http://dx.doi.org/10.5392/IJoC.2015.11.4.031

Subjective Symptom of Visual Display Terminal Syndrome and State Anxiety in Adolescent Smartphone Users

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ABSTRACT

The objectives of this study were: 1) to determine smartphone addiction, visual display terminal syndrome (VDTS) related symptoms, and state anxiety among adolescents, and 2) to identify the relationship among these variables. Data were collected via self-administrated questionnaire survey from May to June, 2013. The survey was carried out with 540 voluntary participants at 13 to 24 years old from middle schools, high schools, and universities in Korea. The presence and severity of smartphone addiction, VDTS symptoms, and state anxiety were measured using Korean Smartphone Addiction Proneness Scale, VDTS Questionnaire, and State Anxiety Inventory, respectively. Data were analyzed by Cohen's Kappa coefficient, Kruskal-Wallis test, and Mann-Whitney U test. The mean score of smartphone addiction for all students was 2.17 ± 0.51. The mean scores of smartphone addiction depending on school grade were 2.12 ± 0.53, 2.03 ± 0.48, and 2.42 ± 0.43 for middle school, high school, and college students, respectively. Subjects who experienced minor level of VDTS symptoms had a score of 0.49 ± 0.49 for VDTS symptoms. The score was increased when the level of addiction was higher. There were significant differences in VDTS subjective symptoms among smartphone addiction groups (p<.001). High-risk group of smartphone addiction had the highest scores in every subdomain of VDTS symptoms. Differences were also found in state anxiety among the three groups with smartphone addiction. The findings of this study showed that approximately one out of three adolescents might be classified into problematic smartphone users. Therefore, it is important to educate problematic smartphone users about smartphone addiction and VDTS symptoms to prevent further addiction and aggravation of anxiety.

Key words*: Smartphone, Addiction, VDT Syndrome, Anxiety, Adolescent.*

1. INTRODUCTION

Smartphone has become an important tool for everyday life. As smartphone adopt leading edge technologies, it is expanding its functions to encompass other digital equipments such as digital camera, media player, and global positioning system unit. Its powerful functions are rapidly pulling in millions of users. The Ministry of Science, ICT and Future Planning of Korea (MSIP) reported that the number of smartphone users had jumped to about 40 million people, which is 69% of mobile communication service users, current at the end of 2014 [1]. Although smartphone penetration is going up among all age groups, young people growing up in digital era are especially leading the way. The spread of smartphone in young people is not a special phenomenon for one country but common in many countries over the world. According to the consumer report of Nielsen, the rates of smartphone users from 16 to 24 years old are the highest in 7 countries, and second in 2 countries among 10 countries surveyed [2].

Though smartphone is certainly an innovative and useful gadget, harmful excessive use of smartphone could lead to problems such as smartphone addiction. In terms of smartphone addiction, the high rate of adolescents in smartphone users needs to be considered. Young users are susceptible to smartphone addiction for they are more receptive to new things and technologies [3] and they believe that mobile phone is useful in maintain their friendship [4]. As they are likely to seek comfort from others and have strong motivation to win others' approval, adolescents tend to show problematic smartphone use [5].

Previous researches indicated that smartphone addiction might result in social and economic problems as well as physical and psychological problems. In social and informative aspects, smartphone addiction was considered to have the problems of information leaking, blind trusting, unbalancing of

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Manuscript received Sep. 08, 2015; revised Nov. 16, 2015; accepted Nov. 23, 2015

relationship, increasing of harmful information [6], and hindering sociality development [7]. Also, problematic use of smartphone may disturb studies and business, and result in financial problems [4], [8].

However, there is no clear definition of smartphone addiction in health aspects since it is related to not only physical but also psychological aspects. Instead of clear definition, several descriptions are available. Lee *et al* explained smartphone addiction as the excessive use of smartphone that interferes with the daily lives of the users [9]. They also added that smartphone addiction has various clinical features including tolerance, withdrawal symptoms, salience, mood modification, craving and loss of control [9].

Visual Display Terminal Syndrome (VDTS) is another problem of excessive smartphone use. VDTS occurs when an individual looks at the screen for a long time during long hours of using computer. The symptoms of VDTS include tiredness of eyes, decrease of visual acuity, headache, shoulder discomfort, and turtle neck syndrome [10].

