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Longitudinal Associations of Children's Hyperactivity/Inattention, Peer Relationship Problems and Mobile Device Use

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Abstract: Children with emotional, behavioral or relationship problems may be more inclined to use mobile touchscreen devices (MTSDs: mobiles and tablets) to regulate their emotions or compensate for the lack of social relationships, which, in turn, may affect their symptoms. Bi-directional longitudinal associations between behavioral difficulties and MTSD use were analyzed. Participants were parents of children aged 4–6 years old at first data collection (n = 173), and 7–9 years old at second data collection (n = 98). They reported on their child's MTSD use and behavioral difficulties at two time points (T1 and T2). It was analyzed whether T1 MTSD use predicts T2 behavioral difficulties (controlling for demographics and T1 behavioral difficulties); and whether T1 behavioral difficulties predict T2 MTSD use (controlling for demographics and T1 MTSD use). Additionally, cross-sectional associations between behavioral difficulties and MTSD use were analyzed. Children's T1 hyperactivity/inattention score positively associated with T2 MTSD use, and peer relationship problems and MTSD use positively associated in T2. Pre-schoolers with more hyperactive inattentive symptoms may use MTSDs more to regulate their emotions. The association between peer relationship problems and MTSD use in T2 is consistent with poorer socio-cognitive skills in MTSD user children and may be bi-directional.

Keywords: behavior problems; digital media; touchscreen; hyperactivity; longitudinal

1. Introduction

In advanced economies, the last centuries' technological development changed a significant part of the typical experience people meet. The widespread usage of electronic media and digital devices (TV, videogames, PC, smartphones, tablets, etc.) may influence even adults' cognition, emotions, and mental health [1,2]. However, children at an age when their brain and cognitive processes are exceptionally plastic are even more liable to the strong and long-lasting influence of experience [3,4]. Children start to use mobile phones and tablets at an increasingly early age [5] and for an increasing amount of time [6]. Although digital media is present in children's lives for some decades, "new media" (mobile touchscreen devices, MTSDs) are relatively new, and children generally use them from a younger age than e.g., console/PC videogames [7], and more often in a lonely way, than, e.g., TV [8].

Due to the relatively recent spread of MTSD devices, there is only a limited amount of empirical research on how the use of these devices influences/associates with children's well-being and mental health [9]. A bit more data is available on the associations of mental health and "old media", or "screen time" in general, but even these studies have been generally carried out on adults, or -in a smaller number- on adolescents [10]. A further problem is that the scientific data gathered so far mainly stems from cross-sectional, correlative studies [10].

These studies have generated a mix of often conflicting small positive, negative and null associations [10]. In children and adolescents, evidence was found for the asso-

ciation of screen time with poorer quality of life, higher depressive symptoms, behavior problems, anxiety, hyperactivity and inattention, lower pro-social behavior, poorer self-esteem, well-being and psychosocial health [10–15], although the strength of associations varies largely between studies. There are much fewer studies on young children (e.g., preschoolers) [16–19]. These studies reported a relationship between increased television viewing or screen time and poor measures of psychosocial health: increased odds for antisocial behavior [19], externalizing behavior [20], behavioral difficulties [16], victimization [17], and bullying [18].

There are only a few longitudinal (detailed below) and even fewer experimental [21,22] studies, making it difficult to infer causality. Mental health and digital media use probably relate to each other in a very complex way. Besides unidirectional causality, there could be a bidirectional relationship as well [23], and/or one or more background variables can affect both. This research aims to review evidence for the existence of the two simplest causal relationships: (1) if digital media use affects mental health, and (2) if mental health affects digital media use. Experimental studies on this topic are almost entirely missing in this age group (children or adolescents), but longitudinal studies give some hints about the possible causal relationships.

Most of the longitudinal studies on this topic have been carried out on the associations between digital media use and later externalizing symptoms. To the authors' knowledge, all of these studies support the existence of such an association across many age groups and different media contents/devices/activities. Specifically, higher digital media use at a younger age is associated with higher attention problems, impulsiveness, conduct problems, externalizing behavior, lower inhibition, lower executive functions in general, or lower self-regulation, in older age [19,23–29]. Digital media use has been also found to be positively associated with later emotional problems [28,30,31], decrease in family functioning, and increase in victimization [17,30]. However, beneficial effects have been also found (e.g., playing with electronic games was positively associated with later intrapersonal and stress management skills and total emotional quotient) [32].

Digital media use can have direct effects on children's mental health (i.e., certain characteristics of the digital activity or content itself may induce changes in cognitive, emotional or social processes) [33]. For example, violent or fast-paced (overstimulating) content may lead to attentional problems, ADHD-symptoms, impulsivity or increased aggression [11,34–36], by making the child habituated to arousing content [37], or by frequently shifting their attention [38]. Violent content is also likely to increase aggression in the child through observing others behaving violently [39,40].

Digital media use may also have indirect effects, through the displacement effect (i.e., that it takes time away from developmentally key activities, such as social interactions, symbolic/role/pretend play, physical activity, or sleep) [41]. These activities are essential in developing appropriate social, emotional and cognitive skills and in mental health [42,43]. For example, mental health problems and suicide are related to screen time/intensive social media use and these associations are largely mediated by displacement of sleep and physical activity [36,44].

The association between digital media use and mental health could be also driven by mental problems leading to higher amount of or more problematic digital media use. Children with ADHD or ASD (which have a strong genetic base, thus, at least their susceptibility should be present before the start of digital media use) are more likely to use digital media (e.g., to play videogames or watch TV [45,46]), and longitudinal studies showed that children with attentional problems, higher impulsiveness, peer relationship problems and lower self-regulation at baseline consume more digital media later [23,24,28].

