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Exploring the variability of media multitasking choice behaviour using a network approach

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ABSTRACT

Many researchers have used the Media Multitasking Index (MMI) for investigating media multitasking behaviour. While useful as a means to compare inter-individual multitasking levels, the MMI disregards the variability in media multitasking choice behaviour: certain media combinations are more likely to be selected than others, and these patterns might differ from one population to another. The aim of the present study was to examine media multitasking choices in different populations. For this means, we employed a social network approach to render MMI responses collected in eight different populations into networks. The networks showed that the level of media multitasking as measured by the network densities differed across populations, yet, the pattern of media multitasking behaviour was similar. Specifically, media combinations which involved texting/IMing, listening to music, browsing, and social media were prominent in most datasets. Overall the findings indicate that media multitasking behaviours might be confined within a smaller set of media activities. Accordingly, instead of assessing a large number of media combinations, future studies might consider focusing on a more limited set of media types.

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1. Introduction

Media multitasking, the behaviour of consuming multiple media streams simultaneously or consuming one media stream while doing another activity, has become increasingly prevalent over the years (Rideout, Foehr, and Roberts 2010). It is thus not surprising that researchers have begun to investigate whether engaging in media multitasking frequently is related to potential difficulties in information processing and everyday functioning. With regard to everyday functioning, studies have found that heavy media multitaskers (HMMs) reported more problems related to executive function (Baumgartner et al. 2014; Magen 2017), and they reported increased levels of attentional lapses and mind-wandering (Ralph et al. 2013) in comparison to light media multitaskers (LMMs). However, with regard to the efficiency of information processing of media multitaskers, the findings have been mixed, with some studies reporting that HMMs performed worse in various performance-based tasks while others found no differences (Cardoso-Leite et al. 2015; Wiradhany and Nieuwenstein 2017), or even that HMMs performed better (Alzahabi and Becker

2013; Baumgartner et al. 2014). Reviews have also indicated that the findings have been mixed (van der Schuur et al. 2015; Uncapher et al. 2017), with meta-analyses showing weak associations between media multitasking and difficulties in information processing (Wiradhany and Nieuwenstein 2017) and everyday functioning (Wiradhany and Koerts, *forthcoming*).

While the mixed findings could be the result of statistical, small-study, or publication biases (Ioannidis 2005; Button et al. 2013; Wiradhany and Nieuwenstein 2017), it could also be the case that previous studies have been comparing different populations of media multitaskers. Indeed, previous studies have been using the Media Multitasking Index (MMI; Ophir, Nass, and Wagner 2009; Pea et al. 2012) computed from responses from the Media Use Questionnaire (MUQ) to distinguish HMMs and LMMs. MMI captures a broad range of media multitasking behaviour combinations, with the number of combinations varying from 36 (Moisala et al. 2016) to 144 (Ophir, Nass, and Wagner 2009; Wiradhany and Nieuwenstein 2017), and the types of combinations ranging from reading while listening to

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music to playing games while having a phone conversation. The basic idea underlying the MMI is that the concept of media multitasking is best captured by including all possible combinations of media activities and that on the individual level it does not matter whether someone multitasks frequently by listening to music while reading, or by watching television while gaming.

Given that the MMI has been used as a single overall score of media multitasking, little is known about the combinations of media underlying the score. Specifically, from the many media multitasking combinations assessed in the MMI, we do not know the number of combinations people typically engage in, and which media types are typically used for the primary activity or the secondary activity. Additionally, patterns of media multitasking might vary across populations. For instance, media multitasking behaviours among younger populations might differ from those among older populations, in that younger people use different types of media to multitask. To further shed light on the number and the types of media combinations that typically occur in media multitasking, and to investigate whether these combinations differ across populations, we reanalysed the responses from several MUQ datasets and rendered the responses into networks. Analysing the properties of these networks provides important insights into the media multitasking behaviours individuals typically engage in, and about potential differences in these behaviours across populations. This approach therefore provides a more nuanced view on media multitasking across populations. This is particularly important for establishing better measurements for specific populations.

1.1. Differences in media multitasking choice

Given the rather broad range of media multitasking combinations assessed in the MUQ¹, it is likely that specific media multitasking pairs are preferred over others. Moreover, it is also likely that from the many media multitasking combinations assessed in the MUQ, individuals only engage in very few media multitasking combinations. Lastly, certain types of media might be more likely to be consumed as a primary, others as a secondary activity. The preference for specific media multitasking combinations over others could stem from at least three possible sources: (1) it could be based on a strategic decision to reduce cognitive load, (2) it could be based on a preference to access emotionally gratifying media, and (3) it could be based on a general preference for specific media types that are used habitually.

With regard to reducing cognitive load, it has been established that the human cognitive architecture is not well-equipped for dealing with multiple things

simultaneously (Salvucci and Taatgen 2008; Courage et al. 2015). As a result, people develop different strategies to deal with interferences induced by multitasking (see for examples, Adler and Benbunan-Fich 2012; Salvucci and Bogunovich 2010). One of such strategies is to select media pairs which induce lower cognitive demands. Specifically, Wang et al. (2015) introduced 11 basic cognitive dimensions of media multitasking behaviours. They showed that the likelihood of media multitasking increases as the cognitive demands created within each dimension decrease. For example, they showed that media multitasking combinations which engage more sensory modalities and those with an overlap of used modalities are less frequently combined. Similarly, in a cross-sectional study, Carrier et al. (2009) found that participants preferred 'easy' (e.g. listening to music while eating) compared to 'difficult' media multitasking combinations (e.g. reading while playing video games), with 'easy' combinations involving fewer modalities compared to 'difficult' combinations.

