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Automaticity facets applied to screen-time sedentary behaviours and active commuting measured by accelerometers

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ABSTRACT

Background: The time adults spend sitting in front of screens is a health risk factor. In contrast, walking and cycling to and from work, also known as active commuting, could promote physical activity and improve population health.

Objective: This study investigated automatic properties role in explaining active commuting and screen-based sedentary behaviours. The stable, daily conditions for carrying out active commuting and screen-based sedentary behaviour are most likely to develop automatic properties. These characteristics mean performing behaviours via external cues (i.e. lack of intentionality), with an unpleasant emotional experience of not carrying out a set routine (i.e. lack of controllability), and without paying much attention (i.e. efficiency).

Method: This article describes findings of a prospective and correlational study in which 128 people participated. First, participants responded to questions assessed using the Generic Multifaceted Automaticity Scale (GMAS), which measured the automatic properties of screen-based sedentary behaviour and active commuting. The following week, both behaviours were assessed by daily logs to document active commuting and screen-based sedentary behaviour events, and by an accelerometer, worn for seven days, as an objective criterion. Confirmatory factor analyses, bivariate correlations, and multiple linear regressions were computed for the associations between the GMAS scores and objective criterion measures of screen-based sedentary behaviours and active commuting.

Results: Automaticity facets displayed different relationships with screen-based sedentary behaviours and active commuting – people with higher lack of intentionality and lack of controllability for active commuting present higher levels of moderate physical activity. In contrast, the lack of controllability of screen-based sedentary behaviours was a significant predictor of sedentary screen time.

Conclusions: The multidimensional approach to automaticity could be useful in determining more precisely the features that need to be addressed to promote the adoption of active commuting and limit the time spent sitting in front of screens.

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It is unquestionable that physical activity contributes to good health (Ekelund et al., 2016). Recent research suggests that sedentary behaviour—defined as time spent sitting or reclining while awake, with low energy expenditure (Sedentary Behaviour Research Network, 2012)—might be linked to an increased risk of depression when this behaviour is associated with screens and exceeds two hours per day (Wang, Li, & Fan, 2019). In the case of physical health issues, sedentary time accumulation increases the cardiometabolic risk (Bellettiere et al., 2017). Time spent watching screen-based entertainment is the most critical indicator of non-occupational sitting behaviour (Clark et al., 2010). Adults can spend two hours per day sitting in front of screens in their free time (Yang et al., 2019). When television – and screen-based activity exceeds four hours per day, mental health is poorer (Hamer, Stamatakis, & Mishra, 2010). Also, television time has proven to be the most advantageous self-report measure of sedentary time (Chastin et al., 2018). As for physical activity behaviours, active commuting—defined as any form of human-powered transportation (e.g. walking and bicycling)—is one of the most widespread physical activities of moderate intensity (Prince, Butler, Rao, & Thompson, 2019). Active commuting could be incorporated relatively easily into everyday lifestyles (Yang, Panter, Griffin, & Ogilvie, 2012) in neighbourhoods and cities where there are safe and convenient cycling paths (Bourke, Craike, & Hilland, 2019; Pucher & Buehler, 2010). Also, active commuting enables an adult to gain health benefits associated with exercise (Flint, Webb, & Cummins, 2016; Soares-Miranda et al., 2011) and increases adherence to physical activity recommendations (Berrigan, Troiano, McNeel, DiSogra, & Ballard-Barbash, 2006).

Consequently, understanding relevant determinants of screen-based sedentary behaviours and active commuting is crucial to reducing screen time (Biddle et al., 2017) and increasing physical activity levels (Guthold, Stevens, Riley, & Bull, 2018) in the contribution towards a healthier lifestyle. With this objective, volitional factors have been proposed to explain the adoption (i.e. intentions; Ajzen, 2002) and maintenance of these behaviours (e.g. self-efficacy and action control; Sniehotta, Scholz, & Schwarzer, 2005). Nevertheless, this approach has often obtained modest results (Conn, Hafdahl, & Mehr, 2011), mainly because the effectiveness of interventions based on these theories to promote physical activity would be overestimated due to methodological weaknesses and the duration of the interventions (Bernard et al., 2017). For this reason, some authors have recently advocated that the challenge for behaviour change should emphasise behavioural strategies over cognitive strategies (Conn et al., 2011) and targeting automatic processes such as habits (Marteau, Hollands, & Fletcher, 2012).