These associations could be explained by individuals with emotion-regulation problems or general negative mood using the digital device/activity for regulating their emotions or improving their mood [47,48]. Individuals with higher sensation-seeking motivation (such as individuals with ADHD [49]) may use digital devices to stimulate themselves [50], especially by consuming violent and fast-paced content [36]. People with

social problems may compensate for the lack of social support by using digital devices to communicate/interact online [51,52]. Furthermore, parents of "difficult children" may be also more likely to calm down or engage their children with the digital device [53].

The touchscreen, the interactivity [54], portability and accessibility of MTSDs and the large variety of potential activities that can be carried out on them make these devices unique compared to other digital devices [55]. Children generally use MTSDs from a younger age than console/PC videogames [7], and more often in a lonely way, than TV [8]. Thus, when analyzing the effects of MTSDs, the authors suggest treating them separately from other digital devices [56] and avoid using umbrella terms, such as "screen time" or "media use".

To the authors' knowledge, only two longitudinal studies [27,28] have examined the associations of mental/behavioral problems with the use of MTSDs in children. Conducting research regarding this field is crucial, as the use of these devices grows dramatically each year [5,28], and little is known about how this affects their development and mental health.

Even the two mentioned studies revealed contradictory findings: while Poulain and colleagues [28] found that baseline mobile phone use was associated with later conduct and hyperactivity/inattention symptoms, McNeill and colleagues [27] found no association between baseline app use and later psychosocial health. In both studies, watching videos was treated separately from the other activities that can be made on MTSDs but was treated together with watching videos/programs on other devices (e.g., TV). For watching videos/programs, the results are also contradictory: in McNeill and colleagues [27] study, program viewing at baseline was associated with externalizing behaviors and total difficulties at follow-up, while in Poulain and colleagues [28] study, it was not. Additionally, McNeill and colleagues [27] did not investigate the reverse association (i.e., whether behavior problems at baseline are associated with MTSD use program/video viewing at follow-up). Therefore, further studies are required to clarify the associations and investigate transactional effects.

Many longitudinal studies investigated whether Time 1 media use is associated with Time 2 behavioral problems, but there is a huge gap in studying the reverse relationship. The aim was to fill in this gap: we explored the bi-directional longitudinal associations between the use of MTSDs (smartphones and tablets) and behavioral difficulties from pre-school age to early school age. This age group was chosen since (1) many childhood behavioral problems start/are discovered/diagnosed in this age group [57], (2) the active use of MTSDs (e.g., playing games, taking photos) increases dramatically in this age [58], (3) in the topic there is little scientific knowledge concerning this age group.

The authors hypothesized that higher amount of MTSD use in pre-school age is associated with later behavioral difficulties (hyperactivity/inattention, conduct problems, emotional symptoms, and peer-relationship problems) and lower prosocial behavior in early school-age. Based on the literature, the strongest associations were expected to be between hyperactivity/inattention and MTSD use. The researchers also hypothesized that behavioral difficulties in pre-school age are associated with increased MTSD use later in school-age. The strongest association was expected to be between hyperactivity/inattention and MTSD use and between peer-relationship problems and MTSD use.

Since many familial factors and parents' own MTSD use influence the child's MTSD use [5] and behavioral difficulties, demographics and parental mobile attachment was controlled.

2. Materials and Methods

2.1. Participants

Children were recruited from the database of a larger questionnaire study (Digital Kids Questionnaire) in which parents reported on their children's digital activity between May and August of 2016 [5]. From this database, parents of children aged between four and six years old were recruited and asked to fill out a questionnaire on behavioral difficulties. A total of 173 parents filled out this questionnaire (Strength and Difficulties Questionnaire) between December 2016 and May 2017. In 2019 researchers reached out to these

parents again and asked them to fill out both a part of the Digital Kids Questionnaire (see Section 2.2.1 for details) and the Strength and Difficulties Questionnaire again. 108 parents filled out the questionnaires for the second time (from November 2019 to January 2020). However, 10 respondents' answers couldn't be matched to the previous data, since they gave different email addresses on the two occasions. Thus, the final sample consisted of 98 parents who reported on 54 boys and 44 girls (see Table 1 for descriptive statistics). Those who participated at second data collection and those who had dropped out did not differ in any characteristics (see Section 3.1).

Table 1. Descriptive statistics.

Variable	Measure	Min	Max	M	SD	Median	IQR
Child age T1	In years	3.842	6.064	4.913	0.596		
Child age T2		7.264	9.542	8.270	0.556		
Child gender	(girl/boy)	N boys = 54 N girls = 44					
Siblings T1	Count	0	6	0.827	0.964	1	1
Siblings T2		0	6	0.944	0.975	1	1
Parent age T1	In years	23	47	37.459	4.445		
Parent age T2		26	50	40.888	4.479		
Parental education	Mean score from the two parents' 6-leveled education.	2	6	4.296	0.858		
Parental mobile attachment T1	Mean score from the four 5-graded items.	1	4.75	2.288	0.918		
Parental mobile attachment T2		1	5	2.503	1.012		
MTSD use T1	In minutes/day	0	110	18.157	27.090	6.965	20.750
MTSD use T2		0	900	65.355	134.392	18	54
SDQ Emotional symptoms T1		0	6	1.888	1.698	1	2
SDQ Emotional symptoms T2		0	7	1.837	1.648	1	2.250
SDQ Conduct problems T1		0	7	1.908	1.547	2	2
SDQ Conduct problems T2		0	6	1.388	1.397	1	2
SDQ Hyperactivity/inattention T1		0	10	3.837	2.469	3	4
SDQ Hyperactivity/inattention T2		0	10	2.98	2.573	3	3.250
SDQ Peer relationship problems T1		0	8	1.684	1.870	1	2
SDQ Peer relationship problems T2		0	7	1.602	1.679	1	2
SDQ Prosocial behavior T1		2	10	7.949	1.830	8	2
SDQ Prosocial behavior T2		3	10	8.214	1.607	9	3

Note: In case of variables with skewed distribution, median and IQR is also presented.

