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Modeling change in cognitive skills and its effects on self-esteem and drug use during adolescence: a latent transition analysis

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ABSTRACT

We used latent transition analysis with a panel cohort of youth to examine change in cognitive skill use and its influence on self-esteem and drug use. Skills were assessed in the 7th and 9th grades, self-esteem in the 10th grade, and drug use in the 12th grade. Three status groups emerged, including both high and low cognitive skill use, and a class employing mostly self-talk reward strategies. There was moderate stability in status; however, over time, some youth transitioned between classes. The mean levels of 10th grade self-esteem were higher in youth who consistently engaged in cognitive skills or remained moderate self-reinforcers over time. Self-esteem was protective with less drug use reported among those with higher self-esteem and more consistent cognitive skill use. These findings reinforce the importance of teaching youth a wide range of cognitive skills that boost executive functioning, especially given their prospective beneficial effects on self-esteem and drug use.

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Introduction

Studies of drug use etiology have long held that youth with low self-esteem are vulnerable to drug use because they lack appropriate coping skills. Self-esteem entails a subjective self-evaluation based on how a person sees themselves and their worth in terms of their accomplishments and achievement of goals (Rosenberg, 1965) and see also Donnellan et al. (2011). Youth who have a poor conceptualization of themselves may think in terms of 'I am not as good as others', resulting in low self-worth and eventual distress. Social deviance theory suggests that low self-esteem promulgates marginalization from conventional institutions, deviant peer bonding, and exposure to drug use norms (e.g. Kaplan & Johnson, 2001; Kaplan, 1980). Despite the sound basis for these conceptualizations, the literature is not as clear on the empirical relationships between self-esteem and drug use. There is evidence from general population studies supporting this contention (Bartsch et al., 2017; Brook et al., 1986; Carbonneau et al., 2022; Lee et al., 2018; Wills, 1994; Zimmerman et al., 1997). Other studies, however, have reported a null relationship between self-esteem and drug use (Newcomb et al., 1986; Stein et al., 1987; Swaim & Wayman, 2004; Swaim et al., 1989). Some studies report counterintuitive effects with higher self-esteem associated with more drug use (Fisher et al., 2007; Scheier et al., 2000; Swaim & Stanley, 2019). In all cases, these relationships attenuate once relevant baseline measures are controlled (Boden et al., 2008; Lee et al., 2018; McGee & Williams, 2000; Richardson et al., 2013).

Cognitive skills as a predecessor to self-esteem

The inconsistent findings in the literature suggest that there may be third-variable alternatives that can contribute to the loss of self-esteem and comport with social deviance theory. One area that might inform

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the self-esteem literature concerns the development of executive functioning that takes place during the early portion of adolescence. Adolescence is a period of rapid development of higher-order cognitive skills, including strategic planning, goal-directed behaviour, decision making and problem solving, that support adult role socialization (Keating, 2004; Kuhn, 2009; Moshman, 2004). It is during this stage of cognitive development that youth begin to introspect on their own thought processes. This type of reflective thinking enables youth to '*think about thinking*' or what is called metacognition (Flavell, 1979; Kuhn, 2000; Weil et al., 2013). One important facet of metacognition is cognitive monitoring, where youth reflect on their decision-making and problem-solving tactics (e.g. Efklides, 2001; Schneider & Lockl, 2002).

When youth apply metacognitive strategies, they are able to monitor their cognitions and change course to correct their problem-solving strategies. This is how they engage in reasoning and critical thinking (e.g. Ku & Ho, 2010) and choose which strategies to apply that help them master various learning tasks (e.g. Veenman et al., 2006). For some youth, the inability to apply executive functioning skills can induce anxiety and stress. For instance, rather than remaining calm and relying on their study habits, they may fret over an exam, feel overwhelmed, and perform poorly on a test. The same holds for decision-making skills, where a youth may not weigh alternatives or consider consequences of a particular action leading to a deleterious outcome. The failure to achieve desired goals can lower their sense of worth, especially if they compare themselves to their peers and see them succeed. According to Kaplan, the combination of not performing well in school and not applying requisite skills in certain situations can encourage youth to pull back and withdraw from mainstream conventional institutions (Kaplan et al., 1984; Kaplan, 1980).

Focus of the current study

In the present study, we emphasize use of cognitive monitoring skills that help youth reflect on their mental strategies, better manage stress and anxiety, and cope with pressures they experience in school and at home (e.g. Dinsmore et al., 2008).[1] We do this using a longitudinal panel sample of youth and apply a person-centered approach. Person-centered analyses are intended to elucidate subgroup heterogeneity, identifying unique 'typologies' or clusters (i.e. mixtures) of individuals who share behavioural similarity. In the current context, this entails finding subgroups of individuals who share similarity in the cognitive skills they use on a regular basis. Combining a mixture model approach with longitudinal data enables us to address four pressing questions: (1) are there unique mixtures of youth that differ in the composition of cognitive skill use, (2) developmentally are these mixtures stable, (3) what is the relationship between membership in a particular mixture and self-esteem, and (4) does membership in a particular mixture influence the self-esteem–drug use relationship. To address the first question, we first apply latent class analysis (LCA) to the 7th grade data and then repeat it with the 9th grade data. Conceivably, some youth may rely on decision-making skills but not use self-reward strategies and compliment themselves for doing well in some activity, whether it is sports or schoolwork. Other youth may rely on self-management skills to calm themselves in stressful situations but may not employ decision-making skills where they consider alternatives and weigh the consequences of their actions. These different patterns of cognitive skill use create 'hidden' subgroups that are not observable to the naked eye (e.g. Collins & Lanza, 2010).