The context stability and behavioural repetition facilitate habit formation, which is characterised by its automaticity (Lally, Van Jaarsveld, Potts, & Wardle, 2010). Bargh (1994) broke down this cognitive process into four features: (a) lack of awareness; (b) lack of intentionality; (c) low degree of controllability; and (d) efficiency. The lack of intentionality means that behaviour is triggered by the stimuli in their environment and not by conscious intentionality. For example, a habitual bicycle user may realise that she/he takes her/his bicycle without making an effortful decision to go to work, and a person who regularly watches TV comes home after a day's work and turns on the TV immediately without reflection. The lack of controllability refers to capturing the aversive affective experience of not adhering to a set routine. For instance, a regular runner will not need to continually check how much time he/she has left to complete his route, and a TV viewer may experience some difficulty in not turning his/her TV on while sitting in front of it. Efficiency is the extent to which a mental process occurs even when attention is directed elsewhere. In this case, the habitual bicycle user may be able to mentally list things to do during the day while getting to work, and a TV viewer could drink or eat in front of the TV. It would not be straightforward to measure a lack of awareness with questionnaires (Sniehotta & Presseau, 2011). For lack of awareness in active transport, we would have to imagine that a person who is going to ride a bicycle has suddenly done so, wondering what this person is doing by taking the same route to work by bike on a Sunday. In the case of those who sit and watch television in their free time, the lack of awareness could imply the focus away from oneself; it would be difficult to recall it by questionnaires.

One of the self-report measures used to study the concept of habit is the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003). However, this scale does not allow independent evaluation of automaticity, as it includes the frequency of behaviour and identity. The frequency may contribute to increasing observed associations between habit scores and behaviours (Gardner, de Bruijn, & Lally, 2011). SRHI associates repetition, which is a prerequisite for habit, with automaticity, which is a problem because mere repetition does not guarantee habitual performance (Armitage, 2005). Moreover, this may contribute to an overestimation of the link with behaviour. Also, this scale includes a measure of identity, which does not appear to be a necessary characteristic of usual behaviour. This limit led Gardner and collaborators (Gardner, Abraham, Lally, & de Bruijn, 2012) to adapt the SRHI by saving automaticity items (SRBAI; Gardner et al., 2012). However, these scales are one-dimensional and do not capture the facets described above.

Despite these limitations, the number of studies conducted with the SRHI encouraged Gardner et al. (2011) to conduct a meta-analysis in the context of various health-related behaviours including diet, physical activity (e.g. active transportation), and sedentary behaviour (e.g. typical television or computer viewing). The studies included were prospective and had a cross-sectional design, and they measured behaviours by questionnaires. There were medium to strong correlations between habit and behaviour ($r = .46$). Five studies were interested in global physical activity in university students ($r = .43$) and two in sedentary behaviours in high-school students ($r = .47$). Habit-behaviour correlations in the domain of active commuting were significantly stronger ($r = .65$). Overall, the results of that study showed that people with a stronger habit of television or computer viewing reported higher levels of TV watching and computer use (de Bruijn & van den Putte, 2009; Kremers & Brug, 2008). Similarly, strong active commuting habits were associated with a higher percentage of people cycling (Gardner, 2009), active commuting duration (de Bruijn & Gardner, 2011; de Bruijn, Kremers, Singh, Van den Putte, & Van Mechelen, 2009), or frequency (Lemieux & Godin, 2009). Also, stronger habits of physical activity represent higher levels of moderate physical activity (Grove, Zillich, & Medic, 2014).

Although there is convincing evidence that the automaticity characteristics of physical activity and sedentary behaviour represent a significant predictor of the level of behaviour, few studies have examined the facets of automaticity in these contexts. For example, recent research reported stronger relationships between the facets of the lack of intentionality and lack of controllability compared to efficiency (Boiché, Marchant, Nicaise, & Bison, 2016). In the case of screen-based sedentary behaviours, habit automaticity was associated with television time through decreased perceptions of controllability (de Bruijn & van den Putte, 2009).

In the present study, we examine whether automaticity and its facets, assessed by the Generic Multifaceted Automaticity Scale (GMAS; Boiché et al., 2016) for active commuting and screen-based sedentary behaviours, were positively correlated with objective measures of behaviours as validation criteria. We expected that the lack of intentionality and lack of control for active commuting would correlate with moderate physical activity measured by accelerometry. Further, we expected that automaticity for screen-based sedentary behaviours would correlate with sedentary behaviour measured by accelerometry.

Method

Participants and procedure

The sample for this study was composed of 128 adults aged 35.11 (SD=12.32) years living in the city of Lyon, France, during the study period (from October 2016 to March 2017), who responded to an invitation. There were two recruitment strategies: (1) in-person or active recruitment (i.e. face-to-face distribution of flyers) in high-traffic areas (e.g. public libraries), and (2) mediated passive recruitment (i.e. postings in public places). There were tear-off tabs which potential participants could remove from the bottom of the flyer and use to contact study staff or learn more about the study. Thus, the people interested in the study contacted the research team. The members of the research team then organised meetings with these people. These meetings were held in the laboratory or at their workplace. In this way, interviews determined whether the potential participants met the following inclusion criteria: (a) healthy adults aged 18 years or more, (b) living a typical week during the post-interview week (i.e. no holidays or days off from work), and (c) available to wear an accelerometer and fill a daily log. Next, individuals signed consent forms. From that moment on, individuals were considered to be participants in the study. Then, they answered the first questionnaire in paper format on socio-demographic variables (i.e. age, gender, civil status, and level of education) and whether they practised sports in their leisure time (Table 1). Eligible participants also completed two automaticity questionnaires in paper format: one about screen-based sedentary behaviours and another related to active commuting. In the following week, the participants wore an accelerometer. Each participant wore the device for at least 10 h per day over seven consecutive days, and they completed daily log sheets recording their activities. Participants removed the accelerometers when they went to sleep and during any water-based activity.