With regard to emotional gratification, it has been discussed that people engage in media multitasking in spite of their awareness of its cognitive cost (Wang and Tchernev 2012; Bardhi, Rohm, and Sultan 2010). People media multitask because it creates an illusion of their ability to manage a vast amount of information efficiently (Hwang, Kim, and Jeong 2014; Bardhi, Rohm, and Sultan 2010), and because it provides emotional gratifications (Wang and Tchernev 2012). For example, when studying for school, young people may choose to simultaneously use social media in order to alleviate boredom experienced from the primary task and receive emotional gratification. This is in line with findings by Hwang, Kim, and Jeong (2014) who found that the main motivations for engaging in specific types of media multitasking are enjoyment, and social motives.

Lastly, some media multitasking combinations might occur as a part of habitual media consumption (Bardhi, Rohm, and Sultan 2010; Hwang, Kim, and Jeong 2014). That is, individuals engage most frequently in media multitasking with those media that they most frequently use (Voorveld and van der Goot 2013). For instance, Hwang, Kim, and Jeong (2014) reported that TV-based multitasking could be predicted by habitual motives. That is, in TV-based multitasking, TV was not actively consumed; it was turned on as a part of a ritualistic behaviour. Similarly, in an observation study, Rigby et al. (2017) reported that the TV was frequently turned on in the background while participants were performing other activities.

In sum, it is likely that not all possible types of media multitasking are equally frequently selected. More specifically, we assume that media multitasking

combinations that require lower cognitive demands (e.g. listening to music while browsing), are emotionally gratifying (e.g. accessing social media while listening to music), or are based on media activities that people frequently engage in (e.g. sending messages while watching TV) are more frequently selected than other media multitasking combinations.

Media multitasking combinations do also differ in terms of which media activity is perceived as primary or secondary activity. As in our description of the habitual TV consumption above, in a typical media multitasking situation one medium may function as the dominant activity on which most attention is focused while another medium is used as a secondary, less prioritised activity (e.g. Foehr 2006; Wang et al. 2015). This distinction is also made in the MMI in which each media activity is assessed both, as a primary and secondary activity. However, we still know little about which media activities are typically used as primary and which as secondary activities. Foehr (2006) found that particularly computer activities are used as secondary activities. In contrast, watching television and listening to music were frequently reported as primary activities. This is somewhat contradictory with common conceptualisations of TV, and listening to music as typical media background activities (Beentjes, Koolstra, and van der Voort 1996; Rideout, Vandewater, and Wartella 2003). The present study therefore aims at understanding in more detail which media activities are used primarily as primary and which as secondary media activities.

1.2. Differences in media multitasking across populations

As argued above, we assume that not all media multitasking pairs are equally frequently selected. However, the specific patterns of media multitasking that individuals engage in might also differ across populations. Studies on the effects of media exposure suggest that media multitasking prevalence differs as the function of audience factors (e.g. socio-economic status) and media factors (e.g. media and technology availabilities; Jeong and Fishbein 2007; Kononova and Chiang 2015). Indeed, for the latter, a cross-cultural survey has shown that media availabilities explained differences in media multitasking levels between U.S.A., Kuwait, and Russian nationals (Kononova et al. 2014). Similarly, in another study, types of media consumed (i.e. traditional, such as print media vs. newer media, such as internet browsing) explained differences in media multitasking levels between U.S. and Western European nationals (Voorveld, Segijn, and Ketelaar 2014). These results suggest that environmental factors play important roles in

explaining differences in media multitasking choices across populations from different countries.

With regard to audience factors, studies have shown an inverse relationship between media multitasking levels and age, likely due to the fact that the adoption rate of media technology is higher in youth (e.g. Bardhi, Rohm, and Sultan 2010). Voorveld, Segijn, and Ketelaar (2014) showed that after controlling for types of media use, younger people media multitasked more often than older people. Similarly, another survey with an U.S. national sample also reported that media multitasking was negatively correlated with age (Duff et al. 2014). Lastly, in a cross-sectional study, Carrier et al. (2009) showed that people who were born after 1978 multitasked using media 56% of their media time compared with people who were born between 1965 and 1978, and 1946 and 1964 who only multitasked 49% and 35.1% of the time, respectively. Interestingly, one diary study also reported that while indeed teenagers of 13–16-year-old media multitasked more often than other age groups, this group was followed by old adults of 50–65 years old (Voorveld and van der Goot 2013), indicating that the relationship between age and the frequency of media multitasking might not be linear.

Together, these findings suggest that not only the frequency of engaging in media multitasking but also the types of media multitasking individuals engage in might differ between one population to another as functions of media and audience factors. Specifically, younger populations and populations with greater access to media may have a higher likelihood to engage in media multitasking. Moreover, as social media are particularly popular among younger media users (e.g. Carrier et al. 2009; Duggan and Brenner 2013), it is likely that media multitasking with social media is particularly prevalent among younger populations. In comparison, older populations might be more likely to multitask with traditional media, such as print media and television (Voorveld and van der Goot 2013).

One major problem of these potential differences in media multitasking across populations is that if the actual media multitasking behaviour differs across populations, findings cannot easily be compared. Thus, even if two populations have similar MMI mean scores, the actual multitasking behaviour on which these means are based might be highly different.

These differences might partly explain why some studies did find effects while others did not.

1.3. The current study

The existing literature suggests that the number and the type of media combinations typically occurring in media

multitasking might vary across individuals and populations. In this study, we reanalysed eight datasets from published studies. Out of these we first compiled a large dataset of MUQ responses from Western European (i.e. The Netherlands), Northern American (i.e. U.S.A. and Canada), and Asian (i.e. Singapore & Indonesia) countries, then rendered the responses into networks. Analysing the properties of the networks will provide insights with regards to the profiles of media multitasking behaviour, as indicated by the types and priorities of media combinations and whether or not these profiles differ from one population to another.