2.2. Materials

2.2.1. Digital Kids Questionnaire

The full description of the questionnaire is published in [5]. This questionnaire was based on an open-ended survey (*n* = 96) on which an inductive content analysis [59] was carried out to develop the final form of the questionnaire [5]. The questionnaire contains questions about demographics, characteristics of the child's MTSD use (frequency and duration of use, typical activities the child engages in on the MTSD), digital parenting styles, parental role-modelling (frequency of parental mobile use and attachment to their mobile phones), and parental attitudes and beliefs regarding early MTSD use. In the present study, only the following parts of the questionnaire were used (See Appendix A for the questionnaire items and response options, and Table 1 for descriptive statistics):

Demographics: Parents reported on the age and gender of their child (child age, child gender), the number of siblings (siblings), the age of the child's parent who completed study questionnaires (parent age) and the level of education of each parent. Parental education had 6 levels: 1 = elementary school; 2 = technical school; 3 = high school; 4 = bachelor's degree/college; 5 = master's degree/university; 6 = doctoral degree/postgraduate. A mean score was computed from the two parents' educational levels (parental education).

Parental Mobile Attachment: Questions were asked about parents' behavioral and emotional characteristics of attachment to their mobile phones (based on [60]; parental MA). Variable included four items from the Mobile Attachment Questionnaire [60], one from each subscale. Parents had to rate each statement on a 5-grade–scale, based on how characteristic it was for them. A total Parental Mobile Attachment score ($\alpha = 0.776$; acceptable) was computed and used for analysis.

Child MTSD Use: Parents were asked whether (Yes/No) and how much (frequency, with 8 levels; and duration, with 7 levels; see Appendix A) their child uses tablets and smartphones. A variable named 'MTSD use' (minutes/day) was computed by the combination of these two data (frequency and duration) and by summing the time spent with tablet and mobile use (if the child used both). To calculate 'MTSD use', numeric values were assigned to the response options (which were approximate intervals) in a way that the exact value fell in the middle of the interval (e.g., for "30–60 min" the value was 45 min). Then, the frequency of use (times/day) was multiplied by the duration of use (min) to obtain the variables 'tablet use' (min/day) and 'mobile use' (min/day). Finally, summing these two variables, we obtained the variable 'MTSD use' (min/day).

2.2.2. Strength and Difficulties Questionnaire

Parents completed the Hungarian version [61] of the SDQ, a 25-item screening scale validated for use with 3–16-year-old youth. It measures the presence of symptoms indicative of psychopathology in children. The SDQ has well-established psychometric properties, including diagnostic predictive validity [61,62]. The measure has five subscales: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems and prosocial behavior. The subscales had variable internal consistencies (the Cronbach's alphas varies from 0.485 [Emotional symptoms] to 0.797 [Hyperactivity/inattention]; Table 2). These values are comparable to those found in other samples (e.g., [61–65]). Descriptive statistics (M $\pm$ SD, range, and median and IQR for variables with skewed distributions) for the final sample (*n* = 98) for the SDQ subscales are presented in Table 1.

Table 2. Cronbach's alphas of the SDQ scales.

	Cronbach's Alpha in T1	Cronbach's Alpha in T2
Emotional symptoms	0.485	0.528
Conduct problems	0.554	0.487
Hyperactivity/inattention	0.744	0.797
Peer relationship problems	0.612	0.571
Prosocial behavior	0.656	0.549

2.3. Procedure

Parents filled out the questionnaires online. At the first data collection (T1) it took ca. 30 min to fill out the Digital Kids Questionnaire (as it was a longer version, see Section 2.2.1), and an additional 10–15 min to fill out the Strength and Difficulties Questionnaire. At the second data collection (T2) it took ca. 30 min to fill out the Digital Kids Questionnaire (short version) and the SDQ together.

The study was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) and approved by the United Ethical Review Committee for Research in Psychology (EPKEB) (reference number of approval: EPKEB-2019/102). Informed consent was obtained from all participants.

2.4. Statistical Analysis

Statistical analyses were carried out using SPSS 28.0.0.0.

First, we compared whether those who participated at second data collection and those who had dropped out differed in demographics (child age, child gender, siblings, parent age, parental education, parental MA score), the child's MTSD use, and scores on the SDQ scales (Mann-Whitney tests, and Chi-square test in case of gender).

MTSD use was modelled as a Tweedie distribution to consider excess zeros in the dataset due to children that did not use devices. SDQ scales, in turn, were analyzed in ordinal regression models.