To address the second research question, we capitalize on the longitudinal component and use latent transition analysis (LTA) to examine discrete dynamic change between classes from the 7th to 9th grades (e.g. Flaherty & Scheier, 2021). Youth may shift between classes if they do not experience beneficial effects from their skill use or if they find that new skills are strategically beneficial, so they employ them more frequently. The LTA model provides statistical information on the probability of transitioning from one status to another. To address the third question, we combine the longitudinal mixture component using LTA with a standard variable-centered regression framework. This enables us to estimate the probability of moving from one status to another and, if dynamic change is empirically related to levels of self-esteem. The fourth research question extends the methodological synthesis and estimates the effect of discrete dynamic change in cognitive skill use on the self-esteem–drug use relationship. This part of the analysis enables us to ask whether membership in a particular cognitive skill use status (capturing movement across time) fosters self-esteem, which is protective against drug use.

Several predictions have been made concerning the different research questions and modelling components. First, we hypothesize that there will be multiple subgroups (i.e. mixtures) of youth based on their

cognitive skill use with no less than three distinct patterns: those who remain consistent in their reliance on cognitive skills (*stable pattern*), those who increase the breadth of their skills (*augmenting pattern*) and those who become more restricted and rely less on their cognitive skills over time (*diminishing pattern*). We also hypothesize that a change in cognitive skill status will be associated with drug use but this effect is conveyed through its protective effect on self-esteem (i.e. representing an intervening mechanism).

Method

Sample

Data were obtained for secondary analysis from two independent cohorts of youth who had participated in a middle-school drug prevention trial. The intervention trials began in the 7th grade and ended in the 9th grade, with follow-up conducted in the 10th and 12th grades. Only control students w ere used in the longitudinal analyses.[2] Details on the study design for the drug prevention trial and assessment protocols, including procedures for obtaining parental consent and student assent can be found elsewhere (Botvin et al., 1995; Botvin et al., 2001; Griffin et al., 2021). The survey administration included using a three-form planned missingness design to maximize coverage of risk and protective factors (e.g. Little & Rhemtulla, 2013). Using this design, forms can be combined as AB, AC, and BC to allow 66% overlap in the questions, with 33% new items appearing on any given form (demographics and drug use items were common across forms).

Measures

Latent transition indicators. Eighteen items were used to assess cognitive skills and used as indicators of latent status membership. All of the items were taken from scales reflecting cognitive–behavioural theories that accentuate self-monitoring and cognitive restructuring (e.g. Kanfer & Hagerman, 1981; Kanfer, 1971). They also reflected the work of Bandura (1977, 1997), reinforcing self-efficacy as an expectancy of outcomes based on effort, mastery, and persistence. The combination of these cognitive behaviours provided a foundation for the drug prevention intervention, which emphasized generic life skills to reinforce youths' social and personal competence as a means of reducing vulnerability to drug use (e.g. Botvin, 2000; Scheier, 2015).

Seven items from the 41-item Coping Assessment Battery (Bugen & Hawkins, 1981) were used to assess decision-making skills. Their inclusion in the original assessment protocol reflects the stress-coping literatures (e.g. Folkman et al., 1979; Pearlin & Schooler, 1978) and also decision conflict theory (Janis & Mann, 1977), the latter including a series of coordinated strategies individuals use to appraise and instrumentally solve problems. The scale was modified slightly in wording to compare with the reading and comprehension levels of middle school students. Wills (1986) conducted extensive factor analyses using an urban sample of middle school students to demonstrate a subscale assessing 'behavioural coping,' which involves active coping strategies used to obtain information, evaluate alternatives, think about consequences, and take action. Additional confirmatory factor analyses provided evidence of a unidimensional scale (e.g. Griffin et al., 2001; Griffin et al., 2009). In the present study, the average factor loadings (λ) from a single-factor CFA positing simple structure were .679 and .776 in the 7th and 9th grades, respectively. The internal consistency estimates using McDonald (1999) were $\omega = .819$ and $\omega = .885$ for the 7th and 9th grades, respectively. Omega is superior to alpha in that they do not require imposition of tau equivalence (Hayes & Coutts, 2020). The items used a common stem, 'When I have a problem …' sample items include 'think about what information is necessary for dealing with the problem' and 'think about the possible consequences of each alternative.' All 18 indicators used a 5-point response format ranging from '*strongly disagree*' (1) to '*strongly agree*' (5) and were recoded as >= 3 = '1' and all other responses '0'.[3]

Four items from the 36-item Rosenbaum (1980) Self-Control Schedule were used to assess self-management strategies to mitigate internal and intrusive cues of anxiety and distress (e.g. 'If I am feeling sad, I try to think about pleasant things' and 'When I'm having difficulty concentrating on my homework, I look for ways to increase my concentration'). The creation of the SCS was based on stress and coping literatures with direct application to cognitive behaviour therapies that teach stress handling methods. This

includes a focus on general coping strategies or what Rosenbaum and Ronen (2013) termed '*learned resourcefulness*', which encompasses self-statements to address unpleasant emotional or physiological experiences. Rosenbaum reported a 12-item subscale assessing cognitions to control emotional and physiological intrusion. Tests for unidimensionality using a non-parametric item response theory (IRT) approach with Mokken (1971) monotone homogeneity coefficient (Hi) showed that in the 7th grade, only four items exceeded Hi > .30 ($Hi_{avg.} = .38$). The average factor loadings from a CFA model positing simple structure were .601 and .679 for the 7th and 9th grades, respectively. Omega for the four items was $\omega = .658$ and $\omega = .736$ in the 7th and 9th grades.

Seven items from the Heiby (1983, 1982) frequency of self-reinforcement questionnaire (FSRQ) assessed self-praise strategies (e.g. 'I encourage myself to improve by giving myself something special whenever I make some progress') and resolve (e.g. 'I can keep trying at something when I stop to think of what I've accomplished in the past'). The scale is based on the work of Rehm (1977) and Kanfer (1971), Kanfer et al. (1969), emphasizing self-control, self-reinforcement, and faulty attributions as core precipitants of depression. This includes the failure of individuals to make correct attributions about causality, control, and a person's belief about the linkages between their actions and consequences. The FSRQ was thus developed to assess covert (internal voice) means of self-reward and making attributions of success from one's own actions. The instrument has been shown to have good split-half reliability (.87), correlates well with intended mood and dysphoria outcomes, and was originally tested with individuals free of depression diagnosis. In the interest of brevity, nine items were culled from the original 30 that directly assess the frequency of self-reinforcement and were age appropriate. Mokken's Hi coefficient indicated that two of the nine items administered to students did not achieve the benchmark of Hi > .3 and were eliminated ($Hi_{avg.} = .33$). The average factor loadings from a CFA model positing simple structure were .548 and .635 in the 7th and 9th grades, respectively. Omega for the seven-item scale was $\omega = .660$ and $\omega = .774$ in the 7th and 9th grades.

