Research article

Reciprocal longitudinal effects among Korean young adolescent' negative peer relationships, social withdrawal, and smartphone dependence[☆]

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A B S T R A C T

The research should consider the complex dynamics of social interaction to better understand smartphone dependence among adolescents. In social situations, adolescents can choose to interact with their peers or use their smartphones, and smartphone dependence can drive adolescents far away from interaction with their peers. Adolescents, conversely, may use smartphones to avoid peer interaction because they have experienced social withdrawal or negative peer relationships. Previous research has not discussed enough what precedes or follows in longitudinal relationships. This study aims to examine the reciprocal longitudinal effects between adolescents' negative peer relationships, social withdrawal, and smartphone dependence. The analysis used longitudinal panel data collected yearly between 2018 and 2020 from the Korean Children and Youth Panel Survey (KCYPS) sampled from adolescents in the Republic of Korea and employed autoregressive cross-lagged modeling on 2230 participants. The reciprocal longitudinal relationships differed depending on the sub-factors of smartphone dependence. For instance, the sub-factor of smartphone dependence, including virtual life orientation and withdrawal, had reciprocal longitudinal relationships with negative peer relationships. The other sub-factor of smartphone dependence, including daily life disturbance and tolerance, influenced negative peer relationships consistently, but the converse path did not. In addition, social withdrawal longitudinally affected negative peer relationships the following year. However, the reciprocal longitudinal relationships between social withdrawal and smartphone dependence were not significant in any path in this research. This research provides practical implications for intervention to reduce smartphone dependence among young adolescents.

1. Introduction

More than 95 % of Koreans have smartphones [1]. The risk ratio of smartphone dependence increases annually in the Republic of Korea, with the highest risk ratio in the adolescent group, particularly middle school students aged between 13 and 15 [2]. Most adolescents in Korea feel smartphone use comfortable [3], and they perceive their smartphones as their "other" hand [4]. Hence,

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adolescents' smartphone use is like a double-edged sword; that is, it has both positive and negative sides. The use of smartphone by adolescents may decrease digital divides in educational fields as well as increase their smartphone dependence.

Previous studies explored the antecedents and consequences of smartphone dependence in various contexts. First, the user's traits such as low self-esteem, insecure attachment, and emotional instability were associated with increasing problematic smartphone use [5]. The motivation for smartphone use, particularly non-communicative usage, can also lead to problematic smartphone use [6–8]. Other studies explain that adolescents' smartphone dependence is associated with relational satisfaction or reassurance in affective relationships [5]. For example, a user with a high fear of missing out or need for keeping in touch may show problematic smartphone usage [9]. Adolescents' smartphone dependence may reduce their social adaptability because they focus more on games or play alone, thus reducing relationships with peers necessary for the developmental process [10,11]. These studies suggest that smartphone dependence relates to young adolescents' need for personal relationships.

The present study examined reciprocal longitudinal relationships between smartphone dependence and the variables related to dissatisfaction with interpersonal relationships. Previous studies emphasize explanatory variables such as negative peer relationships [12–14] and social withdrawal [15–18] in explaining adolescents' smartphone dependence. In contrast, some studies demonstrate the effects of smartphone dependence on negative peer relationships [19] and the reduction of social relationships [10]. Although empirical evidence accounts for the association between negative peer relationships, social withdrawal, and smartphone dependence, there has been little discussion about which variables could precede or follow the others or have reciprocal effects in longitudinal relationships.

Reciprocal relationships between each variable can be explicated by the choice theory perspective indicating that individuals can choose specific behaviors or alternative ways to satisfy their needs [20]. For example, adolescents may choose to spend more time using smartphones when they experience negative peer relationships. Conversely, adolescents with a high level of smartphone dependence may decide to use a smartphone rather than spend time with a peer to satisfy their needs. The socially withdrawn adolescent may experience negative peer relationships or smartphone dependence in their non-satisfied needs for interpersonal relationships. In any case, negative peer relationships and smartphone dependence may lead to avoidance of peer relationships.

This study addresses the reciprocal longitudinal relationships between variables based on the 'choice theory' [20]. We map out conflicting points of view about the following relationships: 1) negative peer relationships and smartphone dependence, 2) negative peer relationships and social withdrawal, and 3) social withdrawal and smartphone dependence. Further, the current study analyzes the relationships between negative peer relationships, social withdrawal, and smartphone dependence to explore reciprocal longitudinal effects.