First, T2 MTSD use (response variable) was analyzed in Tweedie Generalized Linear Models (TGzLM) with T1 SDQ scores (predictors) and T2 child age, child gender, T2 siblings, T2 parent age, T2 parental education, T2 parental MA score and T1 MTSD use (confounding variables) as fixed effects (Figure 1a). To avoid multicollinearity, separate TGzLMs were run including either conduct problem or hyperactivity/inattention (i.e., one model with conduct problem alone, one model with all other SDQ scales), as these two were highly correlated.
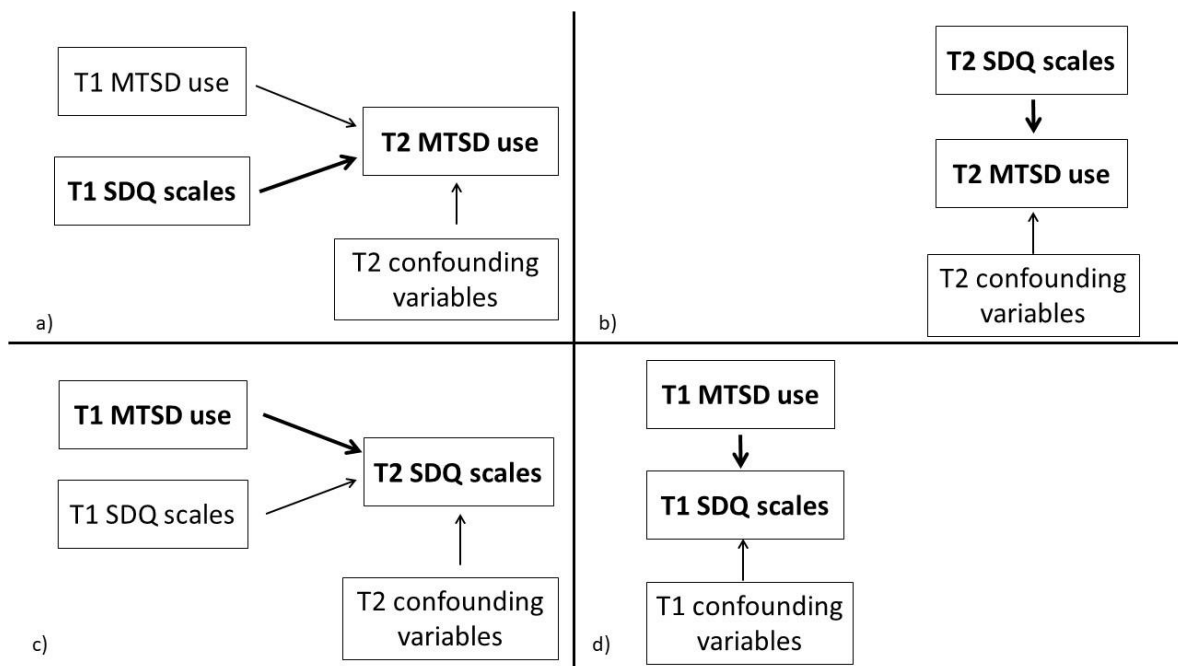

Figure 1. Summary of the analyses: predictor and response variables (bold), and potential confounding variables included in the regression models (with arrow heads towards the response variables). (**a**) Tweedie Generalized Linear Models (TGzLM) with T2 MTSD use as response variable and T1 SDQ scores as predictors (controlling for T1 MTSD use and T2 confounding variables); (**b**) Tweedie Generalized Linear Models (TGzLM) with T2 MTSD use as response variable and T2 SDQ scores as predictors (controlling for T2 confounding variables); (**c**) separate ordinal regressions with T2 SDQ scores as response variables and T1 MTSD use as predictor (controlling for T1 MTSD use and T2 confounding variables); (**d**) separate ordinal regressions with T1 SDQ scores as response variables and T1 MTSD use as predictor (controlling for T1 confounding variables).

To investigate cross-sectional associations between MTSD use and SDQ scales in T2, the above models of T2 MTSD use (response variable) was further analyzed by including T2 (instead of T1) SDQ scores (Figure 1b).

T2 SDQ scales (response variables) were analyzed in separate ordinal regression models with T1 MTSD use (predictor) and the respective T1 SDQ scales and the potential confounding variables at T2 (child age, child gender, siblings, parent age, parental education, parental MA score) as fixed effects (Figure 1c).

Then these analyses were repeated focusing on T1 SDQ scales (instead of T2 SDQ scales) as response variables (with T1 MTSD use and T1 confounding variables as fixed effects) (Figure 1d).

For the interpretation of the results, it was important to analyze whether SDQ scores and MTSD use changed over time, so Wilcoxon signed-rank tests were conducted to compare T1 and T2 SDQ scores and T1 and T2 MTSD use.

3. Results

3.1. Comparison of the Dropout and Retested Participants

Dropout and retested participants did not differ in any variables (demographics, SDQ scales and MTSD use; all $p > 0.13$)

3.2. T2 MTSD Use and T1 Behaviour Problems

Parental MA score (B = 0.241; SE = 0.108; χ^2_1 = 5.043; p = 0.025), T1 MTSD use (B = 0.026; SE = 0.003; χ^2_1 = 63.194; $p < 0.001$) and T1 hyperactivity/inattention significantly (B = 0.092; SE = 0.045; χ^2_1 = 4.104; p = 0.043; Figure 2), child age marginally significantly (B = 0.358; SE = 0.208; χ^2_1 = 2.96; p = 0.085) predicted T2 MTSD use. The other variables had no significant effect on T2 MTSD use (all $p > 0.1$).
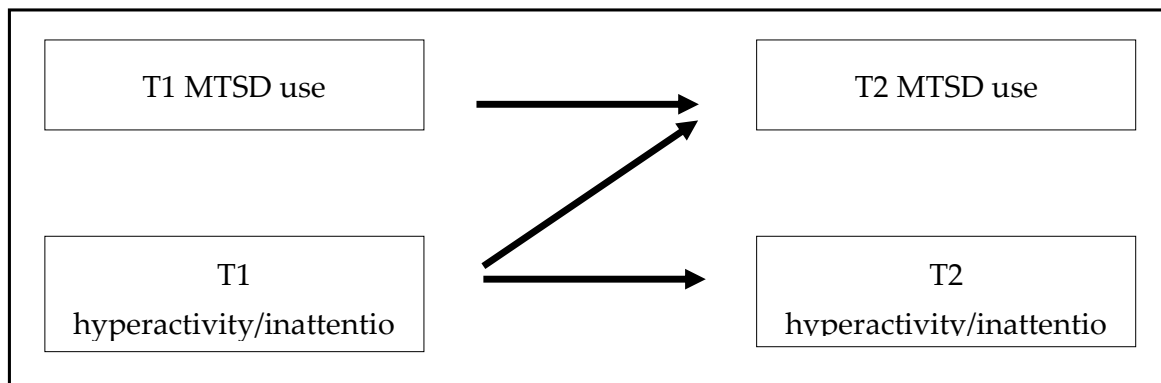

Figure 2. Significant associations between T1 MTSD use, T2 MTSD use, T1 hyperactivity/inattention and T2 hyperactivity/inattention.

