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Assessing metacognition during or after basic-level and high-level cognitive tasks? A comparative study in a non-clinical sample

Comment évaluer la conscience métacognitive ? Une étude comparative de deux outils sur une population non clinique

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Abstract

This study explored in a non-clinical sample whether metacognitive awareness assessments measured during (“*on line*”) and after (“*end line*”) a neuropsychological task lead to comparable results in tests exploring basic-level or high-level cognitive functions. Short-term memory and working memory tests (forward and backward digit recall of the WAIS-III) were used to measure basic-level cognitive function. A social cognition test, the French adaptation of the Faces Test, was used to assess high-level cognitive function through recognition of facial emotions. For these two tests, we explored “*on-line*” metacognitive awareness using a method based upon Koriat and Goldsmith’s protocol. After each answer, participants were asked to rate their level of confidence in the correctness of their response. Persons had also to rate their confidence in their answer only once, at the end of the neuropsychological test, in order to explore “*end-line*” metacognitive awareness. They were then asked “*do you feel you have passed this test?*” and had to rate their feeling of success on a 4-point Likert-type scale (“no”, “rather not”, “rather yes”, “yes”). No association was found between “*on line*” and “*end line*” metacognitive awareness scores on memory tests. Poor “*end line*” metacognitive awareness was associated with lower “*on line*” metacognitive awareness score in the social cognition test. It might be of interest to assess both “*on line*” and “*end line*” metacognitive awareness in persons with schizophrenia to better take into accounts the multi-faceted structure of metacognition.

Keywords: metacognition; metacognitive awareness; metacognitive assessment; neuropsychological tasks.

Résumé

Contexte et Objectif : La métacognition se définit comme la connaissance et la conscience de ses propres processus cognitifs. Des altérations métacognitives ont déjà pu être mises en évidence chez les sujets souffrant de schizophrénie. Il existe plusieurs questionnaires permettant d’évaluer les connaissances métacognitives, indépendantes des tâches cognitives, mais encore très peu d’outils de mesure évaluant la conscience métacognitive, « *on line* », pendant la passation du test cognitif. Dans une étude précédente (Quiles et al. 2014), nous avons présenté un outil d’évaluation de la métacognition reposant sur l’ajout de deux

questions métacognitives « *on line* » à la suite de chaque item de différents tests neuropsychologiques (mémoire de mémoire de travail, mémoire épisodique verbale et test de reconnaissance des émotions faciales). Comme cette stratégie alourdit la passation des tests cognitifs et a un possible impact sur les performances, nous avons développé une version « *end line* », comportant une seule question globale immédiatement à la suite de la passation du test. L'objectif de l'étude est d'explorer si l'évaluation de la conscience métacognitive pendant la tâche cognitive (« *on line* ») telle que construite dans l'étude précédente, conduit à des résultats comparables à l'évaluation de la conscience métacognitive juste après la tâche cognitive (« *end line* »), pour des tests explorant la neurocognition, et des tests explorant les fonctions cognitives dites de « haut niveau ». **Méthode :** Cinquante sujets indemnes de troubles psychiatriques sévères ont été recrutés parmi des donneurs de plaquette. Les tests de mémoire à court terme et de mémoire de travail (tests mémoire des chiffres dans l'ordre et inversée de la WAIS-III), étaient utilisés pour explorer la neurocognition. Un test de cognition sociale (l'adaptation française du test de reconnaissance des émotions sur les visages *Faces Test*) était utilisé pour explorer les fonctions cognitives de « haut niveau ». Une question métacognitive « *on line* », « *A combien avez-vous confiance en votre réponse ?* » était posée après chaque item de chaque test. La question métacognitive « *end line* » « *Pensez-vous avoir réussi ce test ?* » était posée une seule fois à la fin du test. Les scores métacognitifs « *on line* » et « *end line* » ont été comparés à l'aide de test de Student de Welch pour chaque test. **Résultats :** Aucune association n'a été retrouvée entre les scores métacognitifs « *on line* » et « *end line* » concernant les tests mnésiques. Par contre, des scores plus faibles de conscience métacognitive « *end line* » étaient associés à des scores plus faibles de conscience métacognitive « *on line* » pour le test de cognition sociale. **Discussion :** Ces résultats soulignent le caractère complexe et multifacette du concept de métacognition : une évaluation globale de sa performance n'a pas la même signification et conséquence perçue de l'échec qu'une évaluation spécifique de sa performance à chaque item. Lorsque le test fait appel à des domaines familiers, comme les tests mnésiques, les sujets font essentiellement appel à leurs connaissances métacognitives pour évaluer globalement (« *end line* ») leurs performances. Dans le test de reconnaissance des émotions faciales, du fait du manque de familiarité avec le matériel et les questions, les sujets se basent essentiellement sur leur conscience métacognitive (« *on line* ») pour évaluer globalement leurs performances. L'étude de ces modalités d'évaluation de la conscience métacognitive permet d'affiner les outils disponibles et souligner l'importance d'intégrer l'évaluation « *on line* » et « *end line* » de la conscience métacognitive. Des études ultérieures sont nécessaires pour évaluer l'intérêt de ces d'outils, explorer le plus précisément possible les altérations métacognitives dans des populations cliniques, et notamment dans la schizophrénie du fait de leur retentissement important sur les processus de rétablissement.