Ethical considerations

The Institution Ethics and Review Board approved the study (2218452v0-CNIL), and it was carried out by the French methodological reference MR-001. This reference indicates that each participant must be informed of the purpose of the research. The duration of the study was clarified. Participants were assured that the results would be used only for this study and that their privacy would be guaranteed. Participation was voluntary, and after signing the written informed consent, each person was considered a study participant.

Table 1. Selected sociodemographic, physical activity, and sitting-related characteristics of the sample.

	Frequency(%)	Means (*SD*)
Age, years		35.11 (12.32)
<25	34(27)	
25-45	73(57)	
>45	21(16)	
Women	70 (55)	
Civil status		
Single	33(25.8)	
Couple	85(66.4)	
Cohabitation	7.8(7.8)	
Diploma		
No diploma	1(0.8)	
Primary school	4(3.1)	
High-school	26(20.3)	
University	97(75.8)	
Sport practice		
Yes	93(72.7)	
No	35(27.3)	
Type of sedentary leisure activity		
Reading	25(19.5)	
Watching tv	24(18.8)	
Playing electronic games	4(3.1)	
Computer(i.e. internet, series, movies)	61(47.7)	
Unspecified	14(10.9)	
Automaticity of Screen-based sedentary behaviours		3.67(.97)
Lack of intentionality		3.75(.82)
Lack of controllability		2.61(.93)
Efficiency		3.67(.90)
Automaticity of Active Commuting		3.63(.65)
Lack of intentionality		4.10(.91)
Lack of controllability		2.85(1.04)
Efficiency		3.87(.90)
Accelerometer		
Screen-based hours per day in sedentary behaviour [a] (*n*=75)		2.5(2.3)
Screen-based sedentary behaviours per day [a]		3.4(1.81)
Active commuting [a] minutes/day (*n*=84)		
Active commuting behaviours per week		3.7(1.83)
Light Physical Activity minutes/day		39.28(58.63)
Moderate Physical Activity minutes/day		49.04(57.99)
Vigorous Physical Activity minutes/day		3.64(10.20)
Steps counts per day		8364.88(11054.92)

Note: Valid days are defined by convention as those with ≥ 10 h wear-time.
[a] Detailed-log + Troiano algorithm used data from participant logs that make use of date, type of activity, and time (hour, minute, Am/Pm) that the monitor was put on and off.
SD= Standard Deviation.

Measures

Automaticity

Automaticity was measured by nine items of the Generic Multifaceted Automaticity Scale, a validated scale in French (GMAS; Boiché et al., 2016). This instrument assesses three dimensions of automaticity – Lack of intentionality, Lack of controllability, and Efficiency – with three items, each one. For example, one item for lack of intentionality of active commuting was, 'To make my way from home to university/work by adopting an active transport is something [that I do instinctively, no need to mark it down in my agenda].' For sedentary behaviour, it was, 'Sitting to watch TV or computer during my leisure time is something [that I do instinctively, no need to mark it down in my agenda].' In the case of lack of controllability for active commuting, an example of one item was, 'To make my way from home to university/work by adopting an active transport is something [that makes me feel weird if I do not do it].' For sedentary behaviour, it was, 'Sitting to watch TV or computer during my leisure time is something [that makes me feel weird if I do not do it].' For the efficiency facet, an example of an item of active commuting was, 'To make my way from home to university/work by adopting an active transport is something [which I do not have to focus on to do properly].' For sedentary behaviour, it was, 'Sitting to watch TV or computer during my leisure time is something [which I do not have to focus on to do properly].' For each item, participants used a Likert scale, selecting a response ranging from 1 'Strongly disagree' to 5 'Strongly agree.'

Objective physical activity and sedentary behaviour criterion measures

An accelerometer (Actigraph 3-GTX ®) was used to measure physical activity and sedentary behaviour time. Accelerometers measured movement in 1-second epochs in order to capture the sporadic nature of the physical activity and short bouts of sedentary behaviour. Troiano, Berrigan, and Dodd (2008) cut-points were used to quantify accelerometer data sedentary behaviour (sedentary; 0–99 counts/min), light physical activity (100–2019 counts/min), moderate physical activity (2020–5998 counts/min), vigorous physical activity (5999–above) and steps counts. Participants filled out a log that indicated the time they wore the device each day along with their screen-based sedentary behaviours (e.g. TV or computer viewing) and active commuting activities (e.g. walking to work).