2. Literature review

For adolescents, meaningful relationships gradually focus on peers, moving away from parents. Adolescents spend more time with their peers, have reduced oversight by adults, and may think peer opinions and expectations are important [21]. Hence, peer relationships are essential to adolescent psychological development [22]. Hinde defines relationships as interaction patterns between two individuals who know each other [23], influenced by past interactions between individuals concerned and by their expectations for interactions in the future (p. 5). Consequently, negative peer relationships mean the adolescents' perceptions about the interaction with other peers are negative. At the same time, negative peer relationships are associated with negative experiences and expectations in/about peer relationships. The problem is that the need to belong is the embedded need in our genes [24]. Therefore, adolescents who perceive negative peer relationships may not be satisfied with peer relationships even though the connections are essential to adolescents.

In his choice theory, Glasser suggests we can change choice to alternative behavior when basic needs are not satisfied [20]. For example, people may drive engagement in social connection behavior to fulfill their need to belong [25,26]. One of smartphone functions is facilitating interpersonal relationships [27]. Hence, adolescents' high-level negative peer relationships may affect smartphone dependence as an alternative way to fulfill their needs for interpersonal relationships. On the other hand, this perspective paradoxically explains the effects of smartphone dependence on negative peer relationships. Adolescents may not perceive the necessity of recovering negative status in peer relationships when smartphone use satisfies their needs, although they are dependent. Previous research suggests that smartphone addiction affects negative peer relationships by making it challenging to acquire desirable social skills [19]. However, empirical evidence to support longitudinal relationships between negative peer relationships and smartphone dependence among young Korean adolescents is not sufficient.

More complex relationships are intertwined among social withdrawal, negative peer relationships, and smartphone dependence. Social withdrawal means "isolating [oneself] from the peer group," relevant to "anxiety, negative self-esteem, and self-perceived difficulties in social skills and social relationships" [28]. It also refers to "the consistent (across situations and over time) display of solitary behavior in the company of familiar peers" [29]. Rubin and colleagues suggest organic relationships between social withdrawal and peer relationships [28]. According to their view, many children may experience anxiety symptoms that could impair their social interaction and peer relationships. Children with anxiety symptoms can choose to withdraw from the social community to decrease their anxiety, and social withdrawal can be reinforced if avoidance help reduce anxiety [30]. Therefore, socially withdrawn children pursue social goals guardedly in social interactions, and unfortunately, their social goals are less likely to succeed [31]. This perspective explains the assumption that social withdrawal affects negative peer relationships.

Previous study analyzed the circular relationship between social withdrawal and negative peer relationships among adolescents [32]. In sum, the social withdrawal of adolescents affects negative peer relationships, and at that same time, negative peer relationships strengthen social withdrawal. Some children may be socially reticent and have poor social skills, but not every child with

poor social skills experiences social withdrawal [33]. Rubin and colleagues suggested that adolescents may choose social withdrawal or avoidance strategies to cope with peer victimization [28].

Rejection and bullying by peers in peer relationships also strengthen social withdrawal [28,34]. Adolescents excluded by peers have a high level of socially helpless behavior than non-excluded adolescents [33]. In addition, an aggressive peer could target and victimize socially reticent adolescents whose possibility of retaliation may be low [28]. Gazelle and Rudolph interpreted their result to focus on the social environment's influence on subsequent development [33]. Anxious adolescent may reduce social avoidance motivation when they do not experience peer exclusion, and do not have negative expectations about peer relationships in their social interaction [33]. This perspective accounts for the effects of negative peer relationships on social withdrawal, and previous research discusses this assumption concerning adolescents in Korea [13,15,35]. However, the longitudinal relationships between negative peer relationships and social withdrawal are still unclear.

The choice theory also applies to the reciprocal relationships between social withdrawal and smartphone dependence. People have basic needs to belong [20]; so that socially withdrawn adolescents may not fulfill belonging needs through social interactions because they tend to withdraw or avoid social interactions or peer communities. Hence, adolescents in a social withdrawal state can choose over-using their smartphones as an alternative way to satisfy their needs for social interaction. A previous study found that a substantial need for social interaction positively correlated with frequent smartphone usage [36] (Cheng & Meng, 2021). The other study presents empirical evidence of a positive association between the period of social withdrawal and adolescents' involvement in online activities [37]. The research above demonstrates the effects of social withdrawal on smartphone dependence among adolescents.

Conversely, the view of choice theory also explains the effects of smartphone dependence on adolescents' social withdrawal. The definition of smartphone dependence has three dimensions: self-control failure of smartphone use, salience through smartphone overuse, and serious consequences by smartphone overuse [2]. Self-control failure means the lower regulating ability of smartphone use compared with one's goals. Salience implies smartphone usage is a major concern more than other activities in daily life. Serious consequences may be followed by the persistent use of smartphones. In the current research, we noted that smartphone dependence is closely related to the choice of smartphone usage behavior over face-to-face interactions or other activities in daily life.