In the other models, T1 conduct problem had no significant effect on T2 MTSD use (B = 0.010; SE = 0.076; χ^2_1 = 0.018; p = 0.894), and the same variables had significant effects as in the previous models (parental MA, child age, T1 MTSD use).

3.3. T2 MTSD Use and T2 Behaviour Problems

Parental MA score (B = 0.308; SE = 0.102; χ^2_1 = 9.118; p = 0.003), T1 MTSD use (B = 0.024; SE = 0.003; χ^2_1 = 52.374; $p < 0.001$) and T2 peer relationship problems (B = 0.118; SE = 0.059; χ^2_1 = 4.079; p = 0.043; Figure 3) significantly predicted T2 MTSD use. The other T2 SDQ scales (emotional problems, hyperactivity/inattention, and prosocial behavior) had no significant effect on T2 MTSD use (all $p > 0.321$).
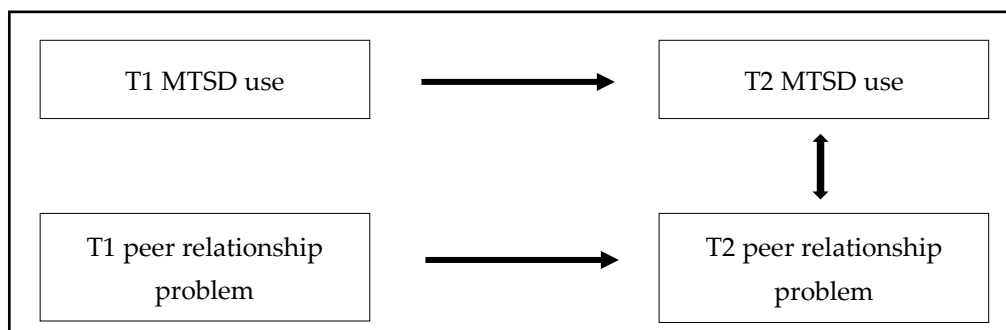

Figure 3. Significant associations between T1 MTSD use, T2 MTSD use, T1 peer relationship problems and T2 peer relationship problems.

In the other models, T2 conduct problem had no significant effect on T2 MTSD use (B = 0.022; SE = 0.077; χ^2_1 = 0.083; p = 0.773), and the same variables had significant effects as in the previous models (parental MA, T1 MTSD use).

3.4. T1 MTSD Use and T2 Behaviour Problems

T2 emotional symptoms: T1 emotional problems score had a significant positive effect (B = 0.774; SE = 0.129; χ^2_1 = 35.617; *p* < 0.001), siblings had a significant negative effect (B = −0.567; SE = 0.2272; χ^2_1 = 6.229; *p* = 0.013) and child age had a marginally significant negative effect (B = −0.586; SE = 0.3433; χ^2_1 = 2.910; *p* = 0.088) on T2 emotional symptoms. T1 MTSD use (B = 0.004; SE = 0.007; χ^2_1 = 0.375; *p* = 0.54) and other confounding variables (all *p* > 0.353) had no effect.

T2 conduct problems: T1 conduct problems score had a significant positive effect on T2 conduct problems (B = 1.063; SE = 0.173; χ^2_1 = 37.782; *p* < 0.001). Child gender (B = 0.782; SE = 0.419; χ^2_1 = 3.492; *p* = 0.062; girls having higher scores), parental education (B = −0.439; SE = 0.244; χ^2_1 =3.235; *p* = 0.072), and parent age (B = 0.078; SE = 0.049; χ^2_1 = 2.887; *p* = 0.089) had a marginally significant effect. T1 MTSD use (B < 0.001; SE = 0.007; χ^2_1 = 0.004; *p* = 0.948) and other confounding variables (all *p* > 0.456) had no effect.

T2 hyperactivity/inattention: T2 parent age (B = 0.122; SE = 0.042; χ^2_1 = 8.302; *p* = 0.004) and T1 hyperactivity/inattention score (B = 0.520; SE = 0.088; χ^2_1 = 34.973; *p* < 0.001; Figure 2) had significant positive effect on T2 hyperactivity/inattention, but T1 MTSD use (B = 0.005; SE = 0.007; χ^2_1 = 0.631; *p* = 0.427; Figure 2) and other confounding variables (all *p* > 0.158) had no effect.

T2 peer relationship problems: T1 peer relationship problems score had a significant positive effect on T2 peer relationship problems (B = 0.875; SE = 0.137; χ^2_1 = 41.113; *p* < 0.001; Figure 3), and child age had a marginally significant positive effect (B = 0.616; SE = 0.349; χ^2_1 = 3.123; *p* = 0.077). T1 MTSD use (B = 0.008; SE = 0.007; χ^2_1 = 1.296; *p* = 0.255; Figure 3.) and other confounding variables (all *p* > 0.339) had no effect.

T2 prosocial behavior: parental education (B = −0.605; SE = 0.239; χ^2_1 = 6.435; *p* = 0.011) and parent age (B = −0.091; SE = 0.0457; χ^2_1 = 3.983; *p* = 0.046) had a significant negative, T1 prosocial behavior score (B = 0.783; SE = 0.129; χ^2_1 = 36.418; *p* < 0.001) and siblings (B = 0.596; SE = 0.2181; χ^2_1 =7.476; *p* = 0.006) had a significant positive effect on T2 prosocial behavior, but T1 MTSD use (B = 0.003; SE = 0.007; χ^2_1 = 0.211; *p* = 0.646) and other confounding variables (all *p* > 0.414) had no effect.