Specific postures at the visual display terminal (VDT) workstation were significantly related to the severity of musculoskeletal symptoms in the shoulders, neck, and upper back [11]. For example, a seated posture and distance from operator is associated with a risk of musculoskeletal symptoms and disorders [12]. Physical symptoms increase with duration of daily VDT use without threshold, while mental and sleep related symptoms increase with VDT work of more than five hours per day [13]. The VDTS subjective symptoms and degree of severity differed from whether the students were computer-addicted or not. In all symptoms, which include general, musculoskeletal, eye related, and mental symptom, the mean subjective symptom score was higher in the addicted group than in the non-addicted group [14].

In the same manner, using smartphone for a long time can lead musculoskeletal problems caused by holding smartphone with hand, and also bring visual fatigue and weak vision due to keeping an eye on small display. As smartphone has relatively small screen in size, the using posture might be more harmful to body than that in which a user looks at display terminal of computer. Moreover, VDTS caused by smartphone might have more negative effects especially on adolescents because their physical growth and development has not ended. However, in the previous researches [12], [13], VDTS have been studied subjecting those who work in offices with computers screen. So the association between VDTS and smartphone overuse is not well-established.

The relationships between smartphone addiction and psychological health variables are various in the literature. Internet addiction was related to psychological health including anxiety but smartphone addiction was not in adolescents [3]. There were no significant differences in trait anxiety among high-risk group, at-risk group and normal group of college students [15] but smartphone addiction group had higher level of state anxiety than normal group [16]. These various results suggest that more research is needed on the relationship between smartphone addiction and anxiety.

Therefore, the aims of this study were to investigate the level of smartphone addiction in adolescents and the differences of VDTS related symptom experience and state anxiety in accordance with smartphone addiction level.

2. METHODS

2.1 Design and sample

This study employed descriptive research design. The study used questionnaire to identify smartphone addiction of adolescences, the differences of VDTS symptoms, and state anxiety according to the smartphone addiction level.

The students enrolled in eight schools or universities in Korea were recruited by convenience sampling and total 540 students volunteered in this study. Minimum sample size was calculated using G*power 3.1 software. With an alpha of .05, power of .95, effect size of .25, and three groups, number of valid samples was required more than 252. The sample size of 540 students was larger than necessary.

The schools or universities participating in the study consisted of two middle schools, four high schools, and two universities. They were chosen from three cities and the subjects consisted of 136 students from middle school, 239 from high school, and 165 from universities. The survey was carried out from May to June in 2013. The questionnaires were distributed and collected by the researchers and took approximately 30 minutes to complete.

2.2 Ethical considerations

The university institutional review board (IRB) granted approval for this study (EU 13-14). The purpose of the study, confirmation of anonymity, and voluntary participation were explained to the principals of the schools and the students. Before the survey, written consents were obtained. The students were also informed that there would be no disadvantages to nonparticipants and that the collected data would be used for only research purposes.

2.3 Data collection instruments

2.3.1 Adolescent: Although there are several definitions of adolescent, we followed here with the definition provided by the Framework Act on Juveniles of Korea. In this study, adolescent was defined as the people whose ages range from 13 to 24 years.

2.3.2 Smartphone addiction: Smartphone addiction was measured in two ways: by instrument and self-report. First, smartphone addiction was measured using Smartphone Proneness Scale for Youth (SAPS-Y) and Adult (SAPS-A), a questionnaire developed by National Information Agency [13]. The SAPS consists of 15 items each of which is measured on a 4-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree), with higher scores indicating higher levels of respondents' smartphone addiction. The Cronbach's alpha coefficient for the previous study [17] was .88(SAPS-Y) and .81(SAPS-A), and that of the current study was .88 (SAPS-Y) and .89 (SAPS-A).

In terms of self-reported smartphone addiction, the participants were asked if they were addicted to smartphone or not. The participants answered this question with 'yes' or 'no.'