Every behavior occurs to fulfill the needs of people [20], and adolescents' smartphone dependence may also be one of the consequences of their attempts to satisfy their needs through smartphone usage. Thus, adolescents depending on smartphones can choose to withdraw from their peer relationships because they expect to gratify their needs by using smartphones. Problematic smartphone usage may interfere with adolescents' interpersonal relationships by diverting their attention from the real world [38]. Smartphones may distract users' attention from a face-to-face conversation by merely having a phone at hand [39]. Moreover, problematic smartphone usage may interfere with other social activities and increase phubbing behavior that too much attention is paid to the smartphone instead of face-to-face conversation [38]. Although these studies dealt with the association between smartphone dependence and social withdrawal, further examinations are needed to prove the reciprocal longitudinal relationships among relevant variables.

Our research model investigates longitudinal reciprocity relationships between a) negative peer relationships and smartphone dependence, b) negative peer relationships and social withdrawal, and c) social withdrawal and smartphone dependence among Korean adolescents. Based on the above-mentioned reasoning, we will explore the following research questions:

RQ1. Is there a reciprocal longitudinal, over-time association between negative peer relationships and smartphone dependence among young adolescents in Korea?

RQ2. Is there a reciprocal longitudinal, over-time association between negative peer relationships and social withdrawal among young adolescents in Korea?

RQ3. Is there a reciprocal longitudinal, over-time association between social withdrawal and smartphone dependence among young adolescents in Korea?

3. Method

3.1. Data and participants

Data used longitudinal panel data from the Korean Children and Youth Panel Survey (KCYPS) by the National Youth Policy Institute in Korea. The KCYPS was collected by repeated measures, and it opened each year as public data without personal information. From December 2022, the fourth data was opened for every researcher who agreed to the data policy of the National Youth Policy Institute. This research, likewise, got permission for data used and analyzed from the National Youth Policy Institute. The participants began the survey during the first year of middle school (Time 1), participated in the second year of middle school (Time 2), in the third year of middle school (Time 3), and participated in the fourth survey after entering high school. The current study used data only from Time 1 (2018) to Time 3 (2020) because entering high school may be conditions confounding the results. The study included 2230 adolescents who answered every survey question: 1204 (53.7 %) male and 1038 (46.3 %) female adolescents.

3.2. Measures

3.2.1. Negative peer relationships

We measured negative peer relationships with five items developed by previous research [40] using a four-point Likert scale (1 =

not at all, 2 = *tend not to*, 3 = *rather much*, 4 = *very much*). Sample items include "I don't reconcile well when I fight with my friend" and "My friends are not interested in my difficulties and hard life." Higher scores mean the adolescents perceived their peer relationships more negatively. This research excluded a single item ("I have frequent disagreements with friends") because it decreased internal consistency. We had acceptable internal consistency scores on the four items for measuring negative peer relationships (Cronbach's alpha, Time 1 = 0.73, Time 2 = 0.80, Time 3 = 0.81).

3.2.2. Social withdrawal

We used five items from the Korean Children and Youth Panel Survey based on previous research (Kim & Kim, 1998) to measure social withdrawal. Participants rated the items on a four-point Likert scale ranging 1 (*not at all*) to 4 (*very much*). Sample items include "I feel difficulty expressing my opinion clearly to others" and "I do not particularly appreciate getting in front of other people." Our study had good reliability on this measure (Cronbach's alpha, Time 1 = 0.87, Time 2 = 0.88, Time 3 = 0.88).

3.2.3. Smartphone dependence

We measured smartphone dependence using 15 items developed from previous research [41]. These 15 items contained four sub-factors - *daily life disturbance, virtual life orientation, withdrawal, and tolerance* [42]. *Daily life disturbance* refers to problems at home, school, and work due to smartphone use. A sample item is "My friends and family are frequently complaining about my behavior of too much use of smartphone." *Virtual life orientation* means feeling (thinking) more comfortable using smartphones to form relationships than in the real world. For example, "I feel like I have lost the whole world when I cannot use my smartphone." Then, *withdrawal* refers to being anxious or impatient if adolescents think the smartphone is not beside them; items include "I feel restless and nervous without a smartphone." Lastly, *tolerance* is a state in which adolescents do not feel satisfied even when they use their smartphones. For example, "I tried to cut down on my smartphone usage time but failed." We applied the same four-point Likert scale as with the above scales. Further, we excluded five items that decreased internal consistency in an exploratory factor analysis.

