation (FS).
[b] Rasch statistics.

the French SGI version including construct validity, internal structural validity and some aspects of external validity. Data analyses were performed using SPSS software (Version 18, PASW Statistics) and LISREL software (Scientific Software International, Inc.).

2.4.1. Computation of the SGI scores

The score for each dimension of the SGI (i.e. PM, OI, D and FS) was obtained by computing the sum of the scores obtained by items associated with it, from 0, "never true", to 5, "always true". A global score was computed as the sum of the dimension scores.

For construct validity and internal structural validity analyses, all dimension scores and the global score were linearly transformed and normalized to a 0–100 scale (0 lowest SGI score, 100 highest score). As the number of items was variable according to dimensions, the use of linearly transformed scores enables an easier internal comparison of the statistical analysis between dimensions (Table 2) than a score based on the sum of the scores obtained by items. For PM dimension, normal range (nr)=(score/80)×100; for OI dimension, nr=(score / 35)×100; for D dimension, nr=(score / 40)×100; for FS dimension, nr=(score/25)×100); and for the global score, nr=(score/180)×100.

For external validity, the scores were not linearly transformed as done by Hetrick et al. (2012). Thus it enables an easier external comparison with their results.

2.4.2. Construct validity and internal structural validity

A confirmatory factor analysis (CFA) was performed to analyze the construct validity and to test the 4-factor structure of the original scale (PM, OI, D and FS) using the LISREL model. Considering the non-normal distribution of the items of SGI and according to the recommendations offered in LISREL, the Robust Maximum Likelihood (RML) estimation method was used for the CFA (Boomsma and Hoogland, 2001). The following indicators were required to be considered acceptable (Botha et al., 1988): a Root Mean Square Error of Approximation (RMSEA) less than 0.08; a Comparative Fit Index (CFI) greater than 0.9; and a Standardized Root Mean Square Residual (SRMR) less than 0.08.

Item-internal consistency (IIC) was assessed by correlating each item with its related dimension using Pearson's coefficient; correlations of at least 0.4 are recommended for supporting item-internal consistency (Carey and Seibert, 1993). Item discriminant validity (IDV) was assessed by determining whether items correlated better with the dimension they were hypothesized to represent compared with the other dimensions (Campbell and Fiske, 1959). As presented in Table 2, IIC are correlations between items and the dimension that they were hypothesized to represent, and IDV are correlations between items and the other dimensions that they were not hypothesized to represent. Therefore, the IIC and IDV ranges should not overlap to be considered as satisfactory.

For each dimension scale, internal consistency reliability was assessed by Cronbach's alpha coefficient. To confirm consistency, a coefficient of at least 0.7 was expected for each dimension (Carey and Seibert, 1993; Cronbach and Meehl, 1955).

The unidimensionality of each dimension was assessed using Rasch analysis. Goodness-of-fit statistics (INFIT) evaluate that all items of a given dimension measured the same concept. Mean-square fit statistics show the size of the randomness. The expected range is 0.7–1.3. Values less than 0.7 indicate that observations are too predictable (redundancy of some items to represent the dimension). Values greater than 1.3 indicate unpredictability (some items of a dimension do not represent the same concept).

Floor and ceiling effects were reported to assess the repartition of the response distribution. The rate of floor and ceiling effects were calculated as the proportion of individuals who obtained the lowest ("never true") and the highest ("always true") scores for any of the items.

2.4.3. External validity

To explore external validity, relations between: i) dimensions of the SGI and the PAS, and ii) dimensions of the SGI and the TAI, were investigated by computing Pearson's coefficients. The PAS is a self-report questionnaire translated and validated in French that measures abnormal body image in schizophrenia (Dumas et al., 2000; Dumas et al., 1999). The relationship between the SGI and the PAS was expected because the body-image distortions measured by the PAS have been conceptually linked to a putatively broader range of perceptual dysfunction in schizophrenia (Chapman et al., 1978). Furthermore, these instruments shared two items, and several other items on the PAS refer to perceptual aberrations of exteroceptive stimuli, as does the PM dimension on the SGI (Hetrick et al., 2012). The TAI is a self-report questionnaire translated and validated in French that measures anxiety traits (Spielberger, 1983). The relationship between the SGI and the TAI was expected because anxiety appears to play a role in sensory gating mechanisms (White and Yee, 1997). Based on the findings from Hetrick et al. (2012), we hypothesized a moderate correlation between the SGI and the PAS and between the SGI and the TAI.