2.3.3 Subjective symptoms of VDT syndrome: VDTS symptoms were assessed using VDTS Symptom Scale, a self-report questionnaire developed by Moon *et al* [10]. In their study, VDTS symptom was divided into five subdomains: eye-related, psychological, general body, musculoskeletal, and skin-related symptom. VDTS Symptom Scale consists of 33 items, which made up with 11 eye-related items, 7 psychological, 7 general body, 5 musculoskeletal, and 3 skin-related items, with 5 point Likert scale from 0(no) to 4(very severe). The higher score means higher level of VDTS symptom. The Cronbach's alpha coefficient for the previous study was .96 [11], and that of the current study was .95.

2.3.4 State anxiety: State anxiety was measured using the Spielberger State-Trait Anxiety Inventory (STAI-X-1), a self-report questionnaire revised by Kim [18]. STAI-X-1 consists of 40 items, each of which is measured on a 4-point Likert scale ranging from 1 (no) to 4 (very severe). In this study, only state anxiety was assessed with 20 items of STAI-X-1 since state anxiety changes over time and reflects a person's immediate perceived feeling of tension [19]. The higher score means higher level of state anxiety. The Cronbach's alpha coefficient for the previous study was .87 [18], and that of the current study was .87.

2.4 Data analysis

Descriptive statistics were used to analyze the characteristics, the level of smartphone addiction, subjective VDTS symptoms, and state anxiety of the participants. Then the participants were divided into three group, which were high-risk, at-risk, and normal groups, according to the smpartphone addiction scores on the SAPS-Y and SAPS-A. Cohen's Kappa coefficient was applied to evaluate the agreement between two smartphone addiction levels which were the subjective level based on the participants' report and objectively measured level using SAPS instruments.

As the data did not follow normal distribution, the Kruskal-Wallis test was used to compare the subjective VDTS symptoms and state anxiety in accordance with the level of smartphone addiction. The Mann-Whitney U test was carried out as a post hoc analysis. Statistical significance was set at $p < .05$, and Bonferroni correction was applied to adjust the significance level for post hoc analysis. Data analyses were performed with SPSS version 22.0 (IBM SPSS Statistics, Chicago, IL, USA).

3. RESULTS

3.1 General Characteristics

Table 1 shows the general characteristics of the sample. The subjects consisted of 238 male (44.1%) and 302 female (55.9%). The sample was aged between 13 and 24 years, with the mean age of 17.29±2.39 years. Of the subjects, 25.2% were the students from middle schools, 44.3% from high schools, and 30.6% from colleges.

In terms of subjective smartphone addiction, 29.1% of the subjects answered that they were addicted to smartphone, while 70.9% replied that they were not.

When asked how many hours a day they spent on smartphone, 25.6% reported 2~3 hours on a weekday with 23.0% reporting 1~2 hours and mean was 2.69±2.37 hours. In contrast to week days, 30.4% spent more than 5 hours on weekend days or holidays and mean was 4.00±3.24 hours.

Regarding the posture during smpartphone use, 35.7% chose 'lying on back' while only 12.8% answered that they sit straight. When they use smartphone, 65.6% had break time irregularly and 7.0% did not have break time at all.

Table 1. General characteristic of the subjects (n=540)

Item		Frequency (%)
Gender	Male	238 (44.1)
	Female	302 (55.9)
School grade	Middle school student	136 (25.2)
	High school student	239 (44.3)
	College student	165 (30.6)
Subjective smartphone addiction	Addicted	157 (29.1)
	Not addicted	383(70.9)
Average hours of use per day in weekday	Less than 1 hour	74 (13.7)
	1 ~ 2 hours	124 (23.0)
	2 ~ 3 hours	138 (25.6)
	3 ~ 4 hours	79 (14.6)
	4 ~ 5 hours	44 (8.1)
	More than 5 hours	77 (14.3)
	No response	4 (0.7)
Average hours of use per day in weekend	Less than 1 hour	49 (9.1)
	1 ~ 2 hours	69 (12.8)
	2 ~ 3 hours	72 (13.3)
	3 ~ 4 hours	81 (15.0)
	4 ~ 5 hours	93 (17.2)
	More than 5 hours	164 (30.4)
	No response	12 (2.2)
Posture while using smartphone	Sitting up straight	69 (12.8)
	Sitting bent	162 (30.0)
	Lying on back	193 (35.7)
	Lying face down	78 (14.4)
	Others	16 (3.0)
	No response	22 (4.1)
Break time while using smartphone	No break	38 (7.0)
	Taking a break irregularly	354 (65.6)
	Taking a break regularly	147 (27.2)
	No response	2 (0.2)

3.2 Smartphone Addiction

The findings on smartphone addiction showed that the mean score for all students was 2.17±0.51 and depending on the school grade, the mean scores were 2.12±0.53, 2.03±0.48

and 2.42±0.43 for middle school, high school, and college, respectively.