2. Method

2.1. Media Use Questionnaire: structure and Index

The Media Use Questionnaire (Ophir, Nass, and Wagner 2009; Pea et al. 2012) is the most used measure of media multitasking to date (Baumgartner et al. 2017). The original questionnaire asks how often people consume two types of media simultaneously, over a combination of 12 different media using a Likert rating (0 = 'Never', .33 = 'A little of the time', .67 = 'Some of the time', and 1 = 'Most of the time' Ophir, Nass, and Wagner 2009). To illustrate, one block of questions with regard to television use would start with the media duration question 'How many hours did you spend watching television last week?' followed by several questions about the frequency of media multitasking with the primary medium, such as 'While watching television, how often do you also listen to music?' The media duration and media sharing proportion questions are then repeated across all media combinations and summed using the formula below:

$$MMI = \sum_{i=1}^j \frac{m_i \times h_i}{h_{total}}$$

where m is the sum score for media multitasking using primary medium i , h is the number of hours spent consuming primary medium i per week, j is the total number of media assessed, and h_{total} is the sum of hours spent consuming any of the 12 media.

Over the years, different versions of the MUQ have been developed to adapt with the current media landscapes (Baumgartner et al. 2014; Loh, Tan, and Lim 2016; Pea et al. 2012), but while the media types might slightly differ from one type of questionnaire to another, the questionnaire structure remains similar. Thus, each version of the MUQ allows for calculating a MMI. Importantly, however, interpreting the MMI could be problematic since two individuals with a similar MMI score could have highly differing media multitasking

behaviour profiles (Baumgartner et al. 2017; Cain et al. 2016; Ralph and Smilek 2016). For instance, two individuals with a similar MMI score could spend very different amount of times with each media activity (because for calculating the MMI, the proportion of media-sharing time is multiplied by the hours spent for media, and divided by the hours again upon summation). Similarly, someone who engages in a high amounts of non-adaptive media multitasking (e.g. playing games while watching television), and someone who engages solely in more adaptive types of media multitasking (e.g. reading books while listening to music) might end up having similar MMI scores. For these reasons, in our analysis, we used the information about the duration of time spent for using media and the proportion of time spent for media-sharing from the raw scores to construct our networks. This allows us gaining insights into both the absolute time people spent with different types of media, and the proportion of time they spent multitasking with different types of media.

2.2. Network analysis

In recent years, there has been an increased interest in the application of network analyses in social sciences (Scott 2011; Borgatti et al. 2009; Vera and Schupp 2006). Typically, network analysis was used for investigating social structures, by mapping such structures into a network of connected actors. Specifically, actors are mapped into individual nodes, and their relationships are mapped into connecting lines (edges). Thus, this method emphasises on the relationships between actors rather than the properties of the individual actor (Otte and Rousseau 2002). More importantly, by mapping the connections between actors, network analysis can help answer important questions related to the structure of the network (e.g. what is the level of connectivity among actors in the network), and questions related to the importance of the actors (e.g. which actor is the most connected, which actor serves as a connector between one with another). In social sciences, this method can be applied to reveal similarities, social relations, interactions, and flows of information among members of networks (Borgatti et al. 2009).

In this study, we constructed weighted, directed networks using network analysis to visualise and to analyse the types of media combinations and media use prioritizations in media multitasking using responses from the questionnaires. The networks were constructed by mapping different media types into different nodes, and time spent for consuming different types of media simultaneously into edges.

2.2.1. Network mapping

In this study, we mapped eight MUQ datasets from published studies (Alzahabi and Becker 2013; Baumgartner et al. 2014; Becker, Alzahabi, and Hopwood 2013; Loh and Kanai 2014; Ralph et al. 2013; Ralph et al. 2015; Uncapher, Thieu, and Wagner 2016; Wiradhany and Nieuwenstein 2017) into networks. Table 1 shows the characteristics of the datasets.

Prior to mapping the MUQ responses, we first removed responses from non-media activities (i.e. homework and face-to-face conversations). This decision helped us focus on media multitasking between two media-related activities only. We then mapped the media duration responses from the MUQ into network nodes and the proportion of media multitasking (i.e. the time spent for consuming two types of media simultaneously) into network edges. For the media duration responses, since different versions of the MUQ might use different time scales, we first standardised the responses into the hours spent for using media per day, and mapped the responses into nodes of varying sizes, with larger nodes reflecting a higher number of hours spent for one specific media per day. For the proportion of media multitasking, we calculated the mean of the proportion of media multitasking responses of each media pair for each dataset. Thus, each edge represents one dyad of two media which were simultaneously used. Sometimes, participants did not provide a response to a media frequency question. Thus, to ensure that these non-responses did not contribute to the calculated mean, they were treated as missing responses. Then, we mapped these means into network edges of varying thicknesses (0 = 'Never' to 1 = 'Almost always').

To visualise media prioritisations, we used the information with regards to primary and secondary media (e.g. watching television while listening to music has television as the primary media and music as the secondary media; listening to music while watching television has music as the primary media and television as the secondary media) and plotted directed networks with outgoing arrows indicating a pairing from a primary to a secondary media activity. Similarly, incoming arrows indicate that the specific media activity is used as a secondary activity in that specific pairing. This method allowed us to compare media uses as either a primary or a secondary activity.

2.2.2. Differences in media choice

To explore which types of media were used most frequently for media multitasking, we calculated the strength of each node in the network. The strength of a node is calculated as the sum of the edges connected to the node (Barrat et al. 2003), which reflected the

proportion of time for media sharing. Thus, stronger nodes reflected media types which were shared more often with others. To explore which types of media were used as either primary or secondary multitasking activity, the edge of each node was binned into outgoing and incoming edges, indicating the use of a particular media as primary or secondary activity, respectively.