Data analysis

The initial sample responded to GMAS active commuting (N=128) and GMAS screen-based sedentary behaviours (n=126) questionnaires. In order to verify the dimensionalities of the GMAS for active commuting and screen-based sedentary behaviours, confirmatory factor analyses, using R lavaan package (Rosseel, 2012), were performed. Out of the initial sample, only participants who wore the accelerometer for at least four weekdays and one weekend day and provided data on daily active commuting logs (n=84), and screen-based sedentary behaviours logs (n=75) were included in the physical activity and sedentary behaviour levels examination. The analysis of the daily log was carried out to determine who declares to adopt the screen-based sedentary behaviours and active commuting and also to identify specific times spent on each behaviour during the various seasons of the year. The detailed log and algorithm used the date of wear from participant logs, daily activities, and time on/off from the respective algorithm.

Daily logs provide an efficient means of documenting events and situations (Pettee, Tudor-Locke, & Ainsworth, 2007) that lead to artefacts in the records and allow the development of scoring procedures that restrict algorithm scoring to documented active commuting and screen-based sedentary behaviours. A series of t-tests were conducted in order to compare the levels of behaviours measured among included and excluded participants, between genders and seasons of the year. There were 40 participants in spring, 5 in summer, 13 in autumn, and 26 in winter. In order to harmonise size samples in season variables, we created two groups: hot seasons (i.e. spring and summer participants, n=45) and cold seasons (i.e. autumn and winter participants, n=39).

Bivariate correlations were run in order to identify the relationship between automaticity and physical activity/sedentary behaviour measured by an accelerometer, considering

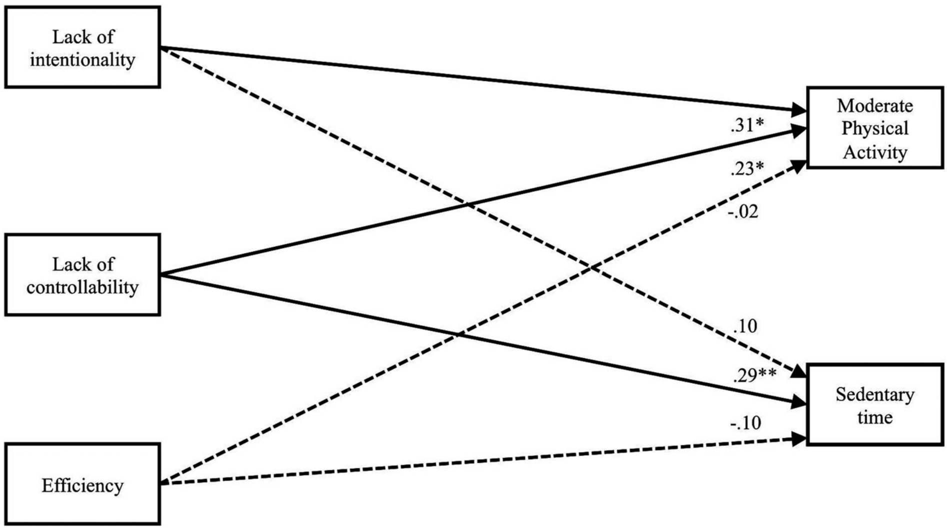

Figure 1. Path model of automaticity facets of active commuting and screen-time sedentary behaviour, predicting objective measured physical activity and sitting time. Active Commuting sample (n= 84); Screen-based sedentary behaviour sample (n= 75). * $p \leq .05$; ** p [?] .01.

only the times declared in the logs to calculate the accelerometer algorithms and obtain the specific times for each behaviour. Multiple linear regression was computed with GMAS facets scores for active commuting and screen-based sedentary behaviours as predictors of the accelerometer physical activity and sedentary behaviour, respectively. A path diagram displays the results (Figure 1).

Results

Preliminary analyses

Table 1 summarizes the sample distributions of age categories, sex, automaticity and the objective criterion for physical activity, active commuting, sedentary behaviour and screen-based sedentary behaviours. Participants had high levels of education (76%), were in a couple (66%), reported to practice a sport (72%) and had a sedentary screen leisure activity (71%). They were, on average, highly sedentary (9.58 h/day sitting) and physically inactive (100 min/week physical activity). The daily logs showed that 84 persons adopted active commuting, and 75 adopted screen-based sedentary behaviours. There were significant ($p \leq .05$) differences in light physical activity, moderate physical activity and steps count (Student's t-test) between participants who adopted active commuting and participants who did not adopt them. There was no significant difference in screen-based sedentary behaviours time between participants who adopted them and participants who did not adopt screen-based sedentary behaviours (Table 2). Participants who adopted such behaviours showed higher levels of light physical activity, moderate physical activity and steps count as efficiency as well. People who adopted screen-based sedentary behaviours had higher scores in the lack of intentionality category.