This research confirmed the two sub-factors from the measurement items of smartphone dependence through the results of the exploratory factor analysis (EFA) (see Table 1). The first factor includes daily life disturbance (four items) and tolerance (two items), and the second includes virtual life orientation (single item) and withdrawal (three items). The internal consistency scores of the first factor were acceptable (Cronbach's alpha, Time 1 = 0.86, Time 2 = 0.86, Time 3 = 0.89). Similarly, the reliability of the second factor was Time 1 = 0.83, Time 2 = 0.85, and Time 3 = 0.83. Confirmatory factor analysis (CFA) had acceptable scores for model fit (including the first factor of smartphone dependence, $\chi2$ (897) = 3765.343, $p < 0.001$, $\chi2/df$ = 4.198, TLI = 0.93, CFI = 0.94, RMSEA = 0.04, and the second factor, $\chi2$ (666) = 2729.014, $p < 0.001$, $\chi2/df$ = 4.098, TLI = 0.94, CFI = 0.95, RMSEA = 0.04), and all regression weights were also appropriate (higher than 0.6).

3.3. Data analysis

The present study employed autoregressive cross-lagged (ARCL) modeling to investigate the reciprocal longitudinal relationships between main variables. Autoregressive cross-lagged modeling can analyze the autoregressive effects of the stability of the same variable over time and the cross-lagged effects of one variable with another variable in longitudinal relationships [43]. Therefore, the current study employed autoregressive cross-lagged models between negative peer relationships, social withdrawal, and smartphone dependence (considering two sub-factors: 1) daily life disturbance and tolerance, and 2) virtual life orientation and withdrawal) using AMOS 26.0.

In this study, we assumed the homogeneity of autoregressive cross-lagged modeling for the five models: Model 1: basic model (no-constraint model), Model 2: measurement homogeneity constraint for each variable, Model 3: homogeneity constraint on the autoregressive coefficient of each variable, Model 4: homogeneity constraint on the cross-lagged coefficient between each variable,

Table 1
Descriptive statistics and factor loadings of the final items for the smartphone dependence.

Items	Factor Loading	Mean (S. D.)	Skewness (Kurtosis)	α
Daily life disturbance and Tolerance		2.21 (.62)	−.019 (−.423)	0.86
My school grades drop due to excessive use of smartphones	0.597			
I have been singled out for using my smartphone from time to time	0.808			
My friends and family are frequently complaining about my behavior of too much use of smartphone	0.808			
There have been times when I could not concentrate on what I was doing/studying because I was using my smartphone	0.655			
I tried to cut down on my smartphone usage time but failed	0.666			
I think I should stop when I use my smartphone, but I keep going	0.692			
Virtual life orientation and Withdrawal		1.62 (.59)	.85 (.40)	0.83
I feel like I've lost the whole world when I can't use my smartphone	0.808			
It would be unbearable if the smartphone became unusable	0.776			
I feel restless and nervous without a smartphone	0.824			
I cannot work (study) all day if the smartphone is not by my side	0.652			

Note. The exploratory factor analysis (EFA) includes all items used in this, but the table only presents the value of smartphone dependence measurement items on Time 1. These items used from the Korean Children and Youth Panel Survey.

Model 5: homogeneity constraint on the error coefficients of each variable. We used the RMSEA, TLI, and CFI to compare model fitness to identify the equivalence assumption because the $\chi2$ and $\Delta\chi2$ difference tests are sensitive to sample size. For the RMSEA, a result smaller than 0.06 is a very good fit, TLI and CFI values of 0.90 or higher are also acceptable models [44–46]. Further, our results satisfy the equivalence assumption when the values of TLI, CFI, and RMSEA become worse or better than 0.01 [47,48].

4. Results

4.1. Preliminary analysis

Table 2 indicates the correlation across time points between key variables in this research. Each variable had a positive correlation with the same variables measured at other time points, and correlations between each variable also were significant. For instance, the negative peer relationships in Time 1 positively correlate with negative peer relationships in Time 2 and Time 3. Further, correlations between social withdrawal and smartphone dependence are positively significant with negative peer relationships. The results of skewness ($-0.17\sim0.85$) and kurtosis (-0.59–0.88) tests were respectively normally distributed on all variables (Kline, 2005).