2.2.3. Differences between populations

To compare the datasets, we first measured the weighted edge density of each network. Network density reflects the general level of connectedness within a network (Otte and Rousseau 2002). In a weighted network, density is shown as a gradient: a network with thinner, fewer edges is less highly connected while a network with more and thicker edges is highly connected. The weighted edge density is calculated as the ratio between the sum of the edges and the theoretical maximum sum of the edges. The theoretical maximum sum of the edges is calculated as the number of possible edges² times the maximum weight³ of each edge. The weighted edge density scores varied from zero to one, with scores closer to zero indicating that on average, in a typical media-consumption hour, fewer numbers of media are shared and scores closer to one indicating that on average a higher number of media is shared. This measure ensures comparability between networks, since different datasets have different numbers of featured media. These weighted edge densities were then compared between different datasets. Secondly, to further explore if media choices differ across different datasets, we also compared the three strongest nodes of each network. Lastly, we compare the datasets from the different regions of origin, and the dataset with exclusively adolescent participants to the other datasets, which were collected among university students.

All analyses were conducted in R using RStudio (R Core Team 2017). Networks were created using the *igraph* package (Csárdi and Nepusz 2006). The networks were rendered using the Fruchterman-Reingold algorithm which ensures evenly distributed nodes, uniform edge lengths, and minimal number of steps between nodes (Fruchterman and Reingold 1991). Other graphs were rendered using the *ggplot2* package (Wickham 2010).

3. Results

3.1. Differences in media choice

Figure 1 shows the rendered networks from different datasets. This figure provides several insights. First, the distribution of the network's edges is not uniform,

Table 1. Characteristics of different MUQ datasets.

Article	Location	Total N	Mean MMI ^a	Types of media assessed	Note
Baumgartner et al. (2014)	Amsterdam, The Netherlands [Western Europe]	523	1.92	Print media, Television, Video on a computer, Music, Video/computer games, Phone calls, Instant/text messaging, Networking sites, Other computer activities	Adolescent participants, 11–15 year olds
Wiradhany and Nieuwenstein (2017; Exp.2)	Groningen, The Netherlands [Western Europe]	205	4.14	Print media, Television, Video on a computer, Music, Non-musical audio, Video/computer games, Phone calls, Instant messaging, Text messaging, E-mails, Reading web pages/other electronic documents, Other computer applications	General population, mostly university students
Alzahabi and Becker (2013); Becker, Alzahabi, and Hopwood (2013)	Michigan, U.S.A. [Northern America]	450	4.13	Print media, Television, Video on a computer, Music, Non-musical audio, Video/computer games, Phone calls, Instant messaging, Text messaging, E-mails, Reading web pages/other electronic documents, Other computer applications	University students
Ralph et al. (2015; Exps 3–4)	MTurk [Northern America]	499	2.12	Print media, Television, Video on a computer, Music, Video/computer games, Phone calls, Instant/text messaging, Social Networking sites, Doing homework, Talking face-to-face	General population, mostly from U.S.A. (96.59%), 18–82 year olds
Loh and Kanai (2014)	Singapore [Southeast Asia]	153	3.12	Print media, Television, Video on a computer, Music, Video/computer games, Phone calls, Instant messaging, Text messaging, E-mails, Reading web pages/other electronic documents, Social networking sites, Other computer activities	University students
Uncapher, Thieu, and Wagner (2016)	Stanford, U.S.A. [Northern America]	143	3.65	Print media, Television, Video on a computer, Music, Non-musical audio, Video/computer games, Phone calls, Instant messaging, Text messaging, E-mails, Reading web pages/other electronic documents, Other computer applications	University students
Ralph et al. (2013); Ralph et al. (2015; Exps 1–2)	Waterloo, Canada [Northern America]	357	1.71	Print media, Television, Video on a computer, Music, Video/computer games, Phone calls, Instant/text messaging, Social networking sites, Doing homework, Talking face-to-face	University students
Wiradhany and Nieuwenstein (2017; Exp.1)	Yogyakarta, Indonesia [Southeast Asia]	148	5.66	Print media, Television, Video on a computer, Music, Non-musical audio, Video/computer games, Phone calls, Instant messaging, Text messaging, E-mails, Reading web pages/other electronic documents, Other computer applications	University students

^aThe mean of MMI was calculated from the graph using a method which corresponds to Equation (1). We first calculated the hour spent for each media type as indicated by the node size times the proportion of media sharing for each media dyads as indicated by the edge thickness attached to each node, then divide it by the total hour spent for all media types, as indicated by the sum of the node sizes.

indicating that certain types of media had a higher likelihood to be shared with others. Specifically, listening to music had the highest node strength, followed by browsing and texting. This indicates that listening to music is the media activity that is most frequently combined with other media activities (see Figure 2 for a comparison of network properties). Second, nodes with larger sizes, indicating the amount of time spent for consuming media are (1) located in the centre of the networks and (2) they have on average more edges than others. Indeed, node sizes and node strengths, as indicated by the number of connected edges, were positively correlated, $r(83) = .44, p < .001$, indicating that as the time for consuming one type of media increases, the likelihood to multitask with this type of media also increases. Third and lastly, the types of media located at the centre of the networks are relatively similar: combinations with music, texting, browsing, and social networking are prominent in the networks. Specifically, music was featured as one of the three largest node in 7/8 datasets and as one of the

three nodes with the highest multitasking proportion in 6/8 datasets; browsing was featured as one of the three largest node in 5/8 datasets and as one of the three nodes with the highest multitasking proportion in 3/8 datasets. Texting, if combined with IMing was featured as one of the three largest node in 6/8 datasets and as one of the threenodes with the highest multitasking proportion in 7/8 datasets (see Figure 2). This indicates the relative similarity⁴ of media multitasking behaviour across different populations.

Lastly, the strength of incoming and outgoing edges, was not significantly different, *Wilcoxon's* $V = 1819, p = .972$, indicating that participants use the different media types as primary or secondary activity interchangeably (see Figure 3).

