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# Validation of the TTM Processes of Change Measure for Physical Activity in an Adult French Sample

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## Abstract

**Background** Processes of change (POC) are constructs from the transtheoretical model that propose to examine how people engage in a behavior. However, there is no consensus about a leading model explaining POC and there is no validated French POC scale in physical activity

**Purpose** This study aimed to compare the different existing models to validate a French POC scale.

**Method** Three studies, with 748 subjects included, were carried out to translate the items and evaluate their clarity (study 1,  $n=77$ ), to assess the factorial validity ( $n=200$ ) and invariance/equivalence (study 2,  $n=471$ ), and to analyze the concurrent validity by stage  $\times$  process analyses (study 3,  $n=671$ ).

**Results** Two models displayed adequate fit to the data; however, based on the Akaike information criterion, the fully correlated five-factor model appeared as the most

appropriate to measure POC in physical activity. The invariance/equivalence was also confirmed across genders and student status. Four of the five existing factors discriminated pre-action and post-action stages.

**Conclusion** These data support the validation of the POC questionnaire in physical activity among a French sample. More research is needed to explore the longitudinal properties of this scale.

**Keywords** Processes of change · Transtheoretical model · Invariance · Physical activity · French

## Introduction

Physical inactivity has been found to be directly responsible for 3 % of disability-adjusted life years lost in the UK [1]. In France, a national survey indicated a prevalence of sufficient physical activity for health benefits of 51.6 % in men and 33.8 % in women (15–75 years) [2].

It is thus essential to develop the understanding of mechanisms involved in behavior change particularly in physical activity. Among the various behavior change models, the transtheoretical model (TTM) of behavior change is one of the most used in research [3]. The TTM emerged from an analysis of change systems that has been conducted in psychotherapy to treat addictive behaviors such as smoking and drug use. The TTM assumes that behavior change is a dynamic process rather than an all-or-nothing phenomenon. This model is based on five dimensions, namely, decisional balance, stages of change (SOC), temptation, self-efficacy, and processes of change (POC) [4].

Decisional balance is a multidimensional set of values perceived as advantages and disadvantages that are associated with behavioral change. SOC are the most described

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dimension of the model. According to this dimension, people nonlinearly move across five different stages according to their readiness to change. These stages are (a) precontemplation (PC)—people do not intend to change in the next 6 months, (b) contemplation (C)—people intend to change in the next 6 months, (c) preparation (P)—people intend to change during the next month, (d) action (A)—people started to change their behavior within the last 6 months, and (e) maintenance (M)—when people are engaged in a behavior for more than 6 months. Temptation describes urges to engage in a specific habit in the midst of difficult situations. Self-efficacy refers to the people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances [5]. The POC are strategies that individuals use to alter their experiences and environment.

The POC include five experiential and five behavioral strategies that people use to move from precontemplation to maintenance. The experiential processes are defined as follows: consciousness-raising (individual seeks new information to gain understanding and feedback about the problem); dramatic relief (affective aspects of change, involving emotional experiences related to the problem behavior); self-reevaluation (emotions and views that the person has of himself/herself in relation to the behavior); environmental reevaluation (how the problem affects the physical and social environments); social liberation (awareness and acceptance by the individual of alternative behavior leading to healthier lifestyles in society). The behavioral processes are conceptualized as: counterconditioning (substitution of alternative behaviors for the problem behavior); helping relationships (support of caring others while attempting to change the problem behavior); reinforcement management (changing the contingencies that control or maintain the problem behavior); self-liberation (choice and commitment to change the problem behavior); stimulus control (control of situations and other causes that trigger the problem behavior).

Initially, the POC scale was specifically developed and validated in English for the physical activity domain with 40 items [6]. This scale was then modified to obtain a 30-item version [7]. Several researchers tested the validity of the POC scale as used to measure the POC in physical activity with different populations: African American adults [8], older adults [9], adolescents [10], and college students [11]. None of them found a similarly underlying model. The physical activity POC questionnaire was developed in different languages: Finnish [12], Iranian [13], Korean [14], and German [15]. To date, no validation in French has been developed.

In a systematic review of TTM in the physical activity domain, Spencer et al. concluded that most TTM scales are valid but that more research is needed to refine these measures [16]. Empirical evidence demonstrated the validity of physical activity SOC [17].