Mots clé : métacognition ; conscience métacognitive ; évaluation métacognitive ; tests neuropsychologiques

1. Introduction

Metacognition is defined as knowledge and awareness about our own cognition (1). “Metacognitive knowledge”, i.e. knowledge about one’s own cognitive processes, is related to the content of thought, is permanently present, and can be measured independently of ongoing neuropsychological tasks. “Metacognitive awareness”, i.e. monitoring and control of the former processes, is related to thought processes and can only be measured “*on line*”, i.e. during a neuropsychological task.

Metacognitive dysfunction has been recognized as a key feature of schizophrenia (2)(3), which plays a crucial role in daily life functioning (4)(5). Unlike the relatively large number of questionnaires measuring metacognitive knowledge (6)(7)(8)(9), few tools have been designed to measure metacognitive awareness either in persons with schizophrenia or in healthy individuals (10)(4). In the domain of memory, metacognitive awareness may be assessed through confidence level tasks, judgment of learning or feeling of knowing (FOK) tasks (11). To our knowledge, no validated metacognitive awareness assessment tool for different cognitive domains and easy to use in clinical practice is currently available.

In a previous study (12) we explored metacognitive awareness in several cognitive domains using an “*on line*” method based upon Koriat and Goldsmith’s protocol in healthy subjects (13). After each answer participants were asked to rate their level of confidence in the correctness of their response. This protocol significantly hampers the neuropsychological assessment which limits its usefulness in clinical practice. Moreover, we showed that this “*on line*” measure had an impact on cognitive performance, improving working memory performance by enhancing concentration and impairing episodic memory performance by acting as a distractor (12). For these reasons, we have developed an alternative “*end line*” method of metacognitive monitoring awareness assessment: participants are asked only once to rate globally their confidence in their answers, immediately after the end of the neuropsychological test.

The aim of the present study was to explore in a non-clinical sample whether “*on line*” and “*end line*” metacognitive awareness assessments lead to comparable results in basic and high-level cognitive tasks.

2. Methods

The study design has been previously described (12). Participants were recruited among persons attending the blood donation center (*Etablissement Français du Sang*

Aquitaine) in Bordeaux, France, between November 2011 and April 2012. Inclusion criteria for the present study were (i) informed consent to participate in the study; (ii) aged from 18 to 60 years; (iii) French-speaking; (iv) no history of neurological illness or trauma; (v) no history of severe mental disorder (i.e. psychotic disorder or bipolar disorder) as evaluated with the Mini International Neuropsychiatric Interview (MINI) (14) (vi) no alcohol or drug dependence (except nicotine) as evaluated with the MINI and (vii) no regular use of psychotropic drugs (less than once a week over the last month). The study conformed to French bioethics legislation. The research was conducted in accordance with the Helsinki declaration.

