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Spontaneous organization in task-switching reflects self-reported polychronicity and media multitasking tendency

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ABSTRACT

Studies on media multitasking behavior and task-switching performance have yielded mixed results. The present preliminary study ($N = 40$) focused on task management, and not performance, by allowing participants to choose the switching frequency between tasks all along the experiment. This design revealed two different patterns of organization, with many participants choosing no variation at all and sticking to this organization throughout the entire experiment. We found no impact of organization type on performance. The participants who switched more often scored higher on polychronicity (i.e., preference for multitasking) and media multitasking scales. We did not find any relationship between executive functioning and task organization or media multitasking scores, but this result should be regarded with caution given the limited sample size. In broad terms, individuals tend to declare a media multitasking tendency in line with their spontaneous organization on multiple tasks, with more sequentially organized participants reporting lower media multitasking behavior. These results point to a seemingly global individual strategy to approach multiple tasks.

1. Introduction

For about a decade, media multitasking and its association with cognition have been a debated topic in the scientific literature. Multitasking refers to the completion of two or more tasks concurrently or by switching from one task to the other in a given amount of time (Salvucci et al., 2009). In media multitasking, at least one activity involves media use. This broad definition assimilates multitasking to a continuum, encompassing parallel activities classically referred to as *dual tasking* (e.g., driving while talking on the phone) as well as more sequential ones (referred to as *task switching*, e.g., reading an email while writing a paper). Performance-based measures of cognition in media multitaskers have yielded mixed results so far (for a review, see Uncapher and Wagner 2018). A significant proportion of these studies have investigated performance in task switching abilities, concluding either in a positive, negative or null relationship between media multitasking and task switching performance (e.g., Alzahabi and Becker 2013, Minear et al. 2013, Ophir et al. 2009).

Surprisingly, few studies have investigated spontaneous organization on multiple tasks. Except for a few exceptions (Damos, 1980; Damos et al., 1983), studies interested in self-organized multitasking remain historically scarce (Reissland and Manzey, 2016). Task management studies so far have generally focused on performance or constrained participants to adopt a given organization (e.g., Buser and

Peter 2012, Ie et al. 2012, Kievit et al. 2014), while it is known that instructions can alter performance and, thus, organization (Laguë-Beauvais et al., 2015). Classical task-switching experiments require well-calibrated designs to evaluate the effects of factors such as task preparation or task transition time on objective performance (Kiesel et al., 2010). To investigate if media multitasking is linked to a more general individual tendency to multitask, it seems reasonable to think in terms of natural organization rather than performance on multiple tasks. Some task-switching studies have tackled this issue, namely voluntary task switching (VTS, Arrington and Logan, 2004), where participants can choose which task to perform on every trial. Reissland and Manzey (2016) introduced a variant of this design, namely the Free-Concurrent Dual Task (FCDT) paradigm. This design allows participants to choose between two tasks to perform on every trial. Stimuli for both tasks are always presented, and only the selected task stimulus is updated on the next trial (see also Brüning et al. 2020). Using the FCDT paradigm, Reissland and Manzey (2016) identified three types of personal strategy in tackling multiple tasks. They characterized their participants either as *blockers* (i.e., adopting a sequential processing of the tasks), *alternaters* (i.e., shifting tasks on every trial), and *switchers* (i.e., a mixed organization between blockers and alternaters). If none of these groups showed any superiority in multitasking efficiency, this distinction is still informative on the existence of several individual preferred ways of processing multiple tasks. Manipulating the similarity between competing tasks, Brüning et al. (2020) used a similar subgroup distinction and showed that more flexible participants (i.e., heavier switchers) exhibited slightly better multitasking efficiency