Distal outcomes

Self-esteem. Ten items assessing self-acceptance and self-rejection were taken from the Rosenberg (1965) self-esteem scale. The response options ranged from (1) '*strongly disagree*' to (5) '*strongly agree*.' Self-acceptance assesses positive attitudes (e.g. 'I take a positive attitude toward myself'), and self-rejection assesses negative attitudes ('At times, I feel that I am not as good as most people'). The scale, which provides an undifferentiated measure of global self-esteem, has extensive psychometric support across various age groups (Gray-Little et al., 1997; Savin-Williams & Jaquish, 1981), including meta-analysis findings (Huang & Dong, 2011). Sufficient evidence also exists that when the negative items are recoded, a single factor underlies the 10 items (Marsh et al., 2010). Omega was $\omega = .823$ and $\omega = .858$ for the 7th baseline and 10th grade panel samples.

Alcohol and drug use. A composite of alcohol and drug use was created in both the 7th and 12th grades and consisted of three alcohol use items assessing frequency ('How often [if ever] do you drink alcoholic beverages?') with response categories ranging from (1) '*never tried them*' through (9) '*more than once a day;*' quantity ('How much [if at all] do you usually drink each time you drink?') with response categories ranging from (1) '*I don't drink*' through (6) '*more than 6 drinks;*' and drunkenness ('How often (if ever) do you get drunk?') with response categories ranging from (1) '*I don't drink*' through (9) '*more than once a day*'; a single item assessing cigarette smoking ('How much do you currently smoke?') with responses ranging from (1) '*I have never smoked*' to (10) '*a pack or more each day*'; and a single item assessing frequency of marijuana use ('How often [if ever] do you usually smoke marijuana?') with responses ranging from (1) '*never tried it*' to (9) '*more than once a day*.' The items were standardized to a unit-normal distribution and then averaged for the analyses.

Confounders. Statistical controls in the model included a five-item scale assessing risk-taking (Eysenck & Eysenck, 1975). It is important to control for risk-taking given its role in decision-making as well as adolescent drug use (Wills et al., 1994). Jessor and Jessor (1977) considered risk-taking as a personality trait that instigates a propensity toward unconventionality and problem behaviours. Risk-taking may emerge during adolescence because of poor cortical control and weak executive functioning, which inhibits the self-control required to override impulsive tendences (e.g. Steinberg, 2004). This can lead to immature

decision-making and confound cognitive monitoring and drug use (e.g. Geier, 2013; Nigg, 2017; Reyna & Farley, 2006). Sample risk-taking items include 'I would do most anything for a dare' and 'I often wish I had more excitement'). Responses ranged from (1) '*strongly disagree*' to (5) '*strongly agree*.' Internal consistency for this scale was satisfactory based on the baseline sample ($\omega = .713$). Additional control measures included gender (female = 1), grades (a seven-point scale with high scores indicating better grades), race (white = 1), and family structure (nuclear = 1). Demographic control measures are essential given the consistent evidence of race, ethnic, and gender differences in the focal risk factors, their relationships with drug use, and patterns of drug use (e.g. Barnes et al., 2002; Griffin et al., 2006; Miech et al., 2024). In addition, meta-analyses have provided evidence of gender differences in self-esteem at various points in the lifespan (e.g. Kling et al., 1999).

Analysis strategy. The analyses testing the basic research questions proceeded in several integrated steps. Figure 1 graphically portrays the model testing procedure. Categorical latent variables indicating class membership are designated by 'C' and are posited both in the 7th and 9th grades. Each of the 'Cs' point to the observed 'indicators' used to indicate latent class (status) membership at each time point (there are 18 threshold parameters in the model for each age group). The class membership at each time point is determined based on the unique (and mutually exclusive) response patterns (Y/N) to the different cognitive skill use indicators. In the LCA framework, the measurement parameter rho (ρ) indicates the probability of an individual endorsing an item conditional on their membership in a particular class or status. A second parameter, gamma (γ), indicates the latent class prevalence or the proportion of the sample assigned to any one particular class based on estimated posterior probabilities (McCutcheon, 1987).

Following derivation of the latent classes, we estimated latent transition probabilities using the longitudinal panel sample from 7th to 9th grade. The path labelled 'a' captures discrete dynamic change as youth transition (or remain stable) between cognitive skill use statuses over time. The τ (tau) statistic represents the probability of being in a particular class in the 9th grade conditioned on class membership in the 7th grade. The stippled line with a 'b' examines the influence of transitioning in cognitive skills on 10th grade self-esteem. This consequence path specifically addresses whether changing the