3.2. Differences between populations

Overall, the rendered networks varied in density, with some networks showing an overall higher connectedness

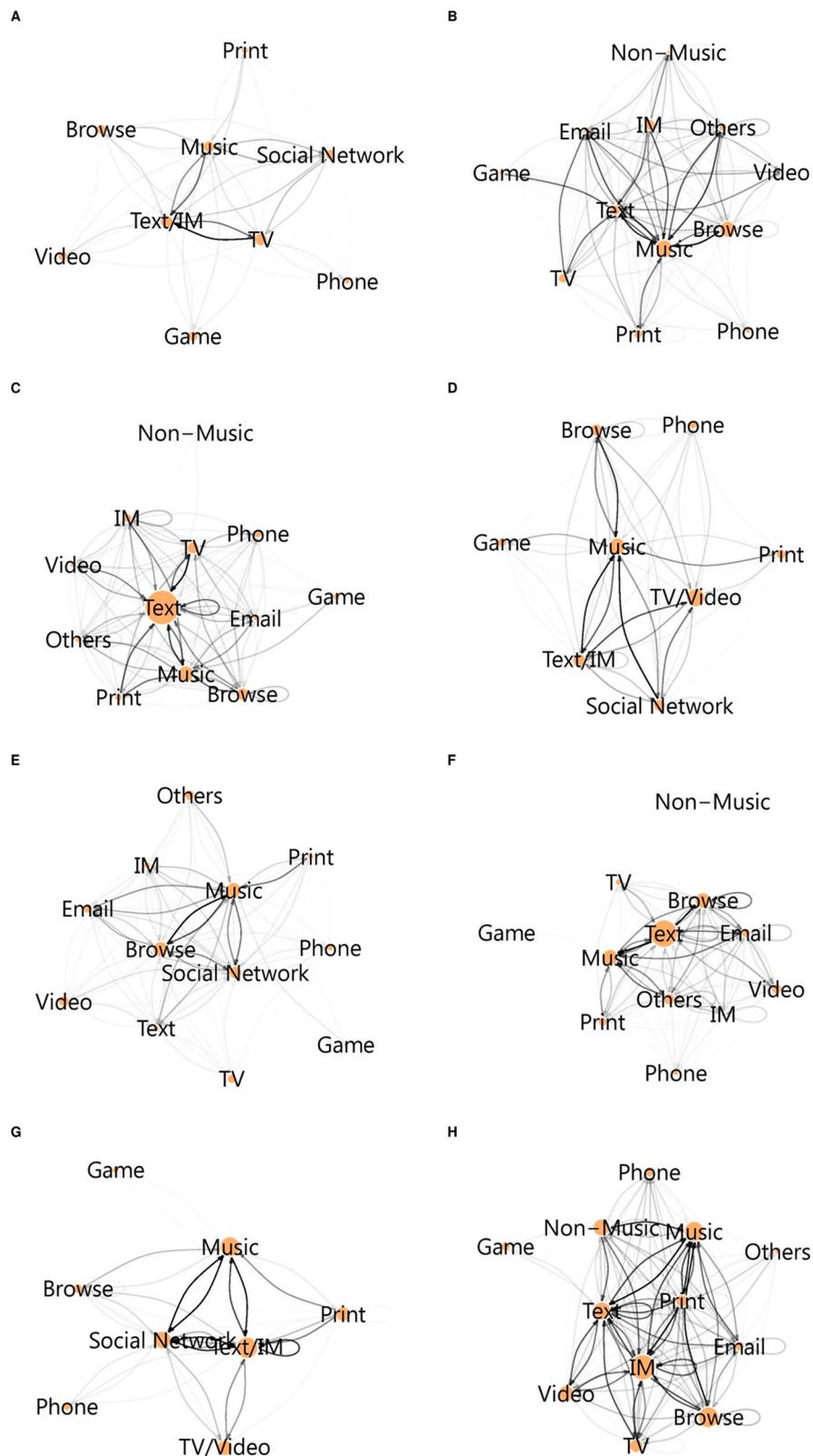


Figure 1. The rendered networks from datasets collected in different locations: A. Amsterdam (the Netherlands), B. Groningen (the Netherlands), C. Michigan (U.S.A.), D. MTurk, E. Singapore, F. Stanford (U.S.A.), G. Waterloo (U.S.A.), and H. Yogyakarta (Indonesia). The node size reflects hours spent per day for different media; the edge thickness reflects frequency pairs of different media.