4.2. Autoregressive cross-lagged model

We tested the competitive models to assess sequentially imposing equality measurement invariance, homogeneity of paths, and error covariance homogeneity (Table 3). The fitness of measurement homogeneity was not significantly different from the basic model, thus confirming the equality of the measurement over time. Moreover, the model, an equality constraint for the autoregressive coefficient, was not significantly different in terms of goodness-of-fit from the homogeneity model measurement. Further, the model for equality constraint for the cross-lagged coefficient was not significantly different from the autoregressive homogeneity model. Lastly, the model with equality constraint for the error covariance also had acceptable goodness-of-fit compared to other models. As shown in Table 3, the goodness-of-fit of the autoregressive homogeneity model, the cross-lagged homogeneity model, and the error covariance homogeneity model were all acceptable and similar in this research. These processes applied to the models all about smartphone dependence sub-factors. Thus, the current study selected the covariance homogeneity model as the final model. We imposed equality constraints for measurement, autoregressive homogeneity, cross-lagged homogeneity, and covariance homogeneity to the final model (sub-factor 1: $\chi2$ (942) = 3942.711, p < 0.001, $\chi2$/df = 4.185, TLI = 0.93, CFI = 0.94, RMSEA = 0.04; sub-factor 2: $\chi2$ (707) = 2943.917, p < 0.001, $\chi2$/df = 4.164, TLI = 0.94, CFI = 0.94, RMSEA = 0.04).

The present study applied autoregressive cross-lagged (ARCL) modeling to the reciprocal longitudinal relationships between negative peer relationships, social withdrawal, and the sub-factors of smartphone dependence. The cross-lagged paths between each time point were equal because they had imposed cross-lagged homogeneity in the final model. Fig. 1 demonstrates the results of ARCLM considering the first factor of smartphone dependence, including daily life disturbance and tolerance. In the cross-lagged paths, social withdrawal at Times 1 and 2 positively influenced negative peer relationships at Times 2 and 3 (β = 0.049, C.R. = 3.299, p < 0.001). Likewise, the first factor of smartphone dependence, which includes daily life disturbance and tolerance, had significant cross-lagged effects on negative peer relationships in the next time point (β = 0.073, C.R. = 3.384, p < 0.05). Namely, social withdrawal and smartphone dependence (including daily life disturbance and tolerance) increased consistently negative peer relationships across three years.

In Fig. 2, the model that considers the second factor of smartphone dependence, including virtual life orientation and withdrawal of smartphone, had significant cross-lagged effects of social withdrawal on negative peer relationships (β = 0.053, C.R. = 3.754, p < 0.001). Further, the cross-lagged effects of negative peer relationships and the second factor of smartphone dependence, including virtual life orientation and withdrawal, were significant in reciprocal longitudinal relationships. In autoregressive cross-lagged (ARCL) modeling, virtual life orientation and withdrawal consistently increased the negative peer relationship (β = 0.058, C.R. = 3.709, p < 0.01). Moreover, the higher negative peer relationships in the previous time point were associated with higher smartphone

Table 2
Descriptive statistics and correlation matrix.

	Mean (SD)	1	2	3	4	5	6	7	8	9	10	11	12
1. Negative peer relationships (Time 1)	1.76 (0.55)	1											
2. Negative peer relationships (Time 2)	1.78 (0.59)	0.29	1										
3. Negative peer relationships (Time 3)	1.76 (0.58)	0.19	0.26	1									
4. Social withdrawal (Time 1)	2.16 (0.75)	0.27	0.15	0.15	1								
5. Social withdrawal (Time 2)	2.13 (0.72)	0.17	0.30	0.16	0.46	1							
6. Social withdrawal (Time 3)	2.18 (0.71)	0.14	0.16	0.24	0.39	0.49	1						
7. Smartphone dependence (D & T) (Time 1)	2.21 (0.62)	0.24	0.13	0.12	0.29	0.18	0.16	1					
8. Smartphone dependence (D & T) (Time 2)	2.26 (0.60)	0.15	0.25	0.16	0.19	0.33	0.21	0.46	1				
9. Smartphone dependence (D & T) (Time 3)	2.29 (0.65)	0.15	0.14	0.20	0.14	0.20	0.31	0.35	0.47	1			
10. Smartphone dependence (V & W) (Time 1)	1.62 (0.59)	0.25	0.15	0.13	0.21	0.10	0.09	0.54	0.25	0.19	1		
11. Smartphone dependence (V & W) (Time 2)	1.76 (0.62)	0.14	0.32	0.16	0.10	0.21	0.09	0.22	0.51	0.22	0.35	1	
12. Smartphone dependence (V & W) (Time 3)	1.82 (0.62)	0.13	0.20	0.25	0.08	0.11	0.17	0.19	0.30	0.57	0.31	0.43	1

Note. All correlation coefficients were significant at the level of *p* < 0.01. Smartphone Dependence (D & T) = Daily life disturbance and Tolerance, Smartphone Dependence (V & W): Virtual Life Orientation and Withdrawal of Smartphone.