For the gender variable, the results showed that there were no significant differences between women and men in physical activity levels: light physical activity (Women

Table 2. Student *t*-test Results Comparing Participants Who Adopted Behaviours on Automaticity facets and Accelerometer outcomes.

	Adoption (*n*=84)		No adoption (*n*=44)		95% CI Mean difference				
Active commuting	*M*	*SD*	*M*	*SD*			*p*	*t*	*df*
Automaticity	3.61	0.65	3.62	0.71	−0.24	0.27	0.91	0.11	126
Lack of intentionality	4.10	0.91	3.97	0.81	−0.46	0.20	0.42	−0.82	126
Lack of control	2.85	1.04	2.83	0.91	−0.38	0.33	0.88	−0.15	126
Efficiency	3.88	0.90	4.08	0.82	−0.11	0.51	0.21	1.26	126
Screen-based sedentary behaviour	Adoption (*n*=75)		No adoption (*n*=53)						
Automaticity	3.29	0.59	3.30	0.74	−0.22	0.25	0.91	0.11	124
Lack of intentionality	3.67	0.82	3.81	0.95	−0.19	0.46	0.41	0.82	124
Lack of control	2.57	0.88	2.47	1.07	−0.44	0.24	0.57	−0.55	124
Efficiency	3.63	0.89	3.64	1.01	−0.34	0.35	0.97	0.04	124
Accelerometer time in minutes per week [a]									
Light Physical Activity	589.61	174.67	504.34	126.60	−138.70	−31.83	<.001	−3.16	126
Moderate Physical Activity	448.97	143.76	334.64	101.62	−157.76	−70.90	<.001	−5.21	126
Vigorous Physical Activity	45.97	42.95	37.59	54.37	−27.20	10.44	0.38	−0.89	126
Steps counts per week	84892.3	43487.1	59005.5	19853.8	−36990.3	−14783.2	<.001	−4.614	126
Sedentary time	4310.01	1961.82	3646.71	2228.13	−1412.85	86.23	0.08	−1.75	126

[a] Variables standardized to device wear time.

$M_{minutes/week}$ = 588.89, *SD* = 154.46 vs Men $M_{minutes/week}$ = 590.51, *SD* = 199.63, t(82) = 1.83, *p* = .96), moderate physical activity (Women $M_{minutes/week}$ = 446.02, *SD* = 152.16 vs Men $M_{minutes/week}$ = 452.71, *SD* = 134.29), *t*(82) = 0.19, *p* = .83), vigorous physical activity (Women $M_{minutes/week}$ = 47.90, *SD* = 42.67 vs Men $M_{minutes/week}$ = 43.50, *SD* = 43.74, *t*(82) = 0.13, *p* = .64). Only step counts per week were significantly different between women (*M* = 10871.62, *SD* = 13923.97) and men (*M* = 5180.65, *SD* = 3925.35), *t*(82) = 11.23, *p* = .010.

Concerning seasons and active commuting, the results showed that there were significant differences in physical activity levels between hot (i.e. spring and summer) and cold seasons (i.e. autumn and winter). Those who participated in the study during hot seasons presented higher levels of light physical activity ($M_{minutes/week}$ = 624.50, *SD* = 200.23) than those who did in cold seasons ($M_{minutes/week}$ = 549.34, *SD* = 130.80), *t*(82) = 3.15, *p* < .01. People who adopted active commuting during hot seasons ($M_{minutes/week}$ = 407.99, *SD* = 131.06) practiced less moderate physical activity than people adopting active commuting in cold seasons ($M_{minutes/week}$ = 496.25, *SD* = 144.79), *t*(82) = 0.23, *p* < .01. Step counts per week were significantly different between hot seasons (*M* = 2927.29, *SD* = 2485.32) and cold seasons (*M* = 14639.03, *SD* = 13578.23, *t*(82) = 18.380, *p* < .001). There was no significant difference between hot seasons (*M* = 44.91, *SD* = 39.02) and cold seasons (*M* = 47.18, *SD* = 47.56, *t*(82) = 0.02, *p* = .81) in terms of minutes per week of vigorous physical activity.