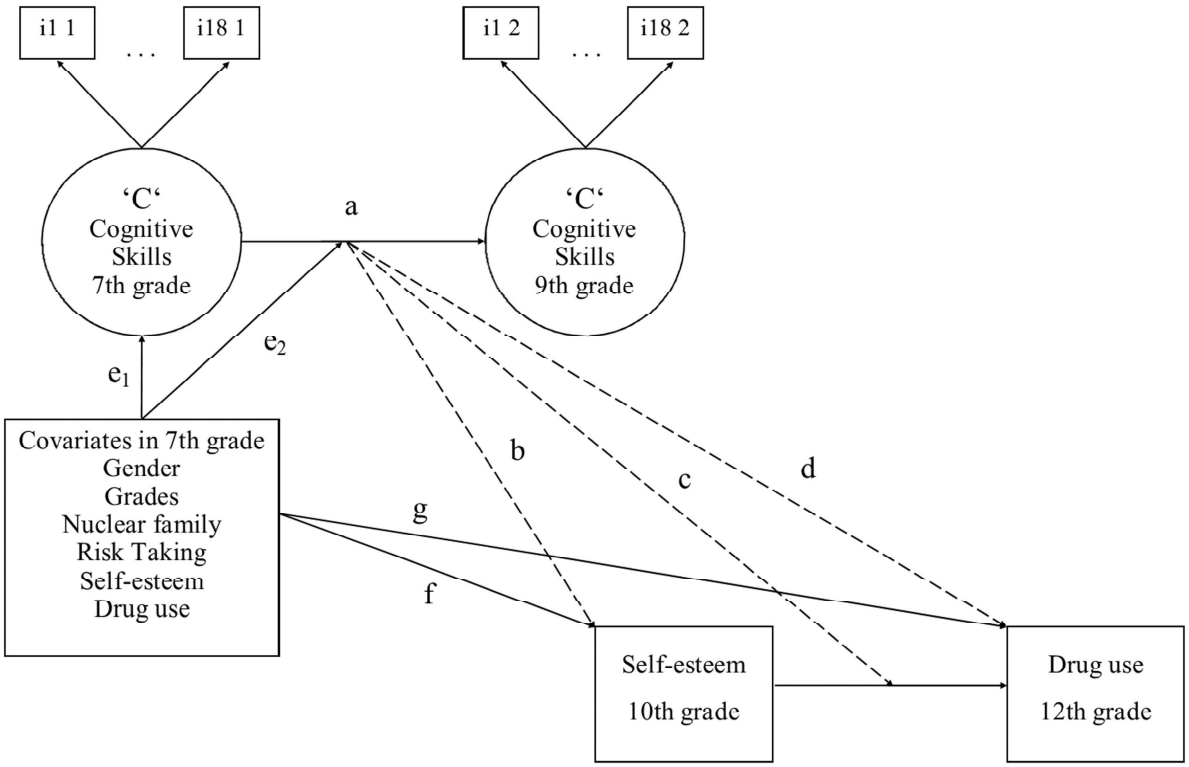

Figure 1. Conceptual Model_FNL.

composition of cognitive skills over time influences self-esteem. Self-esteem is treated as a proximal outcome, and intercepts are contrasted for each transition status using pairwise comparisons. The stippled line with 'c' indicates the effect of transitioning in cognitive skills on the relationship between 10th grade self-esteem and 12th grade drug use. This path addresses whether the slope in the regression of 12th grade drug use on 10th grade self-esteem varies across the latent transition statuses. For instance, self-esteem may be less protective against drug use for youth that show a diminishing pattern in their cognitive skills between the 7th and 9th grade compared to youth who show an augmenting pattern in their cognitive skill use over time.

The stippled line labelled 'd' indicates that the intercepts of 12th grade drug use vary across the transitional status groups, controlling for the effect that a change in cognitive skill use has on self-esteem. The path labelled 'e_1' addresses covariate effects on the mixture portion of the model for 7th grade. This path examines the effects of demographic and psychosocial characteristics on 7th grade class membership and helps characterize membership in different classes. The second path labelled 'e_2' points to the line representing discrete dynamic change in cognitive skill use from the 7th to 9th grades. This path estimates the effect of demographics and psychosocial functioning on transitioning from one status to another over time.

The path labelled 'f' captures covariate effects on 10th grade self-esteem, controlling for the mixture portion of the model. The path labelled 'g' controls for the influence of covariates on 12th grade drug use, with the prior mixture controls in place. Conceivably, the transition probabilities can have a direct influence on drug use, capturing the consequence of change in cognitive skill use (*diminishing, stable, or augmenting*), controlling for mixture effects on self-esteem. Because early baseline measures of both self-esteem and drug use are modelled, the effect of the paths labelled 'b' and 'd' address whether transitions in cognitive skill use are related to 'change' in self-esteem and drug use, respectively (i.e. controlling for normative development over time).

All of the LCA and LTA models were tested using the Mplus program (Muthén & Muthén, 2017). Model testing proceeded from a 2- to an 8-class model.[4] The evaluation of the best fitting model (i.e. how many unobserved components to retain) is based on several model fit indices that provide rough guidance for the superiority of fit for non-nested classification models. We examined shrinkage in the likelihood-based statistics, including the Akaike (1981) and Bayesian (Schwarz, 1978) information criteria, both of which penalize the model log-likelihood for over-parameterization (Nylund et al., 2007). We also evaluated the overall decrement in the Lo-Mendell-Rubin adjusted likelihood ratio test (A-LRT: Lo et al., 2001) obtained by contrasting neighboring models (a model with *k* components compared to *k-1*). This statistic specifically tests whether the increase in model fit from adding components is due to chance alone with a significant *p*-value indicating that the model with *k* classes improves over the model with *k*-1 classes, that is, the model with fewer classes is rejected (e.g. Henson et al., 2007). Solutions were also checked to ensure that the log-likelihood function was not a local maxima and that the model converged on a replicated solution. A rough guide of classification uncertainty in the model is also provided by entropy, which ranges from 0 to 1 (Celeux & Soromenho, 1996). Higher entropy numbers indicate less ambiguity in the mixture components (classes are more homogeneous) and reinforces that there is more precise assignment of individuals into the designated classes.

A key factor in choosing one model over another is that the resulting class structure is substantively meaningful and that the classes are distinguishable and make logical sense. This involves examining latent class separation, which requires careful inspection of the patterns of item response probabilities to determine whether they clearly identify qualitatively distinct classes (Bray et al., 2021; Collins & Lanza, 2010). Once classes are derived, the inclusion of covariates as structural validators in the model-building process facilitates understanding whether the classes can also be differentiated further based on psychosocial or demographic characteristics. To avoid sparse cells and convergence problems that can arise from weak identifiability, we did not consider classes with < 5% of the sample (Garrett & Zeger, 2000). As part of a multistage optimization, we used 400 random sets of starting values in the initial stage and 100 optimizations in the final stage. The perturbation of starting values avoids obtaining a local solution (i.e. maxima) and replicates the best log-likelihood statistic. To avoid class switching (Tueller et al., 2011) in the variable-centered component of the analyses (status membership predicting self-esteem and drug use), we set random starts to zero for these analyses.[5]

Results

Sample description

Supplemental Table S.1 includes a description of the sample, demographic and cohort differences in model variables, and results of attrition analyses.