Table 3
Summary of model comparisons.

Model	Smartphone Dependence: Daily life disturbance and Tolerance					Smartphone Dependence: Virtual Life Orientation and Withdrawal				
	χ2	df	RMSEA	TLI	CFI	χ2	df	RMSEA	TLI	CFI
Basic Model	3874.385	906	.038	.931	.937	2871.393	675	.038	.939	.945
Measurement homogeneity	3920.337	930	.038	.933	.937	2913.536	695	.038	.940	.944
Autoregressive homogeneity	3933.349	933	.038	.933	.936	2923.221	698	.038	.941	.944
Cross-lagged homogeneity	3933.871	939	.038	.933	.937	2928.358	704	.038	.941	.944
Error variance homogeneity	3942.711	942	.038	.933	.936	2943.917	707	.038	.941	.944

Note. The homogeneity model includes the equality constraints of each variable. For example, we verified the autoregressive homogeneity model by imposing identity constraints on the autoregressive coefficient of each variable (i.e., negative peer relationships, social withdrawal, and smartphone dependence).
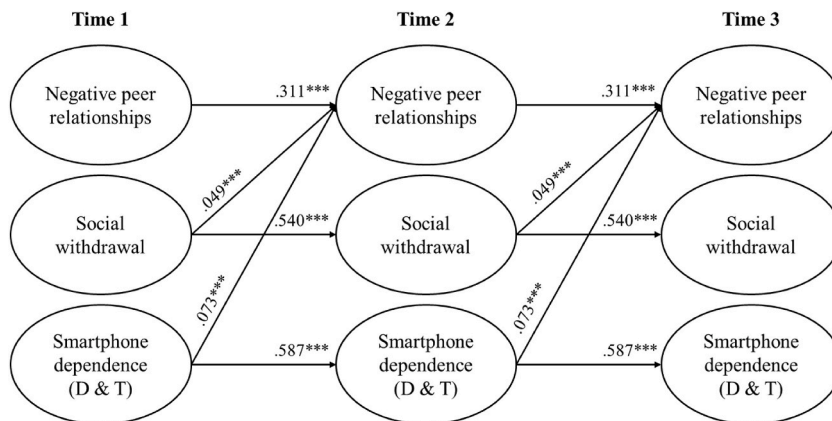
Fig. 1. Autoregressive Cross-Lagged Model between Negative Peer Relationships, Social Withdrawal, and Smartphone Dependence (Daily life disturbance and Tolerance).
Note. All coefficients presented are standardized regression weights. Smartphone dependence (D & T): Daily life disturbance and Tolerance ***$p < 0.001$.
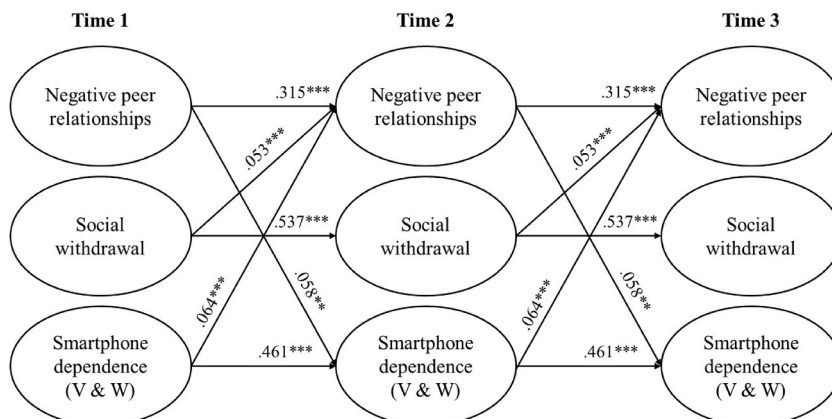
Fig. 2. Autoregressive Cross-Lagged Model between Negative Peer Relationships, Social Withdrawal, and Smartphone Dependence (Virtual Life Orientation and Withdrawal).
Note. All coefficients presented are standardized regression weights. Smartphone dependence (V & W): Virtual life orientation and Withdrawal of Smartphone ***$p < 0.001$, **$p < 0.01$.

dependence, including virtual life orientation and withdrawal in the next time point (β = 0.053, C.R. = 2.697, p < 0.001).

On the contrary, the cross-lagged effects between social withdrawal and smartphone dependence were non-significant in every path.