Empirical evidence demonstrated the validity of the SOC measure related to physical activity [17]. However, the

measurement model of POC and their underlying structures is still in debate and there is a need to find a more consensual measurement model of the POC by computing the five alternative measurement models reported in the literature. [18].

The current study aimed to examine the psychometric properties of the French version of the POC questionnaire related to physical activity. In particular, the aims were (1) to evaluate the factorial validity, in which we compared the fit of competitive models for several versions of the POC models, (2) to test the structure and scaling metrics equivalence/invariance across genders and student status for identified model, and (3) to explore the concurrent validity, which was done by examining potential increases in POC with higher stages.

## Study 1

The purposes of study 1 were to translate POC questionnaires into French and then evaluate the clarity of the items within adults.

### Method

#### *Construction of a Preliminary Version*

An ad hoc committee was specifically set up for this purpose. This committee included researchers specialized in physical activity motivation, adapted physical educator, and bilingual people. A preliminary pool of 46 items was created by translating items from Marcus et al. (16 items) and Nigg et al. (28 items) [6, 7] POC questionnaires on the basis of consensual agreement. We also added two new items (in the social liberation and stimulus control dimensions, respectively).

#### *Participants*

This study was carried out among psychology students and administrative staff of the University of Montpellier in southern France. The preliminary version of the questionnaire was addressed to 77 participants (35 females)

#### *Procedure*

Participants were asked to rate, on a five-point Likert-type scale, how understandable was each item (1=not at all understandable, 5=totally understandable). The order of items was randomized to minimize the response bias of items with their hypothesized construct in the tested version.

#### *Data Analyses*

Item/scale descriptive statistics were obtained using SPSS 16.0. Items with a score below 4 were deemed

unclear, as well as items with standard deviation superior to 1.

Results

All the subjects answered the questionnaire. After this step, 30 items were retained, 3 items per process.

Study 2

In the current literature, different models to describe the POC involved in physical activity are available. The first to be proposed was the ten first-order factors subordinate to two correlated second-order factors [6] (model A). This model was firstly applied to smoking cessation [19]. The second model was the ten fully correlated factors model [8] (model B). The third was a model including two second-order factors and eight first-order factors [18] (model C). In this model, the experiential self-reevaluation process is deleted and one of the behavioral factors is composed of both reinforcement management and self-liberation processes. The fourth one included nine first-order factors subordinate to two correlated second-order factors [11] (model D). In this model, the self-liberation process is not identified. The fifth model was the five fully correlated factors measurement model [18] (model E). In this model, the first factor is represented by self-reevaluation, reinforcement management, and self-liberation processes. The second factor is represented by dramatic relief and environmental reevaluation processes. The other three factors are represented by counterconditioning, helping relationships, and consciousness raising separately. Self-liberation and stimulus control are absent from this model. This model supposes that behavior change is simultaneously mediated by both mixed experiential and behavioral factors.

In past research, the measurement equivalence/invariance of the factor structure and factor loadings in subgroups showed variations across gender, age group, and ethnicity for models A, D, and E of the POC [11, 18]. The longitudinal invariance was observed with model D among college students [11]. In this study, the aims were (1) to evaluate the factorial validity and (2) to test the structure and scaling metrics equivalence/invariance.

Method

Participants

Participants (450 women and 221 men;  $M_{age}=34.7$  years;  $SD_{age}=12.5$ ) were recruited by online and paper

questionnaire (421 online participants). Participants were asked for voluntary participation, and the objectives of the study were explained either orally or in writing. Participants came from 74 out of 101 different local authorities in France. They responded to questions about their gender, age, weight, height, smoking behavior, social status, and level of education. In the sample, 70.6 % had a body mass index (BMI) between 18.5 and 24.9 kg/m<sup>2</sup>. Of them, 82.3 % had a high school level in education. Concerning the employment status, 26.3 % were executive, 29.6 % were employees, and 29.9 % were students. A percentage of 24.9 % of the participants were smokers. Participants were classified according to their SOC: of the sample, 5.7 % was in precontemplation (PC), 8.2 % in contemplation (C), 11.9 % in preparation (P), 4.6 % in action (A), and 69.4 % in maintenance (M). Other