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(i.e., higher number of correct responses in a given time in a dual-task block) when tasks similarity decreased. However, they also confirmed that individual strategies were very robust despite varying conditions of dual tasking, even if said strategies led to suboptimal performance (see also Nijboer et al. 2013). Despite these interindividual differences, the multitasking context (e.g., task availability) has been identified as an important factor influencing task organization: Fröber and Dreisbach (2017) showed that participants tend to switch less often between tasks when they can freely choose which task to perform all along the sequence, compared to a condition where a proportion of forced trials is introduced in the sequence. This repetition bias, well known in the literature on VTS (e.g., Arrington and Logan 2004), can be counterbalanced when repeating the ongoing task becomes too demanding (e.g., when the repeated task stimulus is presented after a delay, compensating the cost of switching; Mittelstädt et al. 2018, Monno et al. 2021). Taken together, these results on voluntary task switching suggest that despite different initial individual preferences, people are generally able to intuitively adapt their strategy to the multitasking context.

A parallel literature recently started developing on voluntary switching with media, finding that freedom to multitask (i.e., checking Facebook while studying) did not impair heavy multitaskers as much as lower multitaskers on a subsequent memory task (Kononova et al., 2016). Likewise, the introduction of a delay in a primary task (e.g., waiting for a web page to appear after clicking) increased multitasking behaviors, even though this led to performance decreases (Katidioti and Taatgen, 2014). One important clarification must be made here concerning what is defined as *multitasking*. On the one hand, some studies define heavy multitaskers as people exhibiting a general tendency to multiply ongoing tasks in a short period, or a preference to adopt this behavior, as measured by questionnaires (e.g., Kirchberg et al. 2015, Kononova et al. 2016). This general preference for multitasking will here be referred to as *polychronicity*, as defined by Poposki & Oswald (2010). The association of polychronicity and general multitasking performance is still unclear, since some older studies did not find significant correlations between these two notions (Ishizaka et al., 2001; König et al., 2005). This suggests that self-reported preference for multitasking and actual multitasking ability are not necessarily linked. On the other hand, some studies are specifically interested in multitasking *with media*. With a few exceptions (e.g., Kononova et al. 2016, Voorveld and Viswanathan 2015), media multitasking is also assessed through questionnaires rather than actual real-life observation. Ophir et al. (2009) developed the Media Multitasking Index (MMI), a widely used questionnaire assessing the propensity to use several media simultaneously. In this case, we will refer to heavy *media* multitaskers as people who tend to frequently combine different media. Research has reported that polychronicity could be correlated to media multitasking, although the association was sometimes weak (e.g., Magen 2017). Media multitasking has been associated with other cognitive predictors, including executive functions and immersive tendencies (i.e., how focused and involved people tend to become in tasks and mediated environments). Magen (2017) suggested that several aspects of executive functions mediated the actual tendency to multitask with media, such as higher impulsivity and inattention, as well as poorer monitoring, working memory, and planning. However, such links were not always found in the literature on media multitasking (e.g., null effect on working memory, Minear et al. 2013). Rubenking (2016) also investigated media multitasking while watching TV, and found that higher polychronicity, as well as higher immersive tendencies, predicted more frequent multitasking. The relationship between media multitasking and immersive tendencies is also unclear, since Wang et al. (2020) found that compared to a single media activity, multitasking induced a drop in self-evaluated immersion. Since most of its definitions include the terms of focus and involvement, immersion could represent an interesting candidate modulating cognitive control, which is supposed to be allocated in a more or less focused fashion in heavy vs low multitaskers (Lin, 2009).

Most of the previous findings rely on self-reported measures, and the influence of media multitasking itself on actual task management is still widely debated (Uncapher and Wagner, 2018). An open question is thus whether a person's tendency to multitask with media is reflected on his/her organization when facing multiple tasks, and if common cognitive predictors can be found in heavier multitaskers. This study aimed to assess if spontaneous organization on multiple tasks would reflect the individual self-reported tendency to multitask with media. Hence, we proposed a task-switching protocol in which participants could adjust the length of each task sequence before each block, without any instructions regarding their performance. Deciding before each block the sequence length is similar to the approach used by Nijboer et al. (2013), and allows to assess the long-term changes in individual local strategies. We hypothesized that individuals who naturally tend to switch tasks more often would report a higher preference toward multitasking in general (similar to Brüning et al. 2020, Exp. 2). Since multitasking with media so far has yielded mixed results in terms of performance in dual-task and task switching studies, we also hypothesized that removing the constraint of performance could lead participants to display a natural organization comparable to the one they spontaneously adopt with media. Therefore, our second prediction was that people with a higher propensity to alternate between tasks would also display a higher level of media multitasking. We investigated these two hypotheses by exploring the variations of organization in a short (i.e., block-level) as well as a longer time frame (i.e., throughout the entire experiment). Finally, since executive functions and immersive tendencies have been identified as potential candidates modulating multitasking, we investigated our participants' self-declared evaluations on these predictors.