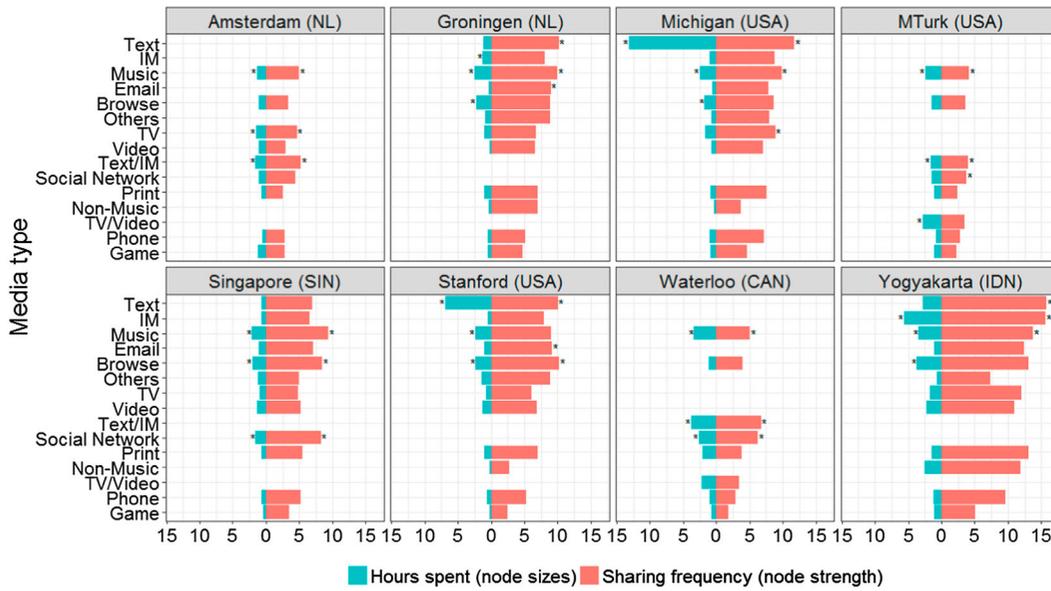


Figure 2. Summary of network properties. The blue bars indicate the hours spent for each media type and the red bars indicate the sum of the proportion of media multitasking. The asterisks indicate the three media types with the largest amount of hours spent and the three media types with the highest multitasking proportion in each dataset.

(as indicated by the strength of individual nodes and the overall edge density) than others, signifying different levels of media multitasking in different datasets. Specifically, the dataset collected in Yogyakarta (Indonesia) had the highest density score, $D = .97$ while the dataset collected using MTurk had the lowest, $D = .41$. Since network densities were calculated as the ratio between overall weight of a network and the maximum theoretical weight of the network, these results indicate that media multitasking frequency varies from one population to another.

We further tested if datasets collected within a similar region (i.e. North America, Southeast Asia, and The Netherlands) have similar density scores compared to datasets collected in a different region. We conducted a one-way ANOVA with density scores as the outcome variable and region as the predictor. The results showed that the density scores of datasets from different regions were not significantly different, $F(2,5) = 1.58, p = .294$. For instance, the datasets collected in the Southeast Asian region had both the highest density score and one of the lowest (i.e. Singapore, $D = .57$). With regard

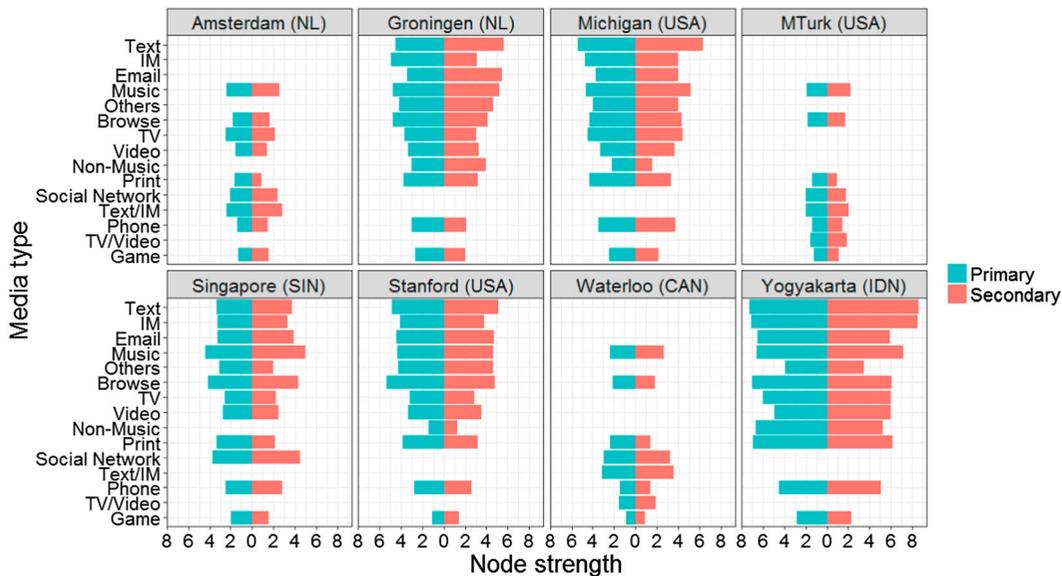


Figure 3. Ranked media use by the node importance as indicated by the node strength. Primary media activities (outgoing edges) are plotted in blue; secondary media activities (incoming edges) are plotted in red.

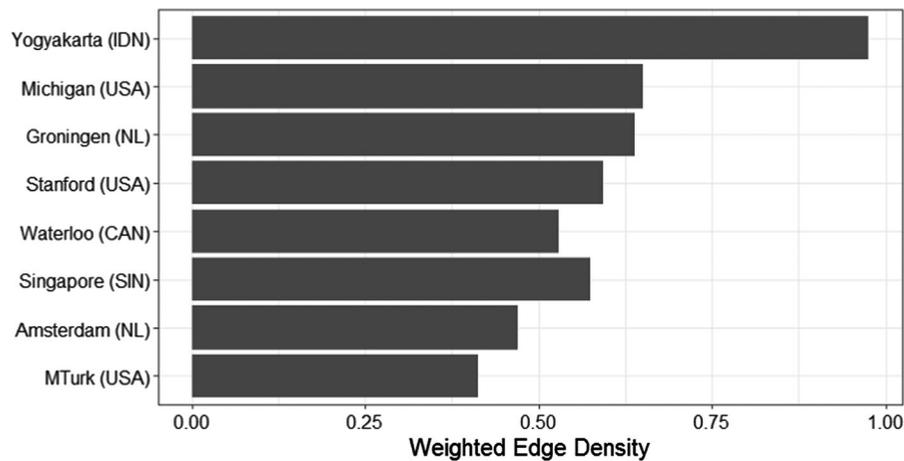


Figure 4. Ranked weighted edge density of the datasets.

to age differences the dataset which contains exclusively young participants (i.e. the Amsterdam dataset) had one of the lowest density scores, $D = .47$, indicating that the level of media multitasking might be lower among younger populations.