Table 1 Demographic characteristics

Characteristic	Sample (n=671)	
	Mean (SD)	Frequency (%)
Age (years)	34.7 (12.5)	
BMI (kg/m <sup>2</sup> )	22.6 (4.5)	
0 (≤17.9)		7.9 % (n=53)
1 (18.0–24.9)		70.6 % (n=474)
2 (25.0–29.9)		15.9 % (n=107)
3 (≥30)		5.6 % (n=37)
Gender		
Male		32.9 % (n=220)
Female		67.1 % (n=451)
Education (%)		
No education		1.5 % (n=10)
Low-level vocational education		1.5 % (n=10)
Secondary school		2.7 % (n=18)
High school		11.2 % (n=75)
College degree or higher		82.3 % (n=526)
Missing values		5.0 % (n=32)
Exercise stage of change		
Precontemplation		5.7 % (n=39)
Contemplation		8.2 % (n=55)
Preparation		11.9 % (n=80)
Action		4.6 % (n=31)
Maintenance		69.4 % (n=466)
Social status		
Executive		26.8 % (n=180)
Employee		29.6 % (n=199)
Manual worker		1.8 % (n=12)
Unemployed		3.3 % (n=22)
Student		29.9 % (n=201)
Other		8.5 % (n=57)
Smoker		24.9 % (n=167)

participants' characteristics are described in Table 1. The data were randomly split into two subgroups: subgroup 1 ( $n=200$ ) (1) and subgroup 2 ( $n=471$ ) (2), respectively.

### Procedures

Data were collected either online or with paper and pencil over March and April 2010. Calls for participation in this research were advertised through posters that were displayed across the campus of the university (for paper-and-pencil form), as well as on the website of the university and several free-access web forums (for the online form). Participants were informed about the purpose of the survey, the content coverage, and the confidentiality of their answers to the questionnaires.

The merging data obtained through Internet and paper-and-pencil data administration is legitimate [20] and showed no differences in the recruited population [21].

### Measure

The scale resulting from study 1 (30 items) was used to evaluate POC in physical activity. Participants responded to each item using a five-point Likert scale (1=never, 5=repeatedly).

### Data Analyses

Structural equation modeling methods were adopted to perform confirmatory factor analyses (CFA). CFA were performed with AMOS 18.0 under maximum likelihood robust estimation to examine the goodness of fit of the different models. Before acceptance of the final model, we allowed for improvements and modifications to the model in the form of error covariances.

### Model Testing and Factorial Validity

The goodness of fit of the models was evaluated using the following criteria on goodness-of-fit indices:  $\chi^2/df < 3.00$ , comparative fit index (CFI)  $\geq 0.90$ , root mean square error of approximation (RMSEA)  $\leq 0.08$  [22], standardized root mean square residual (SRMR)  $\leq 0.08$  [23].

The  $\chi^2$  statistic was used to assess the absolute fit of the model to the data. The  $\chi^2$  was too sensitive to the sample size; therefore, the CFI and the SRMR were also used to judge model fit [24] because it results in lower probabilities of type I and type II errors when compared to the RMSEA and in sample sizes  $\leq 250$  [23]. The Akaike information criterion (AIC) adjusts the  $\chi^2$  statistic to account for model complexity and has been recommended for comparisons between non-nested models. The model with the lowest AIC value is preferred [25]. Cronbach's coefficient alphas were also calculated for all the subscales. The items were considered to represent an acceptable level of internal consistency if the Cronbach's alpha value was more than 0.70 and good level if it was above 0.80 [26].

### Measurement Invariance

We measured the invariance across genders (male/female) and student status (student/nonstudent). We followed the procedure advocated by Bentler et al. [22]. We tested a measurement invariance analysis encompassing a series of hierarchically ordered steps that began with the establishment of a baseline model for each group, followed by tests for increasingly more stringent levels of constrained equivalence across group differences: (a) for configural invariance, no equality constraints were imposed on the parameters across the two groups; (b) for metric invariance, we constrained factor loadings to be equal while factor variances, error variances, and covariances parameters were free to vary between the two samples; and (c) for scalar invariance, we constrained factor loadings and intercepts to be equal across the two groups. As recommended by Cheung and Rensvold [27], the RMSEA ( $< 0.05$ ), which is not affected by model complexity and which is not sensitive to sample size, was used for indicating the configural model fit. These authors also suggested that  $\Delta CFI$  ( $< 0.01$ ) is a good indication of support of measurement invariance. One of the advantages of  $\Delta CFI$  over the  $\Delta \chi^2$  is that it is not as strongly affected by sample size.