When the subjects were divided into three smartphone user groups by addiction level, which consisted of normal group and two problematic groups which were high-risk group and at-risk group, 184 subjects were found to be problematic groups and they can be classified into 33(6.1%) high-risk users and 151(28.0%) at-risk users. There were significant differences in smartphone addiction level among smartphone user groups by gender (p<.001), school grade (p<.001), and daily using time in weekday (p<.001) and weekend (p<.001) (Table 2).

Among female students, 8.6% belongs to high-risk group and 34.1% to at-risk group while in male students, only 2.9% were in high-risk group and 20.2% in at-risk group. When the problematic users were classified by school grade, the proportion of high-risk users was the highest in the college students (13.3%) followed by in middle school students (5.1%) and high school students (1.7%). However, the percentage of the students in at-risk users was the highest in middle school (30.9%) followed by college and high school. The percentage of problematic user, which is sum of high-risk users and at-risk users, were highest in college students (42.4%) followed by in middle school students (36.0%). Daily average hours of use of the high-risk group was 4.92±3.47 hours in weekday and 6.88±4.53 hours in weekend while normal group used 2.34±2.00 hours and 3.55±2.66 in weekday and weekend, respectively.

Table 2. Smartphone addiction by general characteristics

Group	High-risk group [a] (n=33)	At-risk group [b] (n=151)	Normal group [c] (n=356)	χ^2 (p)
Gender (n)				
male	7 (2.9%)	48 (20.2%)	183 (76.9%)	24.01
female	26 (8.6%)	103 (34.1%)	173 (57.3%)	(<.001)
School grade (n)				
middle school	7 (5.1%)	42 (30.9%)	87 (64.0%)	26.53
high school	4 (1.7%)	61 (25.5%)	174 (72.8%)	(<.001)
college	22 (13.3%)	48 (29.1%)	95 (57.6%)	
Using hours (M(SD))				
in weekday	4.92(3.47)	3.02(2.59)	2.34(2.00)	33.16*
		a > b > c**		(<.001)
in weekend	6.88(4.53)	4.40(3.72)	3.55(2.66)	28.93*
		a > b > c**		(<.001)

*Kruskal-Wallis test, **Mann-Whitney U test

3.3 The agreement of subjective and measured smartphone addiction

Kappa coefficient was used to evaluate the agreement between subjective and measured smartphone addiction. For the comparison of two variables, the problematic groups were considered as addicted group in the result of measured smartphone addiction by SAPS.

Table 3. Agreement between subjective and measured smartphone addiction

Measured by SAPS	Reported by respondents		total	k
	addicted	normal		
addicted	111(60.3%)	73(39.7%)	184(34.1%)	.12 (<.001)
normal	46(12.9%)	310(87.1%)	356(65.9%)	
total	157(29.1%)	383(70.9%)	540(100%)	

The Kappa coefficient in table 3 indicated that the agreement between subjective and measured addiction was poor (k =.12, p<.001). When we measured the level of smartphone addiction by SAPS, 34.1% fall into addicted group such as high-risk and at-risk group while 29.1% of the subjects answered that they were addicted. Among the addicted group based on SAPS measurement, 60.3% recognized their addiction but 39.7% did not (Table 3).

3.4 VDTS Subjective Symptoms

Mean score of VDTS subjective symptoms was .49±.49. VDTS subjective symptoms can be divided into five subdomains: eye-related, psychological, general body, musculoskeletal, and skin-related symptom. Among the five subdomains, musculoskeletal symptom had the highest score of .69±.74 and skin-related symptom had the lowest of .25±.50. Most subjects (91.1%) reported that they experienced more than one symptom. Among five symptom categories, the most experienced symptom was eye-related symptom at 76.1% of the subjects followed by general body symptom at 69.8% while skin related symptom was the least perceived symptom at 30.2% of the subjects (Table 4).