4. Discussion

To measure media multitasking, researchers have frequently used the MMI. As the MMI presents an overall score of media multitasking, the MMI might conceal important differences in the types of media that are used for media multitasking. Thus the types of media that are used might differ from one population to another. In this study, we rendered the media duration and media frequency questions which comprise the MMI from eight different datasets into networks to reveal the underlying media choice patterns. Overall, the rendered networks showed that the proportion of media multitasking, as indicated by the density score of each network, varied from one population to another. At the same time, the analysis suggests that the number and the types of media combinations people typically engage in were relatively similar across populations. This study thus provides initial evidence that the level of media multitasking behaviour might vary across different populations, whereas the patterns are relatively similar.

4.1. Differences in media choices

With regard to media choices in media multitasking, our results suggest that media multitasking activities were not uniformly distributed, with some media activities having a disproportionately higher likelihood to be used for media multitasking. Specifically, across all

datasets, listening to music, browsing, and texting/IMing were prominent. Moreover, datasets containing social media activities showed that social media were frequently used for media multitasking. Listening to music, browsing, texting, and accessing social media were also unsurprisingly the nodes with the largest sizes, which indicate that respondents spent most time with these media activities. This finding is consistent with previous reports which showed that time spent with media correlates positively with the likelihood of media multitasking (e.g. Foehr 2006).

The combinations of media multitasking pairs seem to follow specific patterns, which might be based on cognitive load reduction, instant gratifications, and/or habituation. As a means to reduce cognitive load, we found that media activities which involved high numbers of used and shared modalities were less frequently paired with other activities across all datasets (see also Jeong and Hwang 2016; Wang et al. 2015). For example, in all datasets, gaming and having a phone conversation were located in the periphery of the networks, indicating a lower frequency of media multitasking. Both activities engage visual, auditory, and motor modalities, and may thus be highly cognitively demanding, particularly when combined. Additionally, media activities which allow for frequent task-switching were more likely to form dyads; in all datasets, texting, listening to music, and browsing had the highest node strength scores. These findings were in line with what has been suggested by Wang et al. (2015) that media combinations occur adaptively, following the rule of 'less work'. Indeed, combining media activities which involve different sensory modalities and more control over switching between the tasks would invoke less cognitive demand compared to combinations which involve an overlap in one sensory modality and less control over switching.

With regard to instant gratifications, we found that media activities which involved browsing, social media, and texting/IMing were frequently selected. These activities were characterised by an interaction with others, which could provide a certain socio-emotional gratification, namely to stay connected with one's social network (Quan-Haase and Young 2010; Bardhi, Rohm, and Sultan 2010; Hwang, Kim, and Jeong 2014). At the same time, several combinations of these activities (e.g. browsing while texting) involve an overlap in the motor modality, and thus could be said to be maladaptive (Wang et al. 2015). Together, it seems to be the case that media users frequently combine browsing, social media, and texting/IMing activities since they provide gratifications and the benefit of these gratifications might outweigh the cost created by the additional cognitive load.

With regard to habituation, our networks showed two important patterns. First, we witnessed that the pairs which involved watching television were no longer frequently selected. This finding is in contrast to earlier reports on media multitasking which indicated that watching TV is a dominant activity among young people, and as such frequently used for media multitasking (see Foehr et al. 2006). Second, pairs which were characterised by a quick, entertaining escape from the daily routine (Quan-Haase and Young 2010; Wang and Tchernev 2012), were more frequently selected. Together, these patterns showed a general shift in the trend of media use, namely an increase of 'new' media consumption such as internet browsing and mobile phone-related activities and a decrease of 'traditional' media consumption such as television viewing and reading (Anderson 2015; Standard Eurobarometer 86 2016; Kononova et al. 2014). One implication of this could be that the type of media which were traditionally consumed as a part of a ritualistic behaviour without actively consuming it has also changed, namely from watching television to texting, browsing, and social networking. Subsequently, researchers who are interested in studying the potential effects of background media (e.g. Lin, Robertson, and Lee 2009; Pool, Koolstra, and van der Voort 2003) might also want to consider 'new' in addition to 'traditional' media.

Lastly, the findings show that the different media activities were as likely to be chosen as primary or secondary activity. This was rather surprising, considering that a previous study has shown that specific media types are used primarily as primary or secondary activity (Foehr 2006). Specifically, in Foehr's (2006) study, watching television and video, and listening to music were reported to be primary activities while in our datasets they were shown to be as likely to be chosen as

primary and secondary activity. At the same time, our findings confirmed the findings from a cross-cultural study (Kononova et al. 2014), in which popular media such as television, music, and mobile phones were used interchangeably as primary and secondary activity. One explanation could be that the activities assessed in the MMI were typically entertainment-related activities. Thus, there was no need to establish priorities, for instance for work over entertainment in these types of multitasking (see Adler and Benbunan-Fich 2012; Yeykelis, Cummings, and Reeves 2014). Alternatively, it could just be the case that the patterns of media consumption have changed in the past years. The recent developments of smartphones for instance, have allowed individuals to perform multiple unrelated activities with a single device, thus making it unnecessary to distinguish different goals and priorities in multitasking.

4.2. Differences between populations

While the results of our analysis suggest that the types of media multitasking combinations are relatively similar across different datasets, the rendered networks showed different density ratios, indicating that the level of media multitasking differs across populations. There were no clear differences with regard to the pattern of prominent nodes in different datasets. Looking at the overall density ranking, the two datasets with highest density scores were collected in Yogyakarta, Indonesia, and Groningen, the Netherlands while the datasets with the lowest density scores came from Amsterdam, the Netherlands, and MTurk, U.S.A. This is somewhat surprising, considering the possible differences in the level of media ownership and other media-related factors which might influence media multitasking level in different countries (Srivastava, Nakazawa, and Chen 2016; Jeong and Fishbein 2007; Kononova and Chiang 2015). At the same time, these findings confirm findings from a cross-cultural study which showed little qualitative differences in media multitasking patterns among American, Kuwaiti, and Russian respondents (Kononova et al. 2014). While we could not dismiss the possibility that the lack of differences between the datasets might stem from other factors, this result might provide initial evidence that media multitasking has become a global phenomenon, and thus, cognitive and socio-emotional factors might explain media multitasking behaviours better than country-specific indicators.