**Table 2** Fit indices for the five competing models

	$\chi^2$	<i>df</i>	$\chi^2/df$	CFI	SRMR	RMSEA	90 % CI	AIC
Model E [18]	653.46	190	3.4	0.92	0.0564	0.060	0.055–0.065	779
Model C [18]	985.25	307	3.2	0.89	0.0626	0.057	0.053–0.061	1,127
Model D [11]	1,155.17	306	3.77	0.86	0.0661	0.064	0.060–0.068	1,299
Model A [6]	1,126.68	371	3.03	0.90	0.0581	0.055	0.051–0.059	1,314
Model B [8]	1,295.34	360	3.59	0.87	0.0610	0.062	0.059–0.066	1,505

$\chi^2$  chi-square, *df* degrees of freedom, *CFI* comparative fit index, *RMSEA* root mean square error of approximation, *90 % CI* RMSEA's 90 % confidence interval, *AIC* Akaike information criterion

Results

Factorial Validity

The fit indexes of the compared models are displayed in Table 2. Only models A and E showed moderate fit indices with the data. Characteristics of the ten first-order factors model (model A) are as follows:  $\chi^2=1,126.68$ ,  $\chi^2/df=3.03$ , CFI=0.86, RMSEA=0.055, 90 % CI=0.051–0.059, SRMR=0.0581, AIC=1,314, whereas characteristics of the five-factor measurement model (model E) are as follows:  $\chi^2=653.46$ ,  $\chi^2/df=3.4$ , CFI=0.92, RMSEA=0.060, 90 % CI=0.055–0.065, SRMR=0.0564, AIC=779. The proportion of missing item responses for each scale ranged from 0 to 2 %. Two items respectively relevant to dramatic relief (“I get upset when I realize that people I love would have better health if they exercised”) and environmental reevaluation (“I think that my exercising regularly will prevent me from being a burden to the healthcare system”) processes were deleted. These items had unacceptable factor loadings.

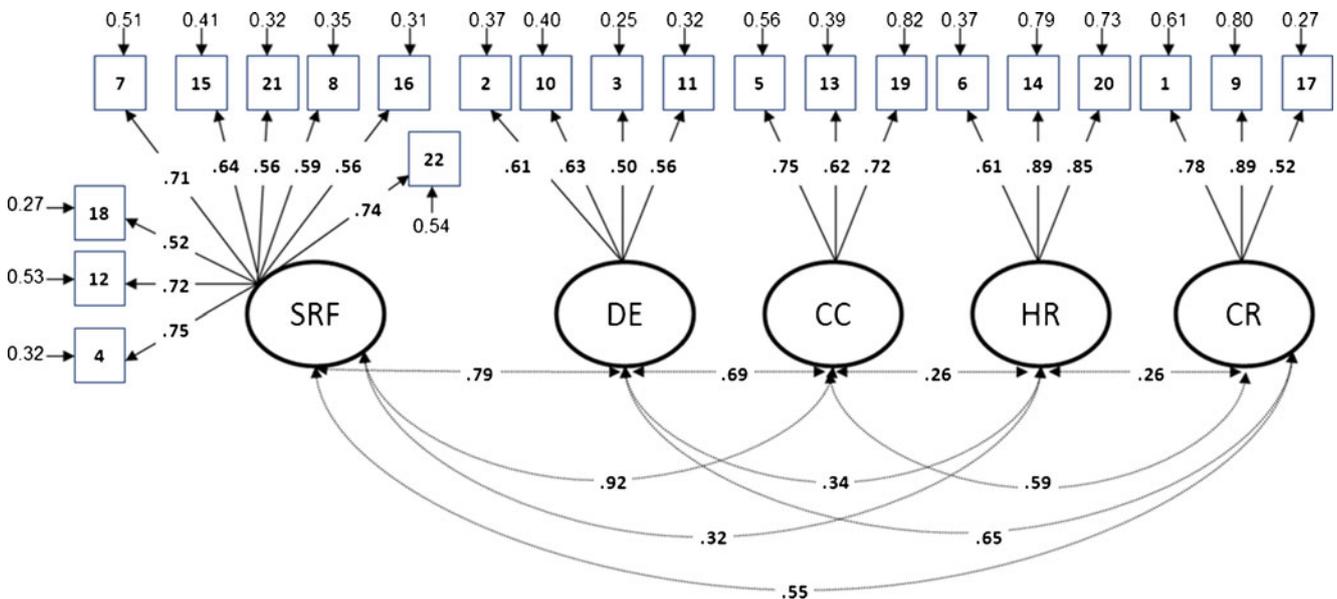
Because of its lowest AIC value, model E offered the best fit to the data. Correlations and factors loadings of model E are presented in Fig. 1. Coefficient alphas were 0.86 for SRF factor, 0.70 for DE, 0.73 for CC, 0.75 for CR, and 0.82 for HR, thus revealing acceptable to good internal consistency for all the subscales.