LCA model results

Table 1 shows the fit statistics for the 7th grade model (top portion) and 9th grade LCA model (middle portion). Careful inspection of the model fit indices shows that both the 3- and the 4-class models could be considered to provide adequate fit based on the information criteria. In both cases, there are decreases in the values of the AIC and BIC, with an eventual slowing down of this decrease around the 5-class model. The entropy decreases in the 4-class model (.639 to .606), indicating less classification certainty. The average classification certainty for the 3-class model in the 7th grade was 83.67% and that for the four-class model was 79.03%. The very same class structure repeated for the 9th grade also showed a progressive slowing of the LL statistic, shrinkage in the AIC and BIC, and in the case of the adjusted LRT eventually a non-significant *p*-value (.144). The diminishing value of entropy (.742–.705) between the 3- and 4-class 9th grade models shows that there is more uncertainty in assignment with the extraction of an additional class. The average classification accuracy for the 9th grade for the 3-class model was 87.60%, and it was 79.03% for the 4-class model. After carefully reviewing the differences in the 3- and 4-class models, we chose the 3-class model because it offered clearly distinguishable classes that were qualitatively different in more than one way. One factor in this decision was the observation that the new class that emerged in the 4-class model (members only endorsing the decision-making skills) was quite small, and in the LTA, there were too few cases to estimate robust means with unbiased standard errors (<1% or ~20 cases).

Table 2 contains the conditional response probabilities for the 7th and 9th grade 3-class LCA models. Supplemental Figure S.1 also graphically plots these numbers and shows the clean separation of classes based on their item endorsement patterns (7th and 9th grades would be identical given the threshold constraints). The likelihood-ratio difference test between a model with and without constraints across the two time points was significant, $\Delta LR\ (54) = 150.2$, $p < .001$, suggesting that the hypothesis of equivalent item response probabilities should be rejected. However, the penalized fit statistics, which are better

Table 1. Model fit statistics for cognitive skills latent class and latent transition analyses.

Classes	LL	npar	AIC	BIC	Entropy	L^2	A-LRT (sign.)
LCA 7 grade							
1	−24490.8	18	49017.5	49128.0	1	4109.3	—[a]
2	−22324.8	37	44723.6	44950.6	0.672	3749.8	4304.2 (.001)
3	**−21897.6**	**56**	**43907.3**	**44250.9**	**0.639**	**2915.3**	**848.8 (.001)**
4	−21706.7	75	43563.3	44023.6	0.606	2913.1	379.5 (.005)
5	−21583.5	94	43354.9	43931.8	0.616	2721.2	244.7 (.050)
6	−21489.3	113	43204.5	43897.9	0.553	2633.6	187.2 (.080)
7	−21434.6	132	43133.3	43943.3	0.542	2726.8	108.6 (.356)
8	21392.8	151	43087.7	44014.3	0.526	2711.6	83.1 (.342)
LCA 9 grade							
1	−20891.3	18	41818.5	41924.5	1	4539.5	—[a]
2	−17976.6	37	36027.2	36245.1	0.805	4009.1	5790.7 (.000)
3	**−17465.2**	**56**	**35042.4**	**35372.1**	**0.742**	**3518.8**	**1016.1 (.144)**
4	−16998.1	75	34146.1	34587.8	0.705	3163.5	928.0 (.021)
5	−16811.0	94	33810.0	34363.6	0.682	2710.9	371.6 (.001)
6	−16699.2	113	33624.3	34289.7	0.662	2676.4	222.2 (.196)
7	−16599.6	132	33463.2	34240.5	0.649	2644.1	197.8 (.054)
8	−16525.9	151	33353.9	34243.1	0.648	2432.8	146.4 (.140)
LTA							
2	−40398.6	39	80875.2	81115.8	0.663	—[b]	—
3	**−39385.5**	**62**	**78894.9**	**79276.9**	**0.624**		
4	−38666.2	87	77506.4	78042.3	0.608		
5	−38335.3	114	76898.6	77600.7	0.601		
6	−38108.3	143	76502.7	77383.5	0.565		

Notes: Labels: LL = Log Likelihood, npar = Number of Parameters, AIC = Akaike's Information Criterion, BIC = Bayesian Information Criterion, L^2 = Likelihood Ratio Chi-Square, A-LRT = Lo-Mendell-Rubin Adjusted Likelihood Ratio Test. Numbers in bold represent the selected models.
[a] Test not available with one class.
[b] L2 not calculated in LTA because the model df values are extremely high.

Table 2. Item response probabilities and LTA results for 3-class model.

	Latent status		
	1	2	3
Latent status prevalence			
Time 1–7th grade	28.34%	55.91%	15.76%
Time 2–9th grade	30.28%	44.75%	24.96%
Item response probabilities			
(% endorsing 1 in 7th/9th grade)			
DEC1 (0.37/0.38)	**0.804**	0.253	0.023
DEC2 (0.44/0.44)	**0.902**	0.316	0.038
DEC3 (0.46/0.42)	**0.885**	0.347	0.027
DEC4 (0.52/0.54)	**0.971**	0.455	0.059
DEC5 (0.48/0.49)	**0.936**	0.384	0.052
DEC6 (0.47/0.48)	**0.917**	0.375	0.048
DEC7 (0.42/0.45)	**0.854**	0.334	0.061
SELF2 (0.70/0.63)	**0.891**	**0.697**	0.222
SELF3 (0.77/0.73)	**0.960**	**0.775**	0.337
SELF4 (0.59/0.62)	**0.859**	**0.589**	0.223
SELF5 (0.42/0.39)	**0.618**	0.377	0.137
SELF6 (0.46/0.42)	**0.745**	0.390	0.083
SELF7 (0.61/0.55)	**0.867**	**0.567**	0.147
SELF9 (0.45/0.45)	**0.727**	0.397	0.123
ROSEN4 (0.49/0.38)	**0.659**	0.444	0.102
ROSEN5 (0.44/0.33)	**0.618**	0.377	0.101
ROSEN6 (0.52/0.40)	**0.700**	0.482	0.078
ROSEN7 (0.49/0.41)	**0.672**	0.452	0.136
Probability of transitioning to …		… 9th grade latent status	
conditional on 7 grade latent status	1	2	3
1	0.56	0.30	0.14
2	0.25	0.51	0.24
3	0.07	0.33	0.60