Short-term memory and working memory tests (forward and backward digit recall of the WAIS-III) were used to measure basic-level cognitive function (15). A social cognition test, the French adaptation of the Faces Test, was used to assess high-level cognitive function through recognition of facial emotions (16). For the two tests described above, we used the “*on line*” metacognitive protocol developed previously (12). Persons had also to rate their confidence in their answer only once, at the end of the neuropsychological test. They were then asked “*do you feel you have passed this test?*” and had to rate their feeling of success on a 4-point Likert-type scale (“no”, “rather not”, “rather yes”, “yes”).

Statistical analyses were carried out using STATA software 11.0 (17). For each item of each test the performance response was categorized as “correct” (score=1) vs. “wrong” (score=0). The “*on line*” confidence scores were categorized as “high” (“strongly” or “fully” confident) (score = 1) vs “poor” (“moderately, slightly, or not confident at all”) (score = 0) (Bacon, Izaute, 2009). The “*end line*” confidence scores were categorized as “high” (“rather yes” or “yes”) (score = 1) or “poor” (“rather no” or “no”) (score = 0).

“*On line*” and “*end line*” metacognitive awareness scores were calculated using a contingency table of concordance and discordance between performance and confidence scores (Table 1). Concerning “*on line*” metacognitive awareness score, as there were several items in each test “a”, “b”, “c” and “d” could have different values in the contingency table. Concerning the “*end line*” metacognitive awareness score, as there was only one item at the end of the test “a”, “b”, “c” and “d” could only be equal to 0 or 1. We used Hamann’s coefficient (HC) to calculate metacognitive awareness scores. In the domain of metamemory, the HC is acknowledged as a relevant score of FOK accuracy in predicting a subsequent performance (18). The “*on line*” metacognitive awareness score was thus a continuous variable ranging from -1 to 1: the closest the score to 1, the greatest the concordance between performance and confidence. The “*end line*” metacognitive awareness score was a

dichotomous variable: a score equal to -1 indicated discordance between performance and confidence (“poor *end line*” metacognitive awareness) and a score equal to 1 indicated concordance between performance and confidence (“high” “*end line*” metacognitive awareness). TABLE 1 HERE

In order to assess whether “*on line*” and “*end line*” metacognitive awareness assessments lead to comparable results, we compared, for each test, “*on line*” metacognitive awareness scores obtained by participants with “poor” vs. “high” “*end line*” metacognitive awareness. As the distribution of metacognitive awareness scores was not normally distributed, these scores were compared using Welch’s Student t-test, which is an adaptation of Student’s t-test for two samples with possibly unequal variances.

3. Results

Fifty participants were included, of whom the majority were women (66%), with a mean age of 43.9 years (SD 1.9), a mean educational level of 13.2 years (SD 3.4); most (76 %) were employed or students. Concerning forward and backward digit recall test, 9.50 (SD 2.17) and 7.14 (2.28) spans were correctly recalled, respectively. On Faces Test, participants obtained a mean score of 15.84 (0.30) faces with correctly recognized emotion.

Concerning short-term and working memory, “*on line*” metacognitive awareness scores did not significantly differ between the two groups with “poor” vs. “high” “*end line*” metacognitive awareness.

Concerning social cognition, participants with “poor” “*end line*” metacognitive awareness had a significantly lower “*on line*” metacognitive awareness score compared to those with “high” “*end line*” metacognitive awareness (Table 1). TABLE 2 HERE

4. Discussion

No association was found between “*on line*” and “*end line*” metacognitive awareness scores on neuropsychological tests exploring basic-level cognitive tasks (short-term and working memory), whereas as “poor” “*end line*” metacognitive awareness was associated with lower “*on line*” metacognitive awareness score in high-level cognitive task (social cognition).