2. Methods

2.1. Subjects

Forty undergraduate students (26 female) from the University of Lyon took part in the experiment ($M_{age} = 23.4 \pm 4.5$). They had a normal or corrected-to-normal vision, and all participants gave written informed consent to the study.

2.2. Materials and procedure

The experiment took place in a dimly lit room. The participants first completed the behavioral task programmed in OpenSesame (Mathôt et al., 2012), which included three subtasks (additions – words – targets). They used the 'A' and 'P' keys to indicate whether the result of a simple addition was even or odd, if the presented word was concrete or abstract, and if the target was on the left or the right side of the screen. Each task was presented eight times in a block, resulting in blocks of 24 items. For every 24 items, the program asked the participants how many items of each task they wanted to answer in a row (Fig. 1). This approach was adopted to maximize endogenous voluntary planning for a sequence of events and minimize on-line impulsivity in the face of every trial. It also prevented any contextual effects leading participants to always choose the easiest task. Participants completed 21 blocks of 24 items, including a practice block that was discarded from analyses, resulting in 20 length choices. Each stimulus remained on screen for a fixed duration of 2500 milliseconds (ms), and the response-stimulus interval was set to 1000 ms so every block lasted about 1.5 min, and the whole behavioral task was completed in approximately thirty minutes. There was a very low emphasis on performance instructions, the experimenter only asked the participants to fulfill the whole experiment.

Following the behavioral task, the participants rated each task difficulty and their overall motivation, then completed several questionnaires to measure immersive tendencies, general and media multitasking habits, as well as executive functioning. Immersive tendencies were evaluated through a short version of the Immersive Tendencies Questionnaire (ITQ - Witmer and Singer, 1998), allowing for calculating sev-

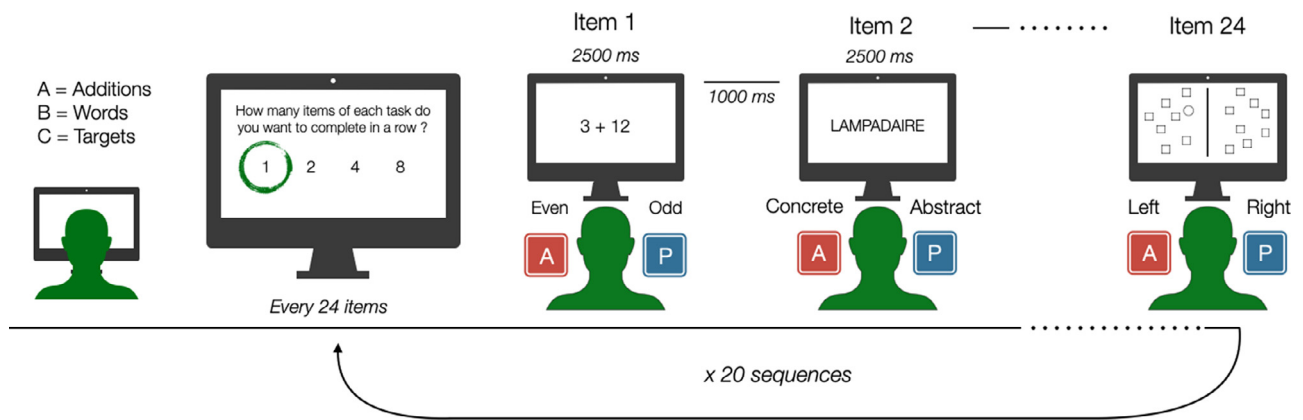


Fig. 1. Example of the behavioral task when the participant chooses to display 1 item in a row. A fixation dot appeared for 1000 ms between every item (not shown in the figure). Presentation times were fixed to discourage the participants from rushing through the experiment.