Looking into regional density rankings, it also became clear that the level of media multitasking as indicated by the density ratio varied within regions. In the Southeast Asia region, the dataset collected in Indonesia showed a

higher level of media multitasking compared to the dataset collected in Singapore. This was somewhat surprising, since a recent survey indicates that access to media devices and the internet were better in Singapore compared to Indonesia (Deloitte Southeast Asia 2017). In addition, previous studies have shown that media ownership positively predicts one's level of media multitasking (Kononova and Chiang 2015; Kononova 2013). One explanation could be that the ownership level of mobile media devices such as smartphones, which allows for a more flexible media multitasking activities, was higher in Indonesia compared to Singapore.

In the Northern American region, aside from the dataset collected in MTurk, datasets collected from Michigan, Stanford, and Waterloo showed comparable levels of media multitasking. One explanation why the MTurk sample showed a lower level of media multitasking than others might be that MTurk respondents were typically more heterogeneous with regards to age, level of education, male to female ratio, and occupations (Huff and Tingley 2015) compared to the non-MTurk samples which consist primarily of university students (Henrich, Heine, and Norenzayan 2010).

In the Western European region, specifically the datasets from the Netherlands, we again witnessed non-homogeneous density ratios between the datasets collected in Groningen and Amsterdam. Indeed, we found that the dataset with exclusively young participants (aged 12–15) had the second lowest density score, indicating a lower level of media multitasking. In comparison, the Groningen dataset, which primarily consists of University student samples, had higher levels of media multitasking. The difference in level of media multitasking was likely to be explained by differences in age: younger adolescent's media use is still partly restricted by parents and in the school context (Wang, Bianchi, and Raley 2005) while young and older adults, in contrast, can decide more freely on their media choices, and therefore may engage more frequently in media multitasking.

Together, the results suggest that while the levels of media multitasking might differ from one population to another, the combinations of media consumed are nevertheless relatively similar. Thus, overall, these findings indicate that the mixed findings in media multitasking literature can most likely not be explained by different patterns of media multitasking behaviours underlying the MMI. At the same time, our findings indicate that media multitasking has become a global phenomenon which is characterised by frequent switching between 'new' media such as browsing, text and instant messaging, and accessing social media. Additionally, the layout of our constructed networks also suggest that media multitasking behaviour revolves around a

limited set of media combinations, and that people use these media as primary or as secondary activity interchangeably.

Our findings have several theoretical and practical implications. Theoretically, our findings that some prominent media combinations occur in a non-adaptive manner (e.g. texting while browsing; since it involves an overlap in behavioural responses) suggest that in selecting media to combine in multitasking, users take into account other factors, such as the possibility to get instant gratifications, in addition to the possible cognitive demands exerted by the activities (Wang et al. 2015). Future studies should examine these other factors in more detail to fully understand why people engage in media multitasking so frequently. Moreover, future studies may want to examine in which situations people tend to choose multitasking combinations in an adaptive or non-adaptive manner.

From a practical point of view, media multitasking behaviour seems to be limited to a small set of media combinations, and media users do not seem to differentiate primary from secondary activities. Consequently, future studies might consider focusing on the cognitive and socio-emotional characteristics associated with specific media pairs instead of assessing a large number of media combinations. Future studies might be able to refrain from assessing each activity as both primary and secondary activity to alleviate the burden for respondents.

The current study has a limitation since our network comparison was done post-hoc, from data collected in previous studies. This means that we could not control over the type of questions asked in the questionnaire and the demographics of the samples. Therefore, it is difficult to attribute the similarities or differences between two networks to specific characteristics of these samples, because the datasets might vary in multiple aspects. For instance, the Yogyakarta and Amsterdam datasets varied with respects to the region, the average age of the samples, and the questions asked in the questionnaire. Ideally, future studies would use a questionnaire with a similar set of questions and would inquire the responses more systematically, i.e. from populations that differ in one instead of several characteristics. This, in turn, would allow for a more direct comparison between the networks and better attributions of the differences across cultures and populations.

5. Conclusion

In an exploration study, we rendered large sets of media use questionnaire datasets into networks. The networks provided several insights with regard to the pattern

of media multitasking combinations. Specifically, we found media combinations which involved texting/IMing, listening to music, browsing, and social media to be the most prominent ones in most datasets. This indicates that media multitasking behaviours might be confined within a smaller set of media activities. We also found several differences in media multitasking behaviour across populations, most importantly that the frequency of media multitasking behaviour differed across populations. Future studies could benefit from further investigating the specific characteristics of the populations that might explain these differences in media multitasking frequency (e.g. age, education, cultural differences).

Notes

1. Here, we refer to the type of media use questionnaire used in Ophir, Nass, and Wagner (2009; see also Baumgartner et al. 2017; Pea et al. 2012). We do not refer to other types of media use questionnaire which also exist in the literature (see for a comparison, Rosen et al. 2013).
2. The number of possible edges varies between different versions of MUQ. In versions with loops (i.e. containing questions such as ‘While you are watching television, how often do you also watch another television’), the number is defined as the square of total media assessed. In versions without loops, the number is defined as the total of media assessed times the total of media assessed -1.
3. The maximum weight is defined as the highest possible rating for each frequency of media multitasking response, which is equal to 1.
4. Note that different versions of the MUQ might feature slightly different media activities. For instance, in two out of eight datasets, texting and IMing, and watching TV and video were combined into one activity.

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