3.5. T1 MTSD Use and T1 Behaviour Problems

T1 emotional symptoms: T1 parental MA had a significant positive effect (B = 0.486; SE = 0.196; χ^2_1 = 6.121; *p* = 0.013) on T1 emotional symptoms. T1 MTSD use (B = 0.005; SE = 0.006; χ^2_1 = 0.631; *p* = 0.427) and other confounding variables (all *p* > 0.107) had no effect.

T1 conduct problems: child gender had a significant effect on T1 conduct problems (B = 1.066; SE = 0.381; χ^2_1 = 7.832; *p* = 0.005) with boys showing higher scores. Parent age had a marginally significant positive effect (B = 0.077; SE = 0.044; χ^2_1 = 3.006; *p* = 0.083). T1 MTSD use (B = 0.009; SE = 0.007; χ^2_1 = 1.932; *p* = 0.164) and other confounding variables (all *p* > 0.243) had no effect.

T1 hyperactivity/inattention: child gender had a marginally significant effect on T1 hyperactivity/inattention (B = 0.701; SE = 0.365; χ^2_1 = 3.683; *p* = 0.055) with boys showing higher scores. Neither T1 MTSD use (B = 0.005; SE = 0.006; χ^2_1 = 0.562; *p* = 0.454), nor other variables (all *p* > 0.113) had significant effect on T1 hyperactivity/inattention.

T1 peer relationship problems: neither T1 MTSD use (B = −0.004; SE = 0.007; χ^2_1 = 0.263; *p* = 0.608), nor other variables (all *p* > 0.112) had significant effect on T1 peer relationship problems.

T1 prosocial behavior: neither T1 MTSD use (B = −0.004; SE = 0.007; χ^2_1 = 0.337; *p* = 0.562), nor other variables (all *p* > 0.111) had significant effect on T1 prosocial behavior.

3.6. Change in SDQ Scores and MTSD Use over Time

MTSD use increased from T1 to T2 (z = −5.249; *p* < 0.001; r = −0.533). Emotional symptoms (z = −0.189; *p* = 0.85; r = −0.019) and peer relationship problems (z = −0.635;

$p = 0.526$; r $= -0.064$) did not change over time. Conduct problems (z $= -3.637$; $p < 0.001$; r $= -0.367$) and hyperactivity/inattention (z $= -3.467$; $p < 0.001$; r $= -0.35$) decreased from T1 to T2 (for descriptive statistics, see Table 1).

4. Discussion

The research aimed to reveal longitudinal associations between the use of mobile touchscreen devices (MTSDs) and behavioral difficulties in pre-school and early school age. There is a gap in research investigating longitudinal associations in both of the causal directions (transactional effects). Additionally, the investigation of longitudinal associations between psychosocial health and contemporary digital device use is especially limited.

4.1. Higher Hyperactivity/Inattention Leads to Higher MTSD Use

Pre-schoolers with more hyperactive/inattentive symptoms used the MTSDs later (in their early school age) more often, suggesting that hyperactivity/inattention leads to higher amount of MTSD use. This is in line with previous findings showing that children with ADHD or hyperactive/inattentive symptoms are more likely to watch TV or play videogames later [23,45].

Children and adolescents with ADHD are characterized with higher levels of emotion regulation problems [66,67]. Individuals with emotion regulation problems are more likely to engage in digital activities [24,68], which often serve an emotion-regulating purpose [68–70]. Pre-schoolers with higher levels of hyperactive/inattentive symptoms may also experience emotion regulation problems and thus turn to MTSDs to regulate their emotions. Additionally, in order to manage/control their child's emotion regulation problems, parents often give them digital devices [49,71,72]. As a consequence, children get used to relying on digital devices to regulate their emotions, leading to negative emotionality and problematic use of digital media [71,72]. Therefore, preschoolers with higher hyperactivity/inattention may be more frequently engaged by the parent with the MTSD, leading to a higher amount of MTSD use some years later.

Individuals with ADHD have also been reported to show significantly higher levels of sensation seeking compared to controls [50,73]. Sensation seeking may be an autoregulatory attempt to create a stimulating environment in order to stabilize vigilance in individuals with hypo-arousal [74]. Digital activities can help in this regulatory process by offering stimulation by e.g., fast-paced, intensive, simultaneous stimuli [23,75], arousing (e.g., violent) contents, and opportunity for multitasking [76]. Sensation seeking is positively correlated with smartphone addiction/abuse in adolescents [51,77], with online gaming addiction in adults [78], and with videogaming in children [79]. Individuals with ADHD are more likely to consume stimulating (i.e., violent and fast-paced media contents) which activate dopamine and the reward pathways [36]. Pre-schoolers with higher hyperactivity/inattention may be also characterized by higher sensation seeking thus driving them to use MTSDs more. Additionally, a child with a difficult or energetic temperament predicts parents to use digital media as a parenting tool/a 'baby-sitter' [80,81]. Hyperactivity and sensation seeking in children may encourage the parents to frequently engage the child with digital devices, resulting in persistent high amount of MTSD use.

There are certainly other alternative explanations for the result. For example, children with ADHD-related behaviors typically face peer difficulties [82], therefore often engage in solitary digital activities. Additionally, ADHD-related behaviors are often associated with parent–child conflicts and parenting stress [83,84], which may leads to a more frequent use of the MTSD as a 'baby-sitter', or the child escapes from the conflicts to the virtual activities [37].