Table 1
Descriptive statistics as a function of experimental groups.

	Group	N	Acc	RT	Intra-block variation (range)	Inter-block variation (range)	Task difficulty (SD)	Motivation (SD)	Performance seeking (SD)
Intra-block variation	High	15	79%	950	3.77 (1–5.70)	8.47 (0–17)	2.73 (1.05)	5.73 (0.80)	6.2 (0.78)
	Low	25	78%	955	7.90 (6.45–8)	0.44 (0–6)	2.60 (0.81)	5.48 (1.30)	5.84 (0.90)
Inter-block variation	High	16	79%	962	4.69 (2.5–7.80)	8.63 (1–17)	2.63 (0.95)	5.25 (1.29)	6 (0.97)
	Low	24	78%	947	7.46 (1–8)	0 (0–0)	2.67 (0.88)	5.79 (0.98)	5.96 (0.81)

Acc: accuracy, RT: response time in milliseconds, SD: standard deviation.

eral subscores, namely involvement (tendency to become involved in activities), focus (tendency to maintain focus on current activities) and games (tendency to play video games). General propensity to multitask was evaluated through the Multitasking Preference Inventory (MPI - Poposki and Oswald, 2010), offering a measure of polychronicity (i.e., one's preference for doing several things at a time). The tendency to use several media at the same time was assessed thanks to the Media-Multitasking Index (MMI - Ophir et al., 2009). This questionnaire includes a measure of the simultaneous consumption of several media, as well as a quantitative measure of the amount of use per media (in terms of hours/week). Finally, executive functioning was assessed using the Behavior Rating Inventory of Executive Function – Adult Version (BRIEF-A, Roth et al., 2013), giving us self-reported evaluations of inhibition, self-monitoring, mental flexibility, emotional control, initiation, working memory, task monitoring, planning and organization.

2.3. Statistical analyses

Two types of indicators were computed. First, we computed a mean score of intra-block variation (i.e., the mean number of items in a row chosen by participants), which is a short-term indicator of organization between the three tasks within a sequence. Second, we calculated the inter-block variation (i.e., the number of different choices between the twenty blocks of the experiment) reflecting the long-term organization of participants.

3. Results

3.1. Group repartition and performance

Our sample was not normally distributed, with a majority of participants adopting a low variation threshold, hence Spearman rank-order correlations were used for the full sample analyses before splitting our population in two groups. In terms of intra-block variation, the *low variation* group was comprised of the participants who chose a mean number of items in a row ≥ 6 ($n = 25$), whereas the *high variation* group was comprised of the participants who chose a mean number of items in a row <

6 ($n = 15$; Table 1). Concerning the inter-block variation, the *low variation* group was comprised of the participants who never changed block organization throughout the experiment ($n = 24$) whereas the *high variation* group was comprised of the participants who changed at least once throughout the experiment ($n = 16$; Table 1). Note that our intra- and inter-block variation groups were quite similar, with only five participants displaying a different short- and long-term organization. Independent samples Student's *t*-tests compared *low* vs *high* groups for both intra- and inter-block variation on response time and accuracy and showed that performance was similar between our groups (all p s > 0.428). Subjective ratings of task difficulty, motivation, and performance seeking were also evaluated on a 7-point Likert scale, and did not differ significantly between groups (task difficulty: all p s > 0.655; motivation: all p s > 0.139; performance seeking: all p s > 0.205).