Note: Status 1 '*High Cognitive Skill Use*,' Status 2 '*Moderate Cognitive Skill Use*,' Status 3 '*Low Cognitive Skill Use*.'

indicators of fit in models with large degrees of freedom, are more favourable to the constrained model. While there was some trivial variability in the item response probabilities, the overall pattern of endorsement between the two grades was quite similar.

Members of Class 1 ($\rho_{avg.} = .810$) endorsed all of the decision-making items ($\rho_{avg.} = .896$), all of the self-reinforcement items ($\rho_{avg.} = .809$), and all of the self-management items ($\rho_{avg.} = .662$). This class was labelled the *High Cognitive Skill Use* (*HCS*) class, with 28.34% of the sample assigned to this class in the 7th grade and 30.28% in the 9th grade. The second class had much lower conditional response probabilities for the decision-making items ($\rho_{avg.} = .352$), a mixed pattern for the self-reinforcement items ($\rho_{avg.} = .542$), and relatively low endorsement of the self-management items ($\rho_{avg.} = .439$). Four of the self-reinforcement items exceeded the benchmark .500 threshold. The four items included: "when I do something right, I take time to enjoy the feeling' (.697), "when I succeed at small things, I become encouraged to go on' (.775), 'I get myself through difficult tasks by planning to enjoy myself afterwards' (.589), and 'I can keep trying at something when I stop to think of what I've accomplished in the past' (.567). We labelled this the *moderate cognitive skill use* (*MCS*) class given its characterization as only consistently using self-reinforcement skills. This was the largest class, with 55.91% assigned to this class in the 7th grade and 44.75% in the 9th grade.

Members of the third class had very low endorsement for all 18 indicators ($\rho_{avg.} = .111$). There was very little differentiation in the magnitude of the conditional response probabilities; however, the smallest differences were observed for decision-making ($\rho_{avg.} = .044$), followed by self-management ($\rho_{avg.} = .104$), and self-reinforcement ($\rho_{avg.} = .182$). We labelled this class the *Low Cognitive Skill Use* (*LCS*) class, with 15.76% assigned to this class in the 7th grade and 24.96% in the 9th grade.

LTA model results

The bottom portion of Table 2 contains the transition probabilities showing latent status membership in the 9th grade conditioned on latent status membership in the 7th grade (this is also shown in the lower part of Figure S.2). The diagonal numbers show that there was moderate stability in status membership over time, with 56% of the youth remaining in the *HCS* status, 51% remaining in the *MCS* status, and 60% remaining in the *LCS* status. The off-diagonal numbers show that there was also considerable movement between statuses over time. For instance, 30% of the youth transitioned from the *HCS* status in the 7th

grade to the *MCS* status in the 9th grade. Similarly, 33% of the youth moved from the *LCS* status in the 7th grade to the *MCS* status in the 9th grade. There was also movement from the *MCS* status in the 7th grade to the *HCS* status (25%), and likewise, 24% of the students transitioned from *MCS* to the *LCS* status[6]. Only 7% moved from the *LCS* to the *HCS* (augmenting), and 14% showed a diminishing pattern in skill use and moved from *HCS* to *LCS*.

Multinomial logistic regression

We next conditioned 7th grade class membership on the covariates and conditioned the transition probabilities, capturing the movement between statuses on the covariates. These models were tested incrementally, adding one covariate at a time to avoid suppression and masking that might occur with highly colinear relations. Efficient covariates that were significant in multiple comparisons from the univariate models were retained for subsequent analyses. The top portion of Table 3 shows the results of the final multinomial logistic regression model predicting 7th grade class membership with all of the covariates that were retained from the initial step entered as a block (only races comparing white vs. other were removed). The lower portion of the table repeats this analysis with the covariates predicting the transition probabilities.

Overall, the odds ratios indicate that higher grades were associated with being a member of both the *HCS* and *MCS* compared to the *LCS* reference status. Being a member of a nuclear family, having lower risk-taking scores, having higher self-esteem and lower drug use in the 7th grade were also associated with membership in the *HCS* status (compared to the *LCS* reference status). Members of the moderate cognitive skill use (i.e. self-reinforcers) class had higher grades and self-esteem, compared to the reference status. The lower portion of Table 3 shows the odds ratios for each covariate associated with the transition probabilities (capturing movement from one status to another over time). Compared to males, females were more likely

Table 3. Multinomial logistic regression results for covariates.