5. Discussion

This study examined the reciprocal longitudinal relationships between negative peer relationships, social withdrawal, and smartphone dependence among young adolescents in the Republic of Korea. We employed autoregressive cross-lagged modeling and analyzed the longitudinal model using repeated measurement data collected yearly from the adolescent panel (from the first year to the third year in middle school)—the present study focuses on reciprocal relationships among three variables. The main finding of this research indicates three crucial points.

First, the results showed smartphone dependence of Korean adolescents increased negative peer relationships over time. However, the reciprocal longitudinal relationship indicates differently according to sub-factors. The results separate the two factors of smartphone dependence (i.e., daily life disturbance and tolerance, virtual life orientation and withdrawal). We found reciprocal longitudinal relationships between negative peer relationships and the sub-factor of smartphone dependence (i.e., virtual life orientation and withdrawal). Adolescents with high-level of virtual life orientation and withdrawal may experience negative peer relationships. Further, the negative peer relationships among young adolescents facilitated by virtual life orientation and withdrawal may reinforce their virtual life orientation and withdrawal in the next period. In sum, virtual life orientation and withdrawal are the causes and consequences of the negative peer relationships of young adolescents. On the other hand, the longitudinal relationships between negative peer relationships and the sub-factor of smartphone dependence (i.e., daily life disturbance and tolerance) are not reciprocal. Only daily life disturbance and tolerance lead to negative peer relationships in longitudinal relationships.

This finding reveals the importance of choice to alternative ways and belonging needs from the perspective of choice theory [20]. While the virtual world offers visitors social and emotional support through communicating with other users, there is a positive association between the need for belonging and problematic internet usage [49]. The high level of smartphone dependence among adolescents may indicate that adolescents satisfy their needs using their smartphones. Thus, adolescents whose smartphone usage satisfies their needs may not feel additional needs for peer relationships. However, peer relationships are essential and fundamental needs for adolescents. Moreover, negative peer relationships mean adolescents should find other ways to replace peer relationships for their satisfaction. The virtual world can be a way to satisfy related needs by providing communication with other users [49]. Therefore, the individual who wants reassurance from others in affective relationships or has the motivation for social inclusion may use the smartphone excessively [5,50,51].

Second, social withdrawal increased negative peer relationships persistently across the three years. The specific result is consistent with the perspective that socially withdrawn adolescents may make their social goals difficult [31]. However, researchers should interpret this result considering theoretical discussion [28] and the effects of negative peer relationships. The finding shows that negative peer relationships are not directly associated with social withdrawal in longitudinal relationships. Thus, this research does not support the assumption that adolescents who experience negative peer relationships also suffer from social withdrawal. For example, adolescents can try social interaction to restore their relationships within the peer group, despite having experienced negative peer relationships for a moment. However, adolescents who experience serious social withdrawal may have negative expectations for their peer relationships next time.

Previous studies analyzed the effects of negative peer relationships on social withdrawal [32] and smartphone dependence [13], but our research results are inconsistent with those studies. Interestingly, a cross-sectional study used the same data as this research to analyze the significant effects of negative peer relationships [13]. This inconsistency may suggest that reinforcement of social withdrawal and smartphone dependence by negative peer relationships happens in less than a year among young adolescents. The longitudinal panel data in this research is based on the Korean Children and Youth Panel Survey collected annually over three years. Each year, as the adolescents ascended in grades, they met new class members and homeroom teachers. After all, negative peer relationships can increase social withdrawal or smartphone dependence at the time but may not have a fixed effect until the following year.

Finally, it is interesting to point out that the reciprocal longitudinal relationships between social withdrawal and smartphone dependence were not significant in any path in this research. This result provides the opposite evidence to previous studies. Some studies demonstrated that social withdrawal led to problematic smartphone use (e.g., smartphone dependence/addiction) among adolescents [12,52]. Studies have reported a positive relationship between social withdrawal and smartphone dependence [13,53], but these studies have cross-sectional data in common. However, our findings suggest that social withdrawal does not impact smartphone dependence in the long term. How can we interpret this difference between cross-sectional data and longitudinal data? This difference suggests that the relationships between social withdrawal and smartphone dependence are associated with each other only in the short term. Adolescents may choose to use smartphone more when they experience social withdrawal. Nevertheless, we cannot predict that adolescents who experience social withdrawal will depend on the smartphone. Likewise, we cannot be sure that adolescents with high smartphone dependence will experience social withdrawal in the following year.