3.2. Task organization and multitasking questionnaires

Intra-block variation (short-term). The intra-block variation correlated positively with the MPI, but this correlation failed to achieve statistical significance ($r_{\text{Spearman}} = 0.213$, $p = .102$). The same pattern was observed for the MMI ($r_{\text{Spearman}} = 0.274$, $p = 0.087$). The group analysis confirmed the effect on MPI, with higher scores for the high variation group ($\text{MPI}_{\text{intra,high}} = 43.87$, $\text{SD} = 10.29$) compared to the low variation group ($\text{MPI}_{\text{intra,low}} = 36.88$, $\text{SD} = 7.22$; $t(38) = 2.52$, $p = .016$, $d = 0.82$; Fig. 2A). The MMI score was also higher for the high variation ($\text{MMI}_{\text{intra,high}} = 3.57$, $\text{SD} = 1.31$) group than the low variation group, even if this result failed to achieve significance ($\text{MMI}_{\text{intra,low}} = 2.95$, $\text{SD} = 0.94$; $t(38) = 1.746$, $p = .089$, $d = 0.57$; Fig. 2B). A binomial logistic regression with MMI and MPI as predictors of the intra-block variation was performed and explained 19.8% of the intra-block variation ($R^2_{\text{McFadden}} = 0.198$, $\chi^2 = 10.5$, $p = .005$). It is important to note that MMI and MPI scores were not correlated ($r_{\text{Pearson}} = -0.091$, $p = .578$).

Inter-block variation (long term). Bivariate correlations indicated a statistically significant relationship between inter-block variation and MPI ($r_{\text{Spearman}} = 0.349$, $p = .027$), and a non-significant but positive relationship between MMI and inter-block variation ($r_{\text{Spearman}} = 0.259$, $p = .107$). Considering groups, a significant difference was found between the



Fig. 2. Mean (SE) MPI scores (A) and MMI scores (B) as a function of intra- and inter-block variation. * Significant at $p < .05$.

inter-block variation groups for both MMI and MPI scores. The mean MMI was higher for the high variation group ($MMI_{inter_high} = 3.68$, $SD = 1.19$) than for the low variation group ($MMI_{inter_low} = 2.85$, $SD = 0.95$; $t(38) = 2.43$, $p = .02$, $d = 0.78$). The same result was found for the mean MPI ($MPI_{inter_high} = 43$, $SD = 10.37$; $MPI_{inter_low} = 37.17$, $SD = 7.38$; $t(38) = 2.08$, $p = .044$, $d = 0.67$). The same logistic regression as before was computed, with MMI and MPI as predictors of inter-block variation, which explained 21.6% of the overall variance ($R^2_{McFadden} = 0.216$, $\chi^2 = 11.6$, $p = .003$).

3.3. Other predictors

There were no correlations between task organization and measures from the BRIEF-A. Concerning ITQ, the mean number of items was only correlated with the ITQ_games subscale, i.e., tendency to play video games ($r_{pearson} = -0.34$, $p = .034$). However, the mean number of items was not associated with the number of hours spent playing video games in the MMI ($r_{pearson} = -0.02$, $p = .480$). There was also no correlation between questionnaires, except for a negative correlation between MMI and ITQ_Focus ($r_{pearson} = -0.33$, $p = .041$). A multiple linear regression was performed for the MMI score with all subscales from the ITQ as predictors and revealed no significant effect ($R^2_{adjusted} = 0.06$, $F(4, 35) = 1.69$, $p = .174$). Since all scales from the BRIEF-A were highly correlated together, we did not compute any regression model.

4. Discussion

This study was primarily designed to examine the relationship between media multitasking as self-reported behavior and actual multitasking on a computerized task. We specifically focused on the freely chosen organization by minimizing experimental demands to provide a more ecological situation.