The discriminant validity was determined by comparing mean scores across each of the 4 dimensions of the SGI for each gender. A difference was expected because gender plays a role in sensory gating mechanisms (White and Yee, 1997). Based on the findings from Hetrick et al. (2012), we hypothesized significantly higher scores for women on the D and the FS dimensions. Another way to test the discriminant validity was to hypothesize that a high PAS score would be associated with schizotypal features. Indeed, according to the methodology of Coleman et al. (1996), it may be possible to identify a subgroup of participants with putative schizotypal personality (thought disorders and idiosyncratic verbalization). High PAS scores were defined as at least 2.0 standard deviation above the PAS entire group mean. The contrast subgroup was required to have PAS scores no higher than 0.5 standard deviation above the entire group mean. Differences on SGI scores were expected because participants with schizotypal features, which resemble those seen in patients with schizophrenia, present abnormal sensory gating (Cadenhead et al., 2000). We hypothesized significantly higher scores for the subgroup of participants with putative schizotypal personality on the 4 dimensions of the SGI. SGI scores differences were analyzed by independent samples *t*-tests.

Finally, we hypothesized no significant correlation between the SGI and age.

3. Results

3.1. Sample characteristics

A total of 363 participants completed the French version of the SGI. The mean age was 31.8 years old (S.D.=12.2, range: 18–63 years old); 75.5% were women. The percentage of responders to the web survey was 62%.

The mean PAS score was 4.5 (S.D.=4.8) and the mean TAI score was 37.2 (S.D.=10.6), which fall within the range of scores that have previously been demonstrated in the literature for healthy subjects (Dumas et al., 2000; Spielberger, 1983).

3.2. Validity

3.2.1. Construct validity and internal structural validity

Results are presented in Tables 1 and 2.

Table 2
Validation of the French version of the SGI.

Dimension (Number of items)	$M \pm$ S.D.[a]	IIC[b] min–max	IDV[c] min–max	Floor (%)	Ceiling (%)	Alpha[d]	INFIT[e] min–max
Perceptual modulation (16)	41.49 ± 16.75	0.54–0.76	0.27–0.62	45	1	0.923	0.76–1.30
Over inclusion (7)	51.57 ± 21.39	0.69–0.80	0.33–0.59	30	4	0.870	0.77–1.30
Distractibility (8)	56.17 ± 19.57	0.63–0.82	0.26–0.60	18	4	0.884	0.73–1.40
Fatigue-Stress modulation (5)	51.14 ± 22.17	0.60–0.83	0.25–0.64	19	8	0.793	0.71–1.24
Global score	51.59 ± 16.88	–	–	32	3		–

[a] Mean ± Standard deviation. SGI scores ranging from 0 to 100 because scores were linearly transformed and standardized on a 0–100 scale (0 lowest SGI score, 100 highest score).
[b] Item Internal Consistency (item-to-own dimension correlations).
[c] Item Discriminant Validity (item-to-other dimensions correlations).
[d] Cronbach's alpha.
[e] Rasch statistics.

The 4 factor-structure of the original scale presented a good fit, and all the indices from the confirmatory LISREL model proved satisfactory (RMSEA=0.069, CFI=0.95, SRMR=0.076).

Internal consistency was satisfactory for all dimensions: each item achieved the 0.40 standard threshold value.

The correlation between items with their contributive dimension was globally higher than items with all other dimensions. However, three items in PM dimension (items 1, 2 and 19) and one item in FS dimension (item 15) did not meet the IDV requirement, i.e. the item-to-own dimension correlation was higher than the item-to-other dimensions correlation (explaining the overlap between IIC and IDV ranges for PM and FS dimensions showed in Table 2).

The Cronbach's alpha coefficients ranged from 0.79 to 0.92 over the entire sample, indicating satisfactory internal consistency.

The overall scalability was satisfactory: only two items of D dimension (items 3 and 17) showed INFIT statistics above the acceptable range (Rasch analysis).

Floor effects ranged from 18% to 45% and ceiling effects ranged from 1% to 8%.