	Latent status		
	1	2	3
7th grade membership	OR (95% CI)	OR (95% CI)	OR (95% CI)
Gender	1.08 (0.94–1.24)	1.06 (0.93–1.21)	ref
Grades	**1.67 (1.43–1.94)**	**1.14 (1.01–1.29)**	ref
Nuclear family	**1.25 (1.10–1.43)**	1.10 (0.98–1.24)	ref
Risk-taking	**0.78 (0.67–0.90)**	0.99 (0.86–1.14)	ref
Self-esteem in 7th grade	**1.84 (1.58–2.14)**	**1.30 (1.14–1.48)**	ref
Drug use in 7th grade	**0.39 (0.30–0.51)**	**0.74 (0.65–0.86)**	ref
Transtition Probabilities to …		… 9th grade latent status	
from 7th grade latent status…	1	2	3
Gender (females = 1)			
1	*1*	***0.73 (0.56–0.94)***	0.88 (0.63–1.23)
2	1.09 (0.89–1.32)	1	0.91 (0.75–1.11)
3	1.31 (0.74–2.34)	1.28 (0.88–1.85)	*1*
Grades			
1	*1*	***0.54 (0.39–0.74)***	***0.45 (0.32–0.65)***
2	***1.64 (1.27–2.11)***	*1*	0.95 (0.77–1.17)
3	1.60 (0.68–3.75)	0.94 (0.67–1.33)	1
Nuclear family (yes = 1)			
1	1	1.09 (0.82–1.43)	1.34 (0.85–2.11)
2	1.12 (0.90–1.39)	1	0.88 (0.73–1.06)
3	0.61 (0.35–1.06)	0.84 (0.62–1.13)	*1*
Risk-taking			
1	1	0.87 (0.68–1.1)	1.27 (0.95–1.71)
2	0.99 (0.81–1.21)	1	0.94 (0.75–1.17)
3	0.67 (0.37–1.21)	1.11 (0.8–1.54)	1
Self-esteem in 7th grade			
1	1	1.16 (0.89–1.51)	1.07 (0.79–1.45)
2	0.80 (0.64–1.01)	1	0.89 (0.73–1.08)
3	1.80 (0.62–5.20)	1.09 (0.69–1.74)	1
Drug use in 7th grade			
1	1	*0.76 (0.35–1.66)*	1.01 (0.48–2.13)
2	0.89 (0.61–1.29)	1	1.01 (0.70–1.44)
3	0.71 (0.40–1.29)	1.04 (0.78–1.37)	1

Note: Bold statistics indicate $p < .05$. All predictors were entered into the model simultaneously, so the estimates are effects controlling for other predictors in the model. For the transition probabilities, the stability parameters were selected as the references (OR = 1). Italics indicate that the transition probability in that cell differs by more than 10% for a particular covariate categories comparison. Continuous measure comparison compares probabilities for minus 1 z-score versus plus 1 z-score (minus 1 z-score is the reference category).

to remain in the *HCS* status than to move to the *MCS* status (OR = 0.73). Youths who were members of the *HCS* status reported lower grades if they transitioned to the *MCS* or *LCS* status compared to youth who remained in the *HCS* status (ORs = 0.54 and 0.45, respectively). Youths who were in the *MCS* status and then transitioned to the *HCS* group had higher grades than those who were in the *MCS* status and remained so over time (OR = 1.64). None of the remaining measures, including drug use, were efficient predictors of status membership.

Comparison of status groups

The next step in the process involved conditioning the proximal (self-esteem) and distal measures (drug use) on the covariates, while controlling for the mixture portion of the model. This addresses pathway 'f' in Figure 1, which corresponds to the effect of covariates on 10th grade self-esteem, and pathway 'g' for the effect of covariates on 12th grade drug use. Table 4 shows the results corresponding to the different labelled paths in Figure 1. The top portion of the table provides a template from which to evaluate findings presented in the lower portions of the table. That is, the cell labelled *HCS* on the first row with a corresponding '1' in the first column (indicating *HCS* status in the 7th grade and remaining in the *HCS* status in the 9th grade) is indicated by 'a', and any comparison that appears in the sections below and that contains a superscripted 'a' indicates that there is a significant difference in a particular contrast.

The first set of comparisons involve the post-hoc comparison for the mean levels of self-esteem (proximal outcome). Numbers in bold are significantly different from zero, and the superscripted letters (a–i) indicate significantly different post-hoc comparisons. As the values of self-esteem were standardized, all of the numbers represent standard deviation units, where 0 represents the average level of self-esteem for the group as a whole. To illustrate, the value for high cognitive skill use youth in the 7th grade and who remained in this status in the 9th grade is .26 standard deviation units above the mean and significantly different from zero (bold). The superscripts associated with this cell indicate that the mean levels of self-esteem differ significantly from those of youth in the 'b' cell (*HCS* to *MCS*), the 'e' cell (*MCS* to *MCS*), the 'f' cell (*MCS* to *LCS*), and the 'i' cell (*LCS* to *LCS*). In effect, these findings indicate that youth with high cognitive skill use in the 7th grade who remain in this status in the 9th grade report levels of self-esteem significantly above the mean and score higher than youth who are in the stable or diminishing status groups over time.

Table 4. Covariate adjusted means corresponding to pathways 'b' and 'd' and regression coefficient corresponding to pathway 'c' from Figure 1 for the 3-class model.

Cell structure for transition to…	… 9th grade latent status		
conditional on 7 grade latent status…	**1**	**2**	**3**
High Cognitive Skill Use 1	a (625)	b (276)	c (106)
Moderate Cognitive Skill Use 2	d (405)	e (1157)	f (386)
Low Cognitive Skill Use 3	g (29)	h (124)	i (402)
Self-esteem (Proximal outcome)	… 9th grade latent status		
(z-score mean)	1	2	3
High Cognitive Skill Use 1	**0.26** ^{b,e,f,i}	−0.25 ^{a,d}	−0.09
Moderate Cognitive Skill Use 2	**0.20** ^{b,e,f,i}	−0.08 ^{a,d}	**−0.29** ^{a,d,h}
Low Cognitive Skill Use 3	0.23	0.16 ^{f}	−0.15 ^{a,d}
Drug use (Distal outcome)	… 9th grade latent status		
(z-score mean)	1	2	3
High Cognitive Skill Use 1	−0.08 ^{e}	0.10 ^{g}	0.31 ^{g}
Moderate Cognitive Skill Use 2	−0.07	0.16 ^{a,g}	0.12 ^{g}
Low Cognitive Skill Use 3	**−0.22** ^{b,c,e,f}	−0.04	0.07
Effect of self-esteem on drug use	… 9th grade latent status		
(stand. regression)	1	2	3
High Cognitive Skill Use 1	−0.06 ^{e,h}	**−0.23** ^{e,g,h,i}	0.27 ^{h}
Moderate Cognitive Skill Use 2	**−0.17** ^{e,g,h,i}	0.29 ^{a,b,d,h}	−0.10 ^{h}
Low Cognitive Skill Use 3	0.08 ^{b,d,h}	**−0.80** ^{a,b,c,d,e,f,g,i}	0.16 ^{b,d,h}

Note: Numbers in parentheses in the upper portion of the table are cell sizes. Bold values indicate that the parameter is significantly different from zero (the group mean). Numbers with superscripts (a–i) indicate that the value is significantly different from that of another transition group, with the comparisons based on the topmost template containing letters 'a' to 'i'.