On basic-level cognitive tasks, the lack of association between metacognitive awareness measured for each item during the test and metacognitive awareness globally measured at the end of the test suggests that the two measures do not explore the same metacognitive

component. According to Toglia and Kirk's model (19), in our study a global appraisal of performance ("*end line*" metacognitive awareness measure) may not have had the same meaning and perceived consequence of failure as a specific appraisal of performance for each item ("*on line*" metacognitive awareness measure). Our results show that different measures should be used to assess the multi-faceted concept of metacognition (20). From a clinical perspective, the "*end line*" metacognitive awareness measure has several advantages compared to "*on line*" metacognitive awareness assessment. First, it is easy and quick to use, unlike the "*on line*" measurement. Second, it has no impact on cognitive performance as the metacognitive question is asked just after the test, contrary to "*on line*" assessment which improves working memory performances and impairs episodic memory performances (12).

Concerning high-level cognitive task, participants with "poor" "*end line*" metacognitive awareness had a significantly lower "*on line*" metacognitive awareness score compared to those with "high" "*end line*" metacognitive awareness. These findings could be explained by the multiplicity of processes involved in high-level cognitive task which require an adjustment to new events and are influenced by emotions. In this facial emotion recognition test, the unfamiliarity of questions and material could lead participants to base their "*end line*" assessment on what they experience through each item of the test ("*on line*" assessments). Conversely, in more familiar cognitive domains such as memory, which can easily remind participants of what they previously experienced at school or work, "*end line*" assessment could also largely rely on metacognitive knowledge. Indeed, in these familiar domains there could be a higher participation of what a person knows about his/her global functioning, i.e. metacognitive knowledge.

Concerning the limits of the study, first, our sample included platelet donors, which may limit the generalization of our results. Second, we used a single test for each cognitive function, which may limit the generalization of our findings to the whole cognitive domain.

5. Conclusion

As impaired metacognitive awareness may have an impact on rehabilitation outcome of persons with schizophrenia, an accurate measure of metacognitive dysfunction is important, for instance to assess cognitive remediation programs effectiveness. Hence, its exploration should integrate "*on line*", as well as "*end line*" measures to better take into account the multi-faceted structure of metacognition.

Conflict of interest: None.

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Table 1. Measure of “on line” metacognitive awareness: contingency table of concordance and discordance between performance and confidence and Hamman’s coefficient inspired by Nelson [18]

Performance ²	Confidence ¹		Mathematical formula of Hamann’s coefficient
	Yes	No	
Yes	a ³	b ⁴	$(a + d) - (c + b) / (a + d) + (c + b)$
No	c ⁵	d ⁶	

¹Assessed for each item by the question "What is your degree of confidence in this answer?" (cf text)

²Performance for each item of each test

³number of items with correct performance for which the participants had confidence in their response

⁴number of items with correct performance for which the participants had no confidence in their response

⁵number of items with incorrect performance for which the participants had confidence in their response

⁶number of items with incorrect performance for which the participants had no confidence in their response

Table 2. Associations between “on line” and “end line” metacognitive awareness

	“End line” metacognitive awareness HC ¹ score (Number of participants)	“On line” metacognitive awareness HC ¹ score Mean (S.D.)	Welch t test	df ²	p value
Forward digit recall	- 1 ³ (15) 1 ⁴ (35)	0.82 (0.19) 0.77 (0.18)	0.78	25.51	0.45
Backward digit recall	- 1 ³ (15) 1 ⁴ (35)	0.79 (0.30) 0.75 (0.21)	0.55	20.42	0.59
Faces Test	- 1 ³ (17) 1 ⁴ (33)	0.40 (0.14) 0.65 (0.18)	- 5.38	45.45	< 0.0001

¹HC: Hamman Coefficient; ²df: Degree of freedom; -1³: “Poor end line” metacognitive awareness; 1⁴: “Good end line” metacognitive awareness score; “End line” metacognitive awareness score was a dichotomous variable: a score equal to -1 indicated discordance between performance and confidence (“poor end line metacognitive awareness”) and a score equal to 1 indicated concordance between performance and confidence (“good end line metacognitive awareness”).