3.2.2. External validity

The magnitude of the correlation between the PAS and the overall SGI scores was moderate ($r(363)=0.53$, $P<0.001$). In particular, the PAS correlated higher with the PM dimension ($r(363)=0.50$, $P<0.001$) and the OI dimension ($r(363)=0.52$, $P<0.001$) than with the D dimension ($r(363)=0.30$, $P<0.001$) and the FS dimension ($r(363)=0.46$, $P<0.001$).

The magnitude of the correlation between the TAI and the overall SGI scores was also moderate ($r(363)=0.41$, $P<0.001$) and r values for the four dimensions ranged from 0.29 to 0.38: PM dimension ($r(363)=0.38$, $P<0.001$), OI dimension ($r(363)=0.29$, $P<0.001$), D dimension ($r(363)=0.35$, $P<0.001$) and FS dimension ($r(363)=0.35$, $P<0.001$).

No statistical association was related to gender concerning the overall SGI scores. Women showed a significantly higher score than men on the FS dimension only ($M=10.96$, S.D.=5.58 for women; $M=8.18$, S.D.=4.87 for men, $t(381)=4.18$, $P<0.001$). Participants with high PAS scores (21 participants, 5% of the entire group, PAS=18.3, S.D.= 4.2) had higher SGI scores than the participants with low PAS score (274 participants, 75%, PAS=2.3, S.D.=1.8) with low PAS scores: overall score ($M=90.71$, S.D.=23.24 for high PAS group; $M=45.53$, S.D.=26.68 for contrast group, $t(293)=7.54$, $P<0.001$), PM dimension ($M=32.67$, S.D.=12.78 vs $M=14.06$, S.D.=12.36, $t(293)=6.63$, $P<0.001$), OI dimension ($M=21.71$, S.D.=6.97 vs $M=13.17$, S.D.=7.27, $t(293)=8.32$, $P<0.001$), D dimension ($M=19.42$, S.D.=6.37 vs $M=13.17$, S.D.=7.27, $t(293)=3.83$, $P<0.001$) and FS dimension ($M=16.91$, S.D.=4.53 vs $M=9.03$, S.D.=5.13, $t(293)=6.82$, $P<0.001$).

The SGI scores did not correlate significantly with age: overall SGI score ($r(363)=0.01$, $P=0.821$), PM dimension ($r(363)=0.05$, $P=0.373$), OI dimension ($r(363)=0.05$, $P=0.296$), D dimension ($r(363)=-0.08$, $P=0.136$) and FS dimension ($r(363)=-0.01$, $P=0.802$).

4. Discussion

The aim of this study was to translate and validate the French version of the SGI, aiming at measuring the daily experience of sensory gating deficit in patients with schizophrenia. The transcultural validation supports the structural validity of the adapted instrument for the French population.

The psychometric properties were satisfactory; the domains described in Hetrick et al. (2012) were considered appropriate for investigating sensory gating experience of French participants. The CFA was similar to the CFA performed by Hetrick et al. (2012) in a sample of undergraduate students. The internal consistency reliability for each of the four dimensions (PM, OI, D, and FS) was shown to be high (Cronbach's alpha >0.70 for all).

The IIC and IDV were globally satisfactory. Only four items (1, 2, 19 and 15) showed unsatisfactory IDV. Item translation and phrasing may have introduced unintended relation between items and other dimensions. Items 1, 2 and 19 belong to the PM dimension that included nearly half of the SGI items. Thus, it could be interesting to examine, in a future study, whether a shorter French version of the questionnaire may avoid such unintended effect and, thus, fit better with the hypothesized LISREL model.

While not being investigated for the original SGI (Hetrick et al., 2012), the goodness-of-fit statistics for the French translation of the SGI revealed that two items (3 and 17) of the D dimension showed a INFIT mean-square above the acceptable range. This result might indicate that these two items did not measure the same concept. Distractibility and inability to focus attention are, most likely, complex phenomena involving more than one dimension. Thus, the D dimension probably includes sub-dimensions that are not well explored by the SGI that focuses more on perceptual abnormal experiences than on attentional disturbances. The Attention Instability Questionnaire or Test of Attentional and Interpersonal Style (Nideffer, 1976), which explores the external validity of the D dimension in the original SGI, could be useful. However it is currently neither translated nor validated in French.