Confirming the initial results of Reissland & Manzey (2016), we found that our task elicited two distinct types of behavior: either sticking to the longest possible task sequence for the whole duration of the experiment, or changing more or less frequently the length of the tasks. Interestingly, most individuals displayed the same type of strategies within and between the sequences, i.e., most people who chose the lowest possible variations in a sequence kept this organization throughout the whole experiment. This is directly in line with the results of Brüning et al. (2020) and Nijboer et al. (2013), emphasizing the stability of individual strategies. An interesting phenomenon is that our population was not normally distributed, with a majority of participants working in a strictly sequential fashion. It may be that our participants have intuitively chosen the more efficient strategy, even in the absence of performance instructions. However, there was no impact

of organization type on performance, suggesting that people spontaneously adopt the organization that best fits themselves to complete the task efficiently. Given the limited sample size, this assumption should be considered as preliminary and demands further investigation. The fact that we also did not find any differences between our groups in executive functioning, task difficulty, performance-seeking or motivation pleads for a trait, a personal preference independent of cognitive abilities or task characteristics. Thus, we might attribute the tendency to multitask to higher challenge seeking or faster and more intuitive 'system-1' decision-making (Kahneman, 2011), which is in line with previous work on media multitasking (Schutten et al., 2017). This finding is also consistent with the conception of polychronicity as a stable trait that can be displayed in all sorts of settings involving multiple tasks to complete, especially when there are few environmental constraints (Poposki and Oswald, 2010). The association between polychronicity and actual multitasking behavior was not always found, especially because of environmental constraints which sometimes dictate the actual behavior (Kirchberg et al., 2015; König et al., 2005). By allowing our participants to freely choose their organization, we reduced these environmental constraints. The five participants who did not display the same short- and long-term organization represent interesting profiles, maybe uncertain as to which organization they should adopt. This is not new since Nijboer et al. (2013) had already found that some participants needed many trials before finding the optimal strategy. Differential studies involving more participants could help comprehend these profiles.

The amount of media multitasking was significantly lower for participants who kept the same organization throughout the experiment. Although the difference was not statistically clear-cut, the same pattern of results was found for the short-term organization. These results seem to confirm that media multitasking habits could be associated with the organization in a way similar to polychronicity, even in the absence of differences in immersive tendencies or executive functioning. An expected result was that our task-switching paradigm did not totally reflect actual media use, presumably because multitasking with media does not generalize to all digital tasks, especially the ones which rely heavily on planning a sequence of events. Since our three tasks shared the same sensory modalities and elicited the same type of motor response, it is possible that they did not reflect participants' usual media multitasking behavior (Baumgartner and Wiradhyani, 2021). However, we found that media multitasking and preference for multitasking both explained a significant part of the variance in our groups.

Finally, even if this aspect of the research should be interpreted with caution given the limited sample size, we did not find any link between executive control and media multitasking as measured via the MMI. This is intriguing because researchers have previously found associations between executive problems and media multitasking (e.g.,

Baumgartner et al. 2014, Magen 2017), the absence of results in our study might be due to the fact that questionnaires such as the BRIEF-A probably represent a suboptimal way of assessing executive functioning. The only association we found was with the *Focus* subscale of the ITQ, confirming original findings by (Ophir et al., 2009) that heavier media multitaskers could be less efficient at filtering irrelevant distraction. These results stress further the observations of Uncapher & Wagner (2018) about the discrepancies in studies involving the MMI, possibly because the concept of media multitasking is more complex than an index score (Baumgartner and Wiradhany, 2021). In a similar way, self-organized multitasking may not have been optimally captured by our experimental paradigm. In real-life, we rarely decide of our organization for the next 24 items. Although this approach allowed us to maximize the appreciation of planning in the decision, it must be pointed out that real-life multitasking is often adopted in an on-line fashion, depending on many contextual factors (Katidioti and Taatgen, 2014). Furthermore, even if all evaluations of multitasking took place after the behavioral task, some participants may have tried to understand and comply with the experimenter's expectancies since the task was novel and unusual for them. Finally, a larger sample size could have led to improved group repartition, yielding stronger and more significant results. Future studies should consider developing and using more ecological paradigms, and finer-grained measures of media multitasking to assess individual multitasking behaviors more precisely.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Vivien Gaujoux: Conceptualization, Methodology, Software, Investigation, Data curation, Writing – original draft. **François Osiurak:** Methodology, Writing – review & editing, Supervision, Funding acquisition. **Emanuelle Reynaud:** Methodology, Writing – review & editing, Supervision.

Data Availability

Data will be made available on request.

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