Table 4. VDTS subjective symptom experience (n=540)

VDTS Symptoms	M(SD)	Symptom experience	
		Yes	No
Total	.49(.49)	492 (91.1%)	48 (8.9%)
Eye related	.47(.55)	411 (76.1%)	129 (23.9%)
Psychological	.50(.60)	367 (68.0%)	173 (32.0%)
General body	.46(.54)	377 (69.8%)	163 (30.2%)
Musculoskeletal	.69(.74)	372 (68.9%)	168 (31.1%)
Skin related	.25(.50)	163 (30.2%)	377 (69.8%)

Regarding the breaking and the posture during smartphone use, the users having breaking irregularly had significantly higher VDTS symptom scores than the users having breaking regularly (χ^2=12.88, p=.002), and VDTS symptom scores was the highest in 'sitting bent' group followed by 'lying face down' group and 'lying on back' group while 'sitting up straight' group had the lowest score (χ^2=38.04, p<.001).

3.5 State Anxiety

State anxiety scores ranged from .55 to 3.40 with mean of 2.07±.44. College students had significantly higher score (2.13± .44) than middle school students (1.98±.46) (F=4.69, p=.010) while there was no difference between genders.

3.6 Differences of VDTS subjective symptom and state anxiety by smartphone addiction groups

There were significant differences in subjective symptoms of VDTS among smartphone addiction groups (p<.001). The VDTS symptom score of high-risk group was the highest followed by those of at-risk group and normal group. High-risk group also had the highest scores in every subdomain such as eye-related symptom (p=.001), psychological (p<.001), general body (p<.001), musculoskeletal (p<.001), and skin related (p<.001). The difference was also found in state anxiety among smartphone addiction groups (p=.001). The score of high-risk group was significantly higher than those of at-risk group and normal group (Table 5).

Table 5. Differences of VDTS subjective symptom and state anxiety by smartphone addiction group

Items	High-risk group [a] (n=33)	At-risk group [b] (n=151)	Normal group [c] (n=356)	χ^2*	(p)	Post hoc test**
Total VDTS symptoms	1.00(.64)	.55(.49)	.42(.45)	38.67	<.001	a>b>c
Eye related symptom	.81(.79)	.54(.56)	.42(.51)	14.3	.001	a,b>c
Psychological symptom	1.21(.79)	.55(.58)	.42(.54)	39.58	<.001	a>b>c
General symptom	.98(.72)	.52(.61)	.38(.46)	30.64	<.001	a>b,c
Musculoskeletal symptom	1.32(.83)	.78(.74)	.59(.70)	32.44	<.001	a>b>c
Skin related symptom	.69(.70)	.27(.53)	.21(.44)	32.07	<.001	a>b,c
State anxiety	2.25(.44)	2.11(.41)	2.03(.44)	13.79	.001	a>b,c

*Kruskal-Wallis test, **Mann-Whitney U test

4. DISCUSSION

The results found that the level of smartphone addiction was similar to the previous researches [7], [20], [21]. The proportion of problematic users in female was higher than in male and this was same result as a previous research [20]. In this context, the difference in the addiction rate between genders should be considered in the development of smartphone addiction prevention program.

The percentage of problematic group was the highest in college students followed by middle school students and high school students. This finding was little different from the survey result of the MSIP that points out addiction rate tends to decrease in older users [22]. This difference might come from the different age grouping of the participants. The MSIP grouped the participants based on age and classified college students into 20s group while this study grouped by school grade and put college students into independent group. However, considering the MSIP's survey also found that the percentage of 20s in problematic users was 28.7% [22], college students might show weakness to smartphone addiction.

The lowest rate of problematic users being high school students may reflect the unique situation of Korean high school. As Korean high school students spent most their time in schools for the preparation of college entrance exam and some schools regulate mobile phone use in school, they do not have enough time or changes to use smartphone. This circumstance cause the decrease of problematic user rate compared to middle school students. However, after they become college students with no mobile phone restriction, mobile phone use including smartphone would increase again.

The rate of problematic users in middle school should also be paid attention. According to the previous researches [23], [24], adolescents who use a phone early would be more likely to be addicted. Therefore, the high rate of problematic user in middle school students may contribute to a higher percentage of problematic adult user including college students in the future. This finding suggested that prevention and treatment programs for middle school students might be necessary in school.