Multigroup Invariance

The results showed that the configural invariance models fitted with the data reasonably well for gender and student, respectively, RMSEA=0.042, 90 % CI=0.039–0.046, CFI=0.923 and RMSEA=0.045, 90 % CI=0.041–0.049, CFI=0.915 (other fit indices are reported in Table 3). The constrained models showed acceptable model fit: RMSEA=0.042, 90 % CI=0.038–0.046, CFI=0.922 and RMSEA=0.044, 90 % CI=0.040–0.048, CFI=0.914 (other fit indices are reported in Table 3). The changes in fit indices between the configural and metric invariant model were not significant:  $\Delta CFI=0.001$  either for gender and student status. The fit indices for scalar invariance were RMSEA=0.042, 90 % CI=0.038–0.046, CFI=0.921 and RMSEA=0.043, 90 % CI=0.040–0.047, CFI=0.911 (for the other fit indices, see Table 3). The changes in fit indices between the metric and the scalar invariance model were not significant,  $\Delta CFI=0.001$  and  $\Delta CFI=0.003$ , which suggests that scalar invariance can be established across gender and student groups.

Discussion

These results, obtained from a national sample of French participants, mainly support the factorial validity of the fully correlated five-factor model (model E) which displayed better fit indices than the other models. Nevertheless, these indices reflected a moderate fit of the data to this model.



**Fig. 1** Five-factor measurement model of the POC (model E). Factor 1 (SRF) is represented by nine items from the constructs of self-reevaluation (items 4, 8, and 12), reinforcement management (items 7, 15, and 21), and self-liberation (items 8, 16, and 22). Four items represent factor 2 (DE) from dramatic relief (items 2 and 10) and environmental

reevaluation (items 3 and 11). Factors 3 to 5 are represented by three-item indicators each for counterconditioning (CC) (items 5, 13, and 19), helping relationships (HR) (items 6, 14, and 20), and consciousness raising (CR) (items 1, 9, and 17)

**Table 3** Model fit of change processes and measurement equivalence invariance across groups according to participant characteristics

	Model	CFI	SRMR	RMSEA (90 % CI)	$\Delta$ CFI	$\chi^2$	<i>df</i>	$\Delta\chi^2$	$\Delta$ <i>df</i>
Gender	M1	0.923	0.0655	0.043 (0.040–0.047)		861.595	381		
	M2	0.923	0.0670	0.042 (0.039–0.046)	0.000	874.816	398	13.221	17
	M3	0.922	0.0696	0.042 (0.038–0.046)	0.001	895.801	413	20.985	15
	M4	0.921	0.0707	0.041 (0.037–0.044)	0.001	934.365	443	38.564	30
Student status	M1	0.918	0.0708	0.045 (0.041–0.049)		895.906	381		
	M2	0.915	0.0719	0.045 (0.041–0.049)	0.003	935.010	398	39.104	17
	M3	0.914	0.0759	0.044 (0.040–0.048)	0.001	951.454	413	16.444	15
	M4	0.911	0.0770	0.043 (0.040–0.047)	0.003	1,000.314	443	48.86	30

*M1* initial model, *M2* configural invariance, *M3* metric invariance, *M4* scalar invariance,  $\chi^2$  chi-square test statistic, *CI* confidence interval, *CFI* comparative fit index, *RSMEA* root mean square error of approximation, *SRMR* standardized root mean square residual,  $\Delta\chi^2$ ,  $\Delta$ *df*, and  $\Delta$ *CFI* the differences between each alternative model

Model A could also be acceptable, but the AIC criteria suggested to prefer model E.

This study is the first one to compare the whole set of structures potentially underlying POC scales proposed in the literature. This result concurs the sense of the model described by Paxton et al. [18], showing that behavior adoption is simultaneously led by both experiential and behavioral processes because the factors from this model consisted of both processes. The factor SRF is composed of two behavioral processes and one experiential process. The second factor DE is composed of two experiential processes, the third and fourth factors are behavioral, and the fifth factor is an experiential process.