Confirmatory factor analysis indicates a fair model fit for a 3-factor model of active commuting (*N* = 128) automaticity (χ^2 = 58.32, *df* = 24, *p* < .001; *RMSEA* = .10, 90% CI: .07 - .14; CFI = .96) as well as screen-based sedentary behaviours (*n* = 126) automaticity (χ^2 = 39.81, *df* = 24, *p* = 0.025; *RMSEA* = .07, 90% CI: .02 - .11; CFI = .93). The internal consistency indices (Cronbach's alpha and Jöreskog's rhô) were all satisfactory for active commuting (Lack of intentionality: α= .78, *ρ* = .78; Lack of controllability: α=.68, *ρ* = .71; Efficiency: α= .74, *ρ* = .74; Automaticity: α= .76, *ρ* = .87). For screen-based sedentary behaviours the internal consistency indices were also satisfactory (Lack of intentionality: α= .70, $\rho = .69$; Lack of controllability: α=.69, $\rho = .70$; Efficiency: α= .69, $\rho = .71$; Automaticity: α= .76, $\rho = .88$).

Relationship between automaticity and objective criterion measure of physical activity and screen-based sedentary behaviours

We observed significant and positive correlations between the automaticity of active commuting and moderate physical activity. In terms of the facets of automaticity for active commuting, there was a significant positive relationship between lack of intentionality and moderate physical activity. The same relationship was observed for lack of controllability and moderate physical activity. In the case of sedentary behaviour, there was a significant correlation between the lack of controllability facet and screen-based sedentary behaviours measured by an accelerometer (Table 3). In the case of people declaring active commuting, we found a positive and significant cross-correlation between lack of controllability for active commuting and sedentary time ($r = .21$, $p = .04$). Of concern for people declaring screen-based sedentary behaviour, there was a significant and positive association between efficiency for this behaviour and step counts ($r = .26$, $p = .03$). In contrast, the lack of intentionality for screen-based sedentary behaviour was negatively associated with time spent on light physical activity ($r = -.24$, $p = .04$). There were no significant associations between efficiency towards active commuting and between lack of intentionality and efficiency for screen-based sedentary behaviour.

Figure 1 shows model predicting moderate physical activity, and sedentary time from automaticity facets for active commuting sample and screen-based sedentary behaviours sample. Using the enter method regression, it was found that lack of intentionality (ß = .31, $p = .02$) and lack of controllability level (ß = .23, $p = .02$) explain significantly the variance in the value of moderate physical activity ($F(3, 80) = 4.38$, $p < .01$, $R^2 = .14$, $R^2_{\text{Adjusted}} = .11$). Concerning sedentary behaviour time, lack of controllability level (ß = .29, $p = .01$) explains significantly the variance in the value of this behaviour ($F(3, 71) = 2.83$, $p = .04$, $R^2 = .10$, $R^2_{\text{Adjusted}} = .06$).

Discussion

This work presented a prospective, correlational study of individuals' self-reported behavioural automaticity for active commuting and screen-based sedentary behaviours in predicting objectively measured physical activity and sedentary behaviour in the subsequent week. Three main results can be retained. First a multidimensional approach can be used to reliably measure active commuting and screen-based sedentary behaviours automaticity. Secondly, there were positive associations between automaticity facets and the time spent in moderate physical activity and sedentary behaviour measured by accelerometers. Third, the regression analysis suggested that different facets' lack of intentionality and lack of controllability of active commuting can predict moderate physical activity. In the case of screen-based sedentary behaviours, the lack of controllability predicts sedentary levels.

Overall, the global automaticity level of active commuting was positively and significantly related to moderate physical activity time. About the automaticity properties of active commuting, the lack of intentionality and lack of controllability were positively and significantly associated with moderate physical activity. One likely explanation for

Table 3. Pearson correlations (*r*) of Active Commuting and Sitting-Time Sedentary Behaviour for automaticity and accelerometer.

	GMAS				Accelerometer				
	1 AC/SB	2 AC/SB	3 AC/SB	4 AC/SB	5 AC/SB	6 AC/SB	7 AC/SB	8 AC/SB	9 AC/SB
1.Automaticity	1	.77**/.74**	.53**/.68**	.76**/.65**	.13/.20	-.04/-.19	.34**/-.09	-.02/-.11	.19/.04
2.Lack of intentionality		1	-.10/.25*	.67**/.31**	.07/.15	-.08/-.24*	.30**/-.17	.05/-.05	.19/-.06
3.Lack of controllability			1	-.05/.07	.21*/.30**	.05/-.09	22*/-.04	-.07/-.05	.10/-.09
4.Efficiency				1	-.03/-.04	-.07/-.06	.18/-.08	-.02/-.14	.10/26*
5.Screen-based SB					1	.06	.80**	.38**	.87
6. Light Physical Activity						1	.-.12	.07	.83
7. Moderate Physical Activity							1	.22*	.142
8.Vigorous Physical Activity								1	-.04
9.Steps counts									1

Note: AC= Active Commuting (*n*=84); SB= Sedentary Behaviour (*n*=75).
 * $p \leq .05$; ** $p \leq .01$.

the relation between automaticity—and its facets—for active commuting and objectively measured physical activity behaviours could be the fact that the times correspond to moderate intensities such as walking and bicycle (Prince et al., 2019). However, some studies have shown that when physical activity is measured with an accelerometer, cycling may be underestimated when it is compared with walking (Herman Hansen et al., 2014).