Surprisingly, the association between hyperactivity/inattention and MTSD use is no longer present in T2 (no concurrent association). A possible explanation is that while hyperactive symptoms decrease with age [29,85], MTSD use does not, as it becomes a habit. In other words, at the beginning of MTSD use, children with hyperactivity/inattention (or their parents) require the MTSD to regulate the child's emotions/arousal; after a while, an

intensive (or even problematic) MTSD use develops and it endures even after it does not fulfil a regulating function.

4.2. Higher MTSD Use Does Not Lead to Higher Hyperactivity/Inattention

Pre-schoolers' MTSD use was not associated with later hyperactive/inattention symptoms. This is in contrast to the findings of several studies which have shown that digital device use leads to hyperactivity/inattention or externalizing behavior [37]. However, as Nikkelen and colleagues' [37] meta-analysis showed, the effects sizes are smaller for longitudinal studies than for cross-sectional ones.

Additionally, most studies have been carried out on "old media", e.g., TV and videogames; or they measured total screen time without nuancing the types of devices or activities. Only two longitudinal studies [27,28] have been carried out on the relationship between newer media (MTSD devices) and psychosocial health. In line with our results, McNeill and colleagues [27] found no association between early MTSD use and later hyperactivity/inattention symptoms, but Poulain and colleagues [28] found. Thus, further studies are required to clarify whether early MTSD use leads to hyperactivity/inattention symptoms or not.

If MTSD use does not lead to hyperactivity/inattention symptoms, in contrast to the use of other digital devices, the question arises why. MTSDs are different from (e.g., TV) in that they are interactive (the use of them require the child to be more active, mainly cognitively) [86,87]. Some studies suggest that the use of interactive media may be more beneficial/less harmful for the children's development and psychosocial health, than the use of passive media [27,30,88–90]. However, not only MTSD use is characterized by interactivity but also videogame playing on any device, therefore one would expect video game playing to not be associated with later hyperactivity/inattention either. Nevertheless, longitudinal studies are much scarcer with video game playing than with TV watching [37], and the findings are inconsistent, as in the case of MTSD use. For example, Parkes et al. [91] did not find an association between videogame playing and hyperactivity/inattention, but Gentile et al. [23] and Swing et al. [29] did. However, in the latter two studies, older children were examined.

Another interpretation for the finding is that applications addressing preschoolers are often of educational nature. Educational applications have been shown to be more beneficial for children's executive functions, than (e.g., watching cartoons [89]), probably since the educative nature is associated with slower pace [92]. Additionally, games for preschoolers are probably much less violent, than games for older children [93]. Fast pace and violence are two features of digital contents the consumption of which is associated with hyperactivity/inattention [35,36]. Thus, it is possible that MTSD use in preschoolers does not lead to hyperactivity/inattention since the contents designed for this age group is much less harmful/more beneficial than those designed for older children.

4.3. Association between Concurrent Peer Relationship Problems and MTSD Use in Early School Years

Association between peer relationship problems and concurrent MTSD use in the early school years (T2) was found, in contrast to the pre-school years (T1). Given that there were no longitudinal associations, firm conclusions about causality cannot be made. On one hand, digital media use may take time away from other, offline activities ('*displacement' hypothesis*), including ones essential for appropriate development of social skills, such as good-quality social interactions with caregivers [94,95]. Indeed, data show that children who spend more time using digital media, spend less time with their parents and siblings [41]. As a consequence, their social skills may be poorer [32,94] resulting in peer relationship problems. Additionally, digital media use (including MTSD use) may take time away from the social interactions with peers, resulting in a higher social exclusion.

On the other hand, children with poorer social skills or peer relationship problems may prefer solitary activities, such as digital media use. A longitudinal study showed

that children with peer relationship problems at baseline use computer/Internet and mobile phones more at follow-up [28]. Children with autism spectrum disorder (who have problems with social communication and interaction) spend more time watching TV or playing video games [45,46]. People with social problems may escape from social interactions into the virtual world [54] or into solitary activities, they can compensate for the lack of social support by using digital devices to communicate/interact online [52,53], or they may use the digital device/activity for improving their mood [47,48].

Regardless of the causal relationship (it is plausible to assume a bi-directional relationship), the finding is in accordance with the poorer socio-cognitive/socio-emotional skills found in frequent MTSD user children/adolescents. For example, frequent MTSD use is associated with poorer theory of mind skills in preschoolers [33], and with reduced understanding of social situations in adolescents [96]. In contrast, participation in an outdoor camp without access to MTSDs was associated with improved social perception skills in school-aged children [97]. In this respect, it seems that MTSD use is similar to general screen media (probably since all media takes time away from social experience): preschoolers' passive screen time/TV viewing/background television is also associated with poorer theory of mind [98] and social skills [87,99], and toddlers' screen use during daily routines is associated with higher risk for social-emotional delay [100]. However, it should be noted that one study found a negative association between video game usage and peer relationship problems in young (school-aged) children [101].

Interestingly, the association between peer relationship problems and MTSD use was absent in preschoolers (T1). It is possible that in younger children, parental restriction of MTSD use limited the manifestation of children's own interest and use: in this age, parents exert much more control over the child's MTSD use [102,103] and preschoolers rarely own a device [6], or don't get access to it whenever they want. When the parental control decreases as the children get older, their own interest may manifest more overtly in their MTSD usage, leading to differences in MTSD use according to their own demands.

4.4. Other SDQ Scales and MTSD Use

There were no associations between the other SDQ scales (conduct problem, emotional symptoms, and prosocial behavior) and MTSD use.