The identification of a more parsimonious model has several consequences on initial TTM. The totality of ten processes and their structure were not used or identified in TTM when applied to physical activity. Indeed, Nigg et al. [28] underline that cessation (e.g., addictive behaviors) or adoption (e.g., physical activity) of a behavior lead to different consequences in terms of intentions and POC. Prochaska et al. [4] suggested that the frequency of behavior (e.g., yearly cancer screening, alcohol dependence) could influence the number of processes required in stage progression [4]. Thus, it is important to recognize that TTM constructs are not directly generalizable to PA.

The construction of model E could explain the high correlation obtained between the SRF factor and the CC in our sample. This finding could be argued because the SRF combined self-reevaluation, which is an experiential process, with items from self-liberation and reinforcement management, which are each behavioral processes. After the creation of the five-factor fully correlated model, the authors highlight that the five-factor scale was positively correlated with the original behavioral [ $r$  (range)=0.54–0.81] and experiential [ $r$  (range)=0.40–0.82] processes [18]. Except for this relationship, our results ranged from  $r=0.26$  to 0.76 which provide evidence about the validity of each factor separately.

The final questionnaire includes 22 items and obtains a good internal consistency. Cronbach's alpha were

0.86, 0.70, 0.73, 0.75, and 0.82 for SRF, DE, CC, CR, and HR, respectively, similar to those obtained by Paxton et al. which were 0.88, 0.72, 0.82, 0.77, and 0.80 [18].

Evidence supported the measurement invariance of the factor structure and factor loadings in subgroups of the sample characterized according to their gender and student status. Item means and items errors were also invariant between gender and status. The equivalence of factor structure and factor loadings indicates that scores from the scales can be interpreted as having similar meaning among French adults regardless of their gender and student status [29]. Our results corroborate previous research showing that the five-factor measurement model seems to be invariant between genders, age groups, or ethnicities [18].

### Study 3

In the original TTM, Prochaska et al. [30] supposed that the individuals were more likely to apply experiential processes to progress through early stages (PC, C, and P), while behavioral processes should be more often used to move toward post-action stage (A and M). However, these relationships had a limited empirical evidence for physical activity [31]. The pattern of change for POC appeared to differ in longitudinal and cross-sectional studies. The results showed that both experiential and behavioral processes are used in stage progression [11, 15, 32].

### Method

#### Participants

The whole sample (described in Table 1) was used to test the hypothesis according to which people should display higher

POC scores as they belong to higher stages of behavior change.

*Procedure and Measure*

The POC resulting from study 2 was used to explore concurrent validity. To assess the SOC, we used the French version of the algorithm of Marcus et al. [32] that was validated by Gourlan [33] and that was then used by Romain et al. [34]. Four questions designed to assess current stage of exercise behavior were administered to all subjects, each with a yes/no response format. For the stage algorithm, regular physical activity (consistent with French Public Health Guidelines) [35] was defined as undertaking moderate physical activity during 30 min and/or vigorous physical activity 20 min, three times a week.

*Data Analyses*

A multivariate analysis of variance (MANOVA) was performed on the whole dimension of the POC questionnaire to analyze the overall variations across SOC. One-way analyses of variance (ANOVAs) were then performed on each process of the selected model. When the ANOVA revealed a significant effect, Tukey's honestly significant difference (HSD) post hoc test was then performed to locate the differences in POC according to the SOC. Post hoc tests were considered as significant with *p* values below 0.05. The partial  $\eta^2$  was used to give the explained variance. The effect size was also assessed with Cohen's  $f^2$ , and by convention,  $f^2$  values of 0.02, 0.15, and 0.35 were respectively considered as small, medium, and large effect sizes [36]. Because of the low number of participants in the precontemplation and action stages, these two stages were combined with contemplation and maintenance, respectively. Further analyses were based on the two combined stages and the preparation stage.

Results

The MANOVA revealed a significant interaction between stage and POC variables (Wilks'  $\lambda=0.746$ ,  $F(10,386)=6.07$ ,  $p<0.001$ ). Table 4 shows the mean scores and summarizes the univariate ANOVAs and Tukey's HSD follow-up tests by stage of change for each of the POC. In relation to the POC, significant effects of stage were found for all processes except for helping relationships.