In terms of automaticity facets, on the one hand, the lack of intentionality reflects that people who present higher active commuting habits are no longer guided by intentions (Gardner, 2009). On the other hand, a strong lack of intentionality for active commuting could result from routinised responses to stable environmental cues (Verplanken & Orbell, 2003). Lack of controllability may be more related to sporadic and intermittent physical activity, such as walking. Active commuting requires the intention to commute but also has many automatic components (at least for the regular commuter); once active commuting has started, commuters are autonomous and very efficient through their lack of need for attentional guidance (Bargh, 1994). For this reason, the less people reflect on active commuting, the more time they spend on this behaviour (de Bruijn et al., 2009). For instance, Verplanken, Aarts, and Van Knippenberg (1997) suggested that the situation (e.g. weather) and available options (e.g. comfort) may mediate the choice of a travel mode. In our study, regarding active commuting, participants who presented a strong lack of intentionality and lack of controllability may have been engaged in minimal appreciation of situational cues and less information search concerning travel mode options because of their stable daily routines.

The weather conditions under which individuals participated in our study could be linked to people's comfort. Adopting active commuting in the hot season may not be comfortable, as people sweat and would need to consider, for example, adding clothing and showering implements (if facilities are available at their workplaces). Also, this would add more significant cognitive effort to the planning involved. These results showed that automaticity of habits in daily behaviours might lead to a narrow focus on the habitually chosen option, independent of the decision-maker's consideration set (Pieters & Verplanken, 1995).

Similarly, the lack of intentionality represents how stable the context is for people adopting active commuting (i.e. situation-specific habits) (Gardner, 2009) since a modification of this context would make them reflect again (Lally et al., 2010). These results showed that the facets of automaticity are strengthened when active commuting becomes a routine and is incorporated as a repeated activity in daily life (Verplanken & Melkevik, 2008). Also, the lack-of-controllability facet is experienced as an aversive affective experience of not adhering to a set routine. Concerning active commuting for work, this makes more sense since it is a behaviour that has stabilised and also represents an essential routine throughout the week during working days. In this way, this facet is developed and strengthened. This facet also could work for automaticity in some behaviours, such as flicking a TV switch or eating a cookie (high reward with less effort), creating a snap, reflexive judgement with less thought than blocked conscious rationality. In this study, no association was found between automatic properties and vigorous physical activity. This result could be due to the high commitment that this type of activity requires: the time, physiological effort and physical discomfort. It would, therefore, be more difficult to achieve a level of automaticity in active transport that is characterised by moderate physical activity (Prince et al., 2019).

In contrast, active commuting efficiency may not have a significant implication concerning the prediction of this behaviour. People who adopt active commuting can have high levels of efficiency since walking or cycling are often activities that involve low attention and cognitive resources, except when someone is learning it. Consequently, one could investigate what the elements are that trigger this type of behaviour, considering how active commuting behaviour is or can be implemented in people's lives.

Regarding the facets of automaticity such as sedentary behaviour related to screens in leisure activities, the lack of controllability facet for sedentary behaviour—was positively and significantly associated with sedentary time measured with accelerometers, and it was a significant predictor of screen-time. These results confirm that strong automaticity levels may influence behaviour through a decreased perception of controllability (de Bruijn & van den Putte, 2009). Our found correlation between lack of controllability and the objective criterion of sedentary behaviour has to do with one's ability to stifle or stop a process once it has started, or at least override its influence (Bargh, 1994). Just as with other complex mental phenomena, such as those involved in television viewing, social cognitive processes are comprised of both automatic and controlled processes. The uncontrollable nature of sitting in front of the television or using a computer may represent two things. First, it demonstrates that there is a goal about process present (i.e. watching TV or using a computer) and second, that it is not causal (i.e. time spent on sitting) (Moors & De Houwer, 2006). This condition is fundamental in the sedentary behaviour associated with screens because as long as there is no disruption, this behaviour can be prolonged. In other words, when habitual environments for performance change, habits cannot be cued by recurring stimuli (Wood, Tam, & Witt, 2005). Also, it should be considered that sitting is a less accessible cognitive representation of seated activities (Gardner et al., 2019). For this reason, the fact of associating the time seated in front of the screens allows for obtaining a proxy measurement of this behaviour (Clark et al., 2010).

Based on the observed correlations between physical activity levels and sedentary time, the present work further provides evidence that some individuals can present simultaneously high physical activity levels and sedentary time (Thivel et al., 2018). These results show that physical activity and sedentary behaviours are not opposites; these behaviours can coexist (Biddle, Marshall, Gorely, & Cameron, 2009). Additionally, the correlation between automaticity facets towards screen-based sedentary behaviours and light physical activity levels was negative, showing that certain psychological dispositions towards one type of behaviour may affect a different category of behaviour. This result goes in the same direction as the current evidence supporting the notion that sedentary behaviour displaces light physical activity (Mansoubi, Pearson, Biddle, & Clemes, 2014).