Emotional symptoms were not associated with MTSD use, in contrast with a longitudinal study [30] finding that the use of computer games were associated with emotional problems two years later in preschoolers. Okada and colleagues [104] also found in a cross-sectional study, that boys using two or more hours of MTSDs a day showed a higher risk of developing emotional problems. Some research findings also suggest the reverse: digital device use is associated with positive emotions. For example, videogames are proven to be stress relief tools for the children as well as for adults [105]. No association in this study could be due to the blurred effects of positive and negative effects of MTSD use on emotional symptoms, or the low Cronbach alfa score and variability in the scale.

Conduct problems were also not found to be associated with MTSD use. However, research findings regarding this result are controversial. Poulain and colleagues [28] found that both Internet/computer and mobile phone use was associated with conduct problems one year later, however the association was weak. Furthermore, a cross-sectional study found an association for 9–10-year-olds [104]. On the contrary, in line with our findings, McNeill and colleagues [27] did not find an association in their longitudinal study. Further studies are required to clarify this issue.

No association was found between prosocial behavior and MTSD use, in contrast to the results of many other studies [106,107]. The lack of linear association does not exclude the possibility that there is a non-linear (e.g., U-shaped association). Two studies demonstrated that moderate use is more beneficial for prosocial skills than non-use or high use [104,108]. Further studies should investigate the possibility of non-linear associations.

4.5. Limitations of the Study

To draw conclusions of the results, the limitations of the study should be addressed. First, MTSD use was solely measured with parent report using data only on the total duration of use, without further specifying the activities, frequency, time of use (weekdays/weekends), or purpose of use. In order to make data of MTSD use even more precise, special tracking apps on the devices should record objective, detailed data [109].

Second, there could be a bias in the assessment of behavioral difficulties. SDQ was assessed by only the parent, however a combination of objective measures would improve the study, such as a teacher report, or using different methodologies engaging parents more actively to support their recall memories or opinions about their child's behavior. These results potentially underestimate behavioral symptoms or provide a socially desirable response.

Thirdly, our study would benefit from measurements in more timepoints. Regarding representativity of the sample, convenience sampling may not be representative of the general population in terms of socio-economic status or other aspects. Larger sample size would be also favourable.

Lastly, additional experimental evidence is needed to identify mechanistic pathways.

5. Conclusions

This longitudinal study is among the firsts investigating transactional effects between contemporary media use and behavioral difficulties. Evidence was provided that early hyperactivity/inattention predicted later MTSD use, which may be due to these children's need for regulating their emotions, stimulating themselves with the MTSD or due to their parents using MTSDs to engage their children. The association found between peer relationship problems and MTSD use in school aged children is in line with poorer socio-cognitive skills found in MTSD users and may be bi-directional.

As children start to use MTSDs at an increasingly early age and amounts of time, it is predictable that the impact of MTSD use on young children will spread and became even more serious emphasizing the importance of good quality longitudinal studies allowing researchers to draw conclusions about causality. Although further research is needed to investigate the exact nature and potential mechanisms of these associations, results of the current study provide initial evidence that reducing or actively mediating MTSD use should be emphasized to parents and teachers. Additionally, studies should clarify how MTSD use, and behavioral difficulties are related to mediating and moderating factors (e.g., emotion regulation problems). This will inform health care workers, who must be aware of the motivations of MTSD use among children with emotional and behavioral difficulties to be able to provide sufficient help.

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Appendix A. Digital Kids Questionnaire (Short Form)

Q1. Your age:

Q2. Your gender:

- Man
- Woman

Q3. Your highest level of education:

- Elementary school
- Technical school
- High school
- College BA Bs(c)
- University MA MS(c)
- Postgraduate PhD

Q4. Child's date of birth:

Q5. Child's gender:

- Boy
- Girl

Q6. Number of siblings: _____

Q7. Husband's partner's highest level of education:

- Elementary school
- Technical school
- High school
- College BA Bs(c)
- University MA MS(c)
- Postgraduate PhD

Q8. With regard to your knowledge, which statement is true about your child's relationship with the smartphone?

- Has never seen or held a smartphone in his/her hand
- Has never held a smartphone in his/her hand, but has seen one
- Has already held/used a smartphone, but only on a few occasions
- Uses/holds a smartphone in his/her hand regularly (but does not have his/her own)
- Has his/her own smartphone (which he/she regularly uses)

[The followings were asked only from those who chose the fourth or fifth option in Q8]

Q9. How frequently does he/she use a smartphone?

- Several times daily
- Daily
- Every 2–3 days
- Every 4–5 days
- Weekly
- Every 2–3 weeks
- Monthly
- Less often than monthly

Q10. When he/she uses smartphone, how long does he/she typically use it for?

- More than 3 h

- 2–3 h
- 1–2 h
- 30–60 min
- 10–30 min
- 5–10 min
- A few min (5 min maximum)

Q11. With regard to your knowledge, which statement is true about your child's relationship with the tablet?

- Has never seen or held a tablet in his/her hand
- Has never held a tablet in his/her hand, but has seen one
- Has already held/used a tablet, but only on a few occasions
- Uses/holds a tablet in his/her hand regularly (but does not have his/her own)
- Has his/her own tablet (which he/she regularly uses)

[The followings were asked only from those who chose the fourth or fifth option in Q11]

Q12. How frequently does he/she use a tablet?

- Several times daily
- Daily
- Every 2–3 days
- Every 4–5 days
- Weekly
- Every 2–3 weeks
- Monthly
- Less often than monthly

Q13. When he/she uses tablet, how long does he/she typically use it for?

- More than 3 h
- 2–3 h
- 1–2 h
- 30–60 min
- 10–30 min
- 5–10 min
- A few min (5 min maximum)

Q14. Please rate the following statements according to how much they describe you. (not at all characteristic——absolutely characteristic)

If I feel uneasy/tense in company, I take out my phone.
I am nervous/tense when I leave my phone at home.
If my phone is in my hand, I feel more confident.
If I do not have my phone on me, I do not feel safe.

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