The concurrent validation examined the discriminant ability of the POC across the stage (PC/C, P, and A/M). The results showed no difference across SOC for the HR process, whereas SRF, CC, DE, and CR discriminated some stages. The HR processes may not help in progressing PA stage. A second potential explanation for this unexpected result could be explained by the collapsing of stages (PC and C; A and M) which reduces the potential for detecting differences. Besides, HR was higher in M stage than other stages in cross-sectional studies [8, 37, 38]. In longitudinal study, a decrease in HR was less likely only in people who maintained their physical activity level [39].

Evidence suggested that three processes, namely, SRF, DE, and CR, delineated the mean differences across pre-action and post-action stages. For SRF and DE, the results are in accordance with a previous prospective study that used a POC measure based on a five-factor model [39]. The SRF process combines self-reevaluation (experiential process), self-liberation, and reinforcement management (behavioral processes). Thus, an increase of SRF across SOC suggests that people use both experiential and behavioral processes to change their behavior [6, 40]. Furthermore, an increase in SRF was also found among adults who stayed active, partially active, or became active [39]. DE (dramatic relief and environmental reevaluation) processes were less likely to decline in people who became physically active [37].

The CC process was the only process to significantly increase across stages from PC/C to P to A/M. A similar pattern was identified in the initial POC validation study [6], as well as in previous studies conducted in healthy adults

**Table 4** Mean scores and standard deviation and Tukey's results by stage of change for POC across stage of change

	PC/C	P	M/A	HSD	<i>P</i> value	Partial $\eta^2$	$f^2$	Observed power
SRF	3.24 (0.91)	3.63 (0.51)	4.12 (0.66)	PC/C, P<M/A	<0.001	0.18	0.22	0.99
DE	2.80 (0.91)	3.08 (0.60)	3.38 (0.89)	PC/C, P<M/A	0.004	0.05	0.052	0.85
CR	1.84 (0.74)	2.11 (0.72)	2.75 (0.96)	PC/C, P<M/A	<0.001	0.13	0.15	0.99
HR	2.51 (1.15)	2.98 (0.91)	2.86 (1.06)	ns	0.21	0.01	0.015	0.33
CC	2.32 (0.85)	3.08 (0.80)	3.62 (0.95)	PC/C<P<M/A	<0.001	0.19	0.23	0.99

PC precontemplation, C contemplation, P preparation, A action, M maintenance, SRF self-reevaluation, reinforcement management, and self-liberation, DE dramatic relief and environmental reevaluation, CC counterconditioning, HR helping relationships, CR consciousness raising, HSD honestly significant difference, ns not significant

[37, 41]. However, opposite results were found in people with chronic disease [38, 42].

## General Discussion

The purposes of the present research were to compare available structural models supposed to underline POC and to develop and validate a French version of questionnaire measuring POC in physical activity settings. Compared to the ten-factor correlated model or ten, nine, or eight first-order factors subordinate to two second-order factors different models, the five fully correlated factors model was found to better account for the factorial structure of the POC, which is consistent with research conducted by Paxton et al. and Dishman et al. [18, 39]. The POC questionnaire is provided in Appendix 1.

Several limitations to this research need to be addressed. First, the cross-sectional design that was used did not enable the observation of progression in SOC. Multigroup invariance was not tested across a number of characteristics such as BMI, tobacco status, and age due to low sizes of specific samples. To test such multigroup invariance, a minimum of 250 subjects per group should have been necessary [43].

Our sample's stage distribution showed an overrepresentation of people in M in comparison with distributions observed in previous studies [44]. Future research should refine the French SOC algorithm. Methodological considerations showed that an algorithm with more precise definition of PA resulted in larger numbers of individuals staged in PC and C [45].

We conclude that this French version of the POC can provide valid assessment of TTM POC in physical activity. Specifically, the French POC questionnaire measure showed internal consistency and construct validity similar to Paxton's revised scale. Nonetheless, future research is needed to explore the longitudinal invariance and to assess the POC construct among diverse populations. The identification of a unique POC model stays a future issue. Two important ways need to be developed. First, matching the existing data could provide the possibility to compare AIC and Bayesian information criterion indices between the competing models. Second, testing the invariance of the models across different languages and cultures could promote the emergence of a unique POC model. Moreover, validating the other dimensions of the TTM (i.e., decisional balance, temptation, self-efficacy) would permit to explore the temporal sequencing of TTM constructs in longitudinal studies.

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