Perspectives, limitations, and future directions

The results of this study should be interpreted with caution, as the adoption of active commuting and screen-based behaviours is complex. Thus, approaches targeting the automatic properties of active commute and screen-based sedentary behaviours need to consider that these behaviours take place in such complex environments as cultures, cities, and families. These factors directly affect people's health and are closely related to the individual choices they can make about their behaviour. In this sense, contextual elements could be incorporated in order to understand better the cues that regulate an automatic process and the adoption of behaviours. Another aspect that should be explored is how the automatic properties of one behaviour could influence another behaviour. For example, in our study, screen-related sedentary behaviour shared an automatic property with physical activity.

The following limitations of our study should be kept in mind when interpreting our findings. First, the data for this study was a seven-day survey. This period enabled us to examine active commuting and screen-based sedentary behavioural patterns of a typical week, but further studies could examine these behaviours in more extended periods. Examining the behaviours over a longer period could have the particular benefit of measuring changes in health behaviours, such as physical activity and automaticity as possible predictor variables that might be associated with a change in this behaviour. Second, in line with previous research examining the relationships between the automaticity of behaviours and their adoption assessed objectively, the associations observed were modest. This result is expected since automaticity strength is distinct from the amount of physical activity, which is quantified by accelerometers. The correlations found between automaticity facets and objective criterion measures were lower compared to relationships with subjective criteria in terms of active commuting (de Bruijn & Gardner, 2011) and sedentary behaviour (de Bruijn et al., 2009; Kremers & Brug, 2008). This difference in the association could be because self-reported physical activity and sedentary behaviour levels could present social desirability and recall bias (Kang & Rowe, 2015). Third, although the goal was to examine screen-based sedentary behaviour, regardless of specific domains (e.g. work-related) or contexts (e.g. working on a computer), the generalizability of our findings would be limited to the validity of the GT3X for the assessment of specific types of sedentary behaviour across different domains.

Conclusion

This study is the first one in which the facets of automaticity are analysed and differently related to active commuting and screen-based sedentary behaviours measured by an objective criterion. We could confirmed that the GMAS is a useful, reliable, and valid instrument to measure the multidimensionality of automaticity in active commuting and screen-based sedentary behaviours contexts. The scale represents a valuable alternative to a one-dimension approach.

The benefits of changes in health behaviour, such as increased physical activity and reduced sedentary behaviour, are only achieved if the changes are sustained over the long term, becoming a habit (Hagger, 2019). In this study, active commuting and screen-related sedentary behaviours have been targeted, habits which could be promoted in one case and fought in the other. Thus, for the habit of adopting active commuting, to acquire its automatic properties and those of sedentary behaviour to reduce its power, two types of strategies should be considered. The first is the alteration of people's environment, and the second is the way individuals respond to environmental signals (Marteau et al., 2012). Interventions of this type require little or no conscious (i.e. intentional) involvement or automatic processes to change health-related behaviours and thus could be implemented at the population level. Taking the car instead of the bicycle usually requires less effort from the individual who has a car habit. The interventions to encourage the adoption of active commuting could consider making the car a less appealing option by increasing the effort required to use the car. For example, reducing car access to city centers, thus increasing the journey time, could increase walking or bicycle use. However, this must be accompanied by other modifications that facilitate the bicycles' use, such as relay stations where a person can leave their car and take a bike. Similarly, implementing bicycle paths should allow people to get to work in less time than if they chose the car. If these elements are combined, it will facilitate the repetition of the behaviour in a stable context (Verplanken & Orbell, 2003) and will eventually become automated enough to do so without thinking (Lally et al., 2010).

In terms of screen-based sedentary behaviours, a conducive environment should be created to eliminate the signals that trigger the adoption of these behaviours (i.e. alteration of the situation)—for example, removing televisions from bedrooms or the living room. Also, the incorporation of prompts to disrupt sitting time and increase physical activity could be useful (Keadle, Conroy, Buman, Dunstan, & Matthews, 2017). Another approach to developing automaticity in a new behaviour is to support new health behaviour in an existing habit. For example, flossing habits were most successfully established when people practised flossing immediately after brushing their teeth rather than before (Judah, Gardner, & Aunger, 2013). For sedentary behaviour associated with screens, it could be established that immediately after one hour of television, individuals should change their position by moving around the house or going for a walk in the neighbourhood.

Furthermore, understanding the determinants of screen-based sedentary behaviours and active commuting is an essential step in designing effective interventions to reduce sedentary behaviour and to incorporate physical activity in daily life. Our results would lead to different interventions to break screen-based sedentary behaviours or create habits of active commuting.

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