External validity of the SGI was also explored in the French sample. The hypotheses that the PAS and the SGI, and the TAI and the SGI are correlated were supported by the obtained results. They confirmed that the PAS and the SGI instruments shared several items corresponding to perceptual aberrations of exteroceptive stimuli. We found that both the PM and the OI dimensions were highly correlated with the PAS, in contrast to Hetrick et al. findings that only the PM dimension was highly correlated with the PAS. Interestingly, the D dimension, which is not associated with perceptual aberrations of exteroceptive stimuli, demonstrated the lowest correlation with the PAS. This point provides additional support for the discriminant validity of the SGI's factors. Concerning gender, the result was similar to the original SGI, with women scoring higher on the FS dimension. The results confirmed that women are more vulnerable to the effects of stress than men. However, contrary to Hetrick et al. (2012), we found that the gender difference was not significant on the D dimension: women did not report a higher level of distractibility than men. Concerning our hypothesis on a subgroup of participants with putative schizotypal personality (Coleman et al., 1996), the higher scores on the SGI are in line with abnormal sensory gating in patients with schizotypal personality (Cadenhead et al., 2000). The result indicates also that the SGI could be useful to psychometrically identify schizotypal feature, as it was shown with the PAS (Coleman et al., 1996). Further studies are needed to investigate the perceptual abnormalities reported with the SGI in patients with schizotypal personality disorder or with patients at high risk of schizophrenia.

Some limitations of this study need to be addressed. First, acceptability of the SGI was poorly determined because the percentage of responders to the web survey can be over evaluated (the exact number of subjects that received the mail can be under evaluated because of possible multiple forwards), missing values were forbidden in the format of our web-survey implementation and the completion time was not recorded. However, the reports obtained from some responders revealed good acceptability. The main point raised by responders was the interpretation of the word "Sometimes" at the beginning of three items (2, 7 and 20) that caused confusion regarding how to respond using the Likert scale (from 0, "never true", to 5, "always true"). Take for example the item "Sometimes I notice background noises more than usual". If the subject wishes to report that he actually notices background noises all the time in his everyday life, he could hesitate between rating as "never true" (because due to the presence of the word "sometimes", the item is therefore never true) or as "always true" (because "I notice background noises" anyway, the item is therefore always true). This ambiguity was not discussed in the original version of the SGI. However, the modified version of the SGI used by Kisley et al. (2004) and by Sable et al. (2012, 2013) removed the word "sometimes" from the SGI. Hence, we suggest deleting the word "sometimes" in the French version of the SGI. Second, test-retest reliability was not assessed. Test-retest intra-class correlation for the original SGI was found to be good. Third, compared with Hetrick et al. (2012), only two scales (PAS and TAI) were used to investigate external validity. The other scales used by Hetrick et al. (2012) were neither translated nor well validated in French. Fourth, the gender ratio of our sample was in favor of women. Since it is not representative of gender ratio in France, further studies are needed using larger samples with an appropriate gender ratio. Fifth, the mean age of the sample exceeded that of the sample evaluated in the Hetrick et al.'s study by ten years. This is explained by the fact that Hetrick et al. included only undergraduate students, while in our present study both undergraduate students and graduate teachers and engineer researchers formed the sample. Finally, despite our satisfactory findings, our psychometric analyses should be replicated on a population of patients with schizophrenia.

In conclusion, the French version of the SGI is a psychometrically acceptable self-report questionnaire for measuring phenomenological sensory gating experiences in French subjects. Thus, we support that the SGI (French and original versions) offers the possibility of extending psychophysiological investigation to better understand sensory gating in schizophrenia (Jin et al., 1998; Johannesen et al., 2008; Kisley et al., 2004; Light and Braff, 2000). Indeed, sensory gating can also be neurophysiologically assessed by the P50 amplitude changes in dual click conditioning-testing auditory Event Related Potential (ERP) procedures. However, the relationship between abnormalities in the neurophysiological and phenomenological dimensions of sensory gating in schizophrenia remains unclear. Thus, the advantages of the SGI (items mainly based on verbatim and self-ratings) may enable us to bridge the gap between the phenomenological experience of the patients and the electrophysiological exploration of sensory gating (Micoulaud Franchi et al., 2013; Micoulaud-Franchi and Vion-Dury, 2013).

Conflict of interest

The authors report no conflicts of interest.

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