Previous cross-sectional studies found that social withdrawal affected smartphone dependence [15,54]. These results suggest that it need to take a closer look at the measurements for social withdrawal. These items were adopted from the 'shy behavior' among the 'behavior problem scales of children and adolescents' [55]. Shy adolescents may experience difficulty with social relationships due to their lack of sociability, but this may not be enough to explain why they become dependent on smartphones. For example, a previous study shows that shyness indirectly affects depression through maladaptive self-focused attention rather than directly influencing depression [56]. In addition, shy children and adolescents may frequently experience negative emotions in social interactions [57]. In line with these results, if social withdrawal has increased smartphone dependence in cross-sectional research, the research should consider including the other variables, for example, negative self-cognition or negative experience in social relationships among adolescents.

The current study provides some practical implications. First, our findings indicate that adolescents may have negative

expectations about peer relationships because of social withdrawal and smartphone dependence. Thus, the intervention design for young adolescents should consider the association between social withdrawal or smartphone dependence formed from past experiences and their negative expectations for peer relationships—for example, posing a question about the causality of negative expectations to adolescents who experience negative peer relationships. The intervention should focus on satisfying needs through peer relationships if the adolescent answers that smartphone use is better than peer relationships for gratifying their needs. On the other hand, the intervention may pay attention to the cause of social withdrawal or their negative self-cognition if adolescents answer that peers do not like or accept them for any reason. This approach can be a good entry point for solving the cue of negative peer relationships among young adolescents.

Second, the intervention for virtual life orientation and withdrawal as a sub-factor of smartphone dependence can focus on adolescents' positive expectations for smartphone usage. For instance, designing a positive interaction in the real world may be proper for adolescents who answer that they use the smartphone for positive social cues or social acceptance. However, one may need to revise the intervention relevant to positive interaction with a peer when adolescents answer relevant to another purpose of smartphone usage (i.e., achieve their personal goals, entertainment). In sum, the intervention for reducing smartphone dependence should consider various contexts surrounding each factor.

This research has some limitations. This study did not consider positive peer relationships in long-term reciprocal relationships. Adolescents simultaneously experience positive and negative relationships [13,40]. Therefore, we suggest future studies consider various mechanisms of peer relationships on social withdrawal and smartphone dependence. In addition, future research may compare the reciprocal longitudinal relationships of positive peer relationships and negative relationships based on the results of this research. This study focused only on two sub-factors of smartphone dependence among adolescents. However, adolescents may experience various aspects of smartphone dependence through smartphone use, like text message or game dependence. We encourage further theoretical and empirical research for comparing smartphone dependence with the other sides of smartphone dependence. Lastly, the current study focused only on adolescents in specific countries, and participants responded to surveys between 2018 and 2020. Therefore, to develop exciting opportunities for future research, scholars can compare the results of this research across other cultures (e.g., the U.S., Europe, Africa, Asia, and other countries) or other periods (e.g., before and after the COVID-19 pandemic).

6. Conclusion

Despite some limitations, this study investigated the longitudinal reciprocal relationships between negative peer relationships, social withdrawal, and smartphone dependence. The present study focused on adolescents in Korea, with a high smartphone usage ratio, which provides implications for other countries. Returning to our initial questions in reciprocal longitudinal relationships, the smartphone dependence relative to both virtual life orientation and withdrawal of smartphones influenced negative peer relationships across three years. Since negative peer relationships also increase smartphone dependence, a negative loop may exist between smartphone dependence and negative peer relationships. Therefore, strategic interventions are needed to interrupt the negative loop. Strategic interventions to reduce smartphone dependence are based on empirical evidence of longitudinal interrelationships, including smartphone dependence among adolescents. Based on our findings, it is possible to intervene in longitudinal relationships by keeping down negative social interactions. This intervention can go a long way in breaking the negative loop and reducing adolescent smartphone dependence.

Data availability statement

The public data with no identifiers that support the findings of this study are available from the National Youth Policy Institute in Korea, and it can be found here: https://www.nypi.re.kr/archive/mps. Data, only including the main variables in the current study, are further available from the authors upon reasonable request and with permission of the National Youth Policy Institute. The requests should be directed to hsle@sogang.ac.kr, and ena@sogang.ac.kr, beginning 3 months and ending 3 years after publication.

Ethics declarations

Review and/or approval by an ethics committee was not needed for this study because it used robustly anonymized public data. This study did not require informed consent because the National Youth Policy Institute collected and opened the data. Any personal data was not included in the public data, and the authors got direct approval for using and analyzing data from the institute.

CRediT authorship contribution statement

Hye-Sun Lee: Conceptualization, Methodology, Writing – original draft, Formal analysis, Visualization. **Mikyung Choi:** Conceptualization, Writing – review & editing. **Eun-Yeong Na:** Writing – review & editing, Supervision.

Declaration of competing interest

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

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