In this study, smartphone addiction assessments were carried out in two ways; the self-reported addiction assessment and measured addiction assessment using the SAPS. It was found that the agreement level between two assessments was low. This gap implied that the adolescent smartphone users might not realize their situation accurately. Furthermore, 39.7% of problematic users who belong to high-risk or at-risk group, when assessed by the SAPS, recognized themselves as normal users. This could be understood that the smartphone addiction risk might be underestimated among adolescents. As the MSIP reported, the number of smartphone users in Korea has already exceeded 40 million and is continuing to increase [1]. Considering this increase of smartphone users, the disagreement between their awareness of addiction and real addiction level would also be inflated. Therefore, the objective assessment must be provided for adolescents to understand their smartphone use exactly and to reduce the risk of being addicted to smartphone through self-control.

The subjects seemed to not have experienced VDTS symptoms very seriously, but most subjects had experienced at least one of the symptoms. The high-risk group especially had experienced VDTS symptoms more frequently than other groups. This finding supported the previous studies showing that computer addicted group perceived more VDTS symptoms than non-addicted group [14]. This was also linked to several studies on VDTS. Kim *et al* pointed that the excessive use of mobile phones and video media caused weak vision [25] and Choi reported that most smartphone users complained eye strain [26], and Kang *et al* found that long use of visual display terminal could lead to musculoskeletal problems [27]. It was suggested that problematic smartphone

use may cause various VDTS symptoms and smartphone use guidelines for adolescents should be developed as well.

Among VDTS symptoms, eye-related symptom was the most commonly experienced but the severity of symptom was the highest in musculoskeletal symptom. This reflects the characteristics of smartphone. Smartphone is smaller in size compared to traditional VDT and does not have stand body for screen. Due to these characteristics, users have to hold smartphone with their hands while they look at the small screen. This posture might cause the increase of severity in musculoskeletal symptom. Moreover, the subjects of this study used smartphones at an average of 2.69 hours on the weekdays and 4.00 hours in the weekend mostly in 'sitting bent' and 'lying on back' posture. Therefore, since long hour of smartphone use and improper posture raise VDTS symptom, the education for adolescents will be necessary.

Considering the users having breaks regularly had lower severity in VDTS symptom, breaks during smartphone use should be emphasized and included in the guideline for the prevention of smartphone addiction to alleviate musculoskeletal symptom as well as eye related symptom. The recommendation of the Ministry of Employ and Labor regarding the breaks, which is that the users must take at least 10 minutes of rest per every hour they use VDT [28], could be referred to the guideline for smartphone use.

The level of state anxiety in high-risk group was higher than those of at-risk group and normal group. This finding that state anxiety was associated with smartphone addiction is consistent with the related literatures [16], [29], [30]. The previous researches found that smartphone addicted group had higher level of state anxiety than normal group [16] and the more addicted group in mobile phone use showed higher level of anxiety [29]. In similar manner, Mehroof and Griffiths pointed out that state anxiety was significantly associated with online gaming addiction [30]. These findings suggest that state anxiety factors encourage excessive smartphone use like online gaming. However, as state anxiety is related to the immediate situation and the extent of a subject's relaxation [31], the intervention program for smartphone addiction might alleviate the state anxiety of addicted users in adolescents and the intervention program should reflect the characteristics of the addicted users such as anxiety.

5. CONCLUSION

This study was carried out to examine smartphone addiction, VDT symptoms, state anxiety and their relationship in adolescents to provide empirical evidence for development of smartphone addiction prevention and treatment program. The results showed that the rate of problematic users was found to be higher in female than male and was the highest in college students followed by middle school students. As considerable number of problematic users understood that they were normal, there were the gaps between the self-reported addiction assessment and the measured addiction assessment. Therefore, the objective assessment would be necessary to help adolescents identify themselves correctly.

The level of the VDT related symptoms was not serious in this study but most subjects experienced more than one symptom. The state anxiety was found to be higher in high-risk group than in at-risk group and normal group. These findings suggest that the prevention and intervention program would be helpful to enhance both physical and mental health of adolescent smartphone users.

This study provides evidences that problematic smartphone use is related to VDTS symptom experiences and increase of state anxiety. However, as the subjects of this study were recruited in limited area, there were difficulties in the generalization of the study results.

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