Looking at the transition group that moves from *MCS* to *LCS* (status 2–3), we see that self-esteem is –.29 SD units lower than the mean and significantly different from three other status groups. That is, youth who were *MCS* in the 7th grade and who transitioned to the *LCS* status in the 9th grade had lower self-esteem compared to youth who were consistently members of the stability or augmenting transitions (e.g. *MCS* who became *HCS*). In all of the remaining comparisons, youth who diminish in their skills over time also report lower self-esteem and, comparatively speaking, lower self-esteem than other subgroups who were stable or augmenting.

The next section below in the table presents the findings for drug use as a distal outcome. The table contains the same post-hoc comparisons but with standardized drug use means (intercepts). In this case, only one value was significantly different from zero, and this was for youth in the *LCS* status who transitioned to the *HCS* status in the 9th grade, whose value was 0.22 standard deviation units below the mean. This is a protective effect because their movement to a higher skill use status corresponded to lower reported drug use than the average level for all students. In fact, their lower levels of drug use significantly differed from youth in cells labelled 'b,' 'c,' 'e,' and 'f.' In all but one of these comparisons, the statuses represent declines in cognitive skill use over time, with the exception of cell 'e,' which represents stability for members of the *MCS* status across time. Again, the lower level of drug use should be contrasted with the other groups that had positive values indicating drug use on average that is above the mean for the entire sample.

The final lower portion of this table indicates differences in the standardized regression coefficient for self-esteem predicting drug use. Three of the regression coefficients are significantly different from zero, and all three are negative, indicating that higher values of self-esteem are protective and associated with lower levels of drug use. The first of the three cells indicates that youth were members of the *HCS* status and transitioned to the *MCS* status ($\beta = -.23$), which was significantly different from youth in cells 'e,' 'g,' 'h,' and 'i.' In three of these comparisons (e, g, and i), the other transitional statuses had positive regression coefficients, indicating that higher self-esteem was associated with more drug use. One exception was cell h, which involved youth who improved from the *LCS* status to the *MCS* status, and whose regression weight was $\beta = -.80$, by far the largest magnitude of all the cells (and most likely an artifact of small sample size). The next cell comparison involved members of the *MCS* status who transitioned to the *HCS* status ($\beta = -.17$), who also significantly differed from the same four cells (e, g, h, and i). The final comparison involved youth in the *LCS* status who transitioned to the *MCS* status ($\beta = -.80$; 3.5% of the sample with 124 individuals) and who differed from all of the remaining cells.

Discussion

The current study addressed the self-esteem–drug use relationship using a novel study design combining a person-centered approach with longitudinal panel data. The use of panel data afforded the chance to examine normal maturation over an important period in life when youth experience rapid development of cognitive skills. The use of mixture modelling combining LCA and LTA provided an analytic means to examine whether there are unique clusters of youth based on cognitive skill use and if the composition of these skills changes over time. Four research questions were posed to address these issues and take advantage of the longitudinal, panel data. These included addressing the composition of cognitive skill use in the 7th and 9th grades, whether youth shift in their reliance on cognitive skills, the influence of discrete dynamic change in skill use on self-esteem, and whether change in skill use influences the self-esteem–drug use relationship. It is to each of these questions that we now turn based on the study findings.

The first research question addressed the composition of cognitive skill use in the 7th and 9th grades using LCA to examine subgroup heterogeneity. The 18 cognitive skills that were assessed were coping and decision-making, self-management, and self-reinforcement. These represent vital executive functioning skills that help youth monitor their own thought processes and make decisions regarding which problem-solving strategies to apply both inside and outside of school. Decision-making skills are essential to help youth gather information, weigh alternatives, consider the consequences of their actions, and think through their actions by planning. These are important skills, especially during adolescence, when risk-taking behaviours increase and they can be readily taught using various instructional strategies (e.g. Callender et al., 2016; Shelton et al., 2022). Self-management skills encompass self-control strategies to

ward off unpleasant thoughts and acquire what Rosenbaum termed learned resourcefulness. Learning self-control is important in terms of regulating one's emotions, learning how to handle stressful situations and delaying gratification. Self-reinforcement involves internal self-talk, finding ways to reward oneself for stellar performance, and recognizing when one performs well. These cognitive skills are useful for helping individuals persist at tasks that may seem difficult at first, provide an impetus to take on more challenging tasks, and praise themselves as a form of encouragement. A major premise underlying the current study is that the collective nature of these cognitive monitoring skills will help boost a youth's self-esteem and even serve a protective function against drug use. Collectively, these are considered '21st century skills' (e.g. Partnership for 21st Century Skills, 2007), and through innovative educational practices can strengthen critical thinking (e.g. White & Frederiksen, 2005).

The LCA models in both the 7th and 9th grades indicated a well-fitting three-class model, with clear differences in the characterization of the classes. Overall, members of the largest class endorsed relying primarily on self-reinforcement skills, using internal self-talk strategies to reward themselves for small accomplishments. These skills can be useful if youth face obstacles and have to encourage themselves to find ways to accomplish difficult tasks both inside and outside of school. The next largest class was distinguished by members endorsing all three sets of cognitive skills. This may indicate an underlying flexibility in how they handle problems and the willingness to monitor their cognitions in diverse ways. The third and smallest class was characterized by members with very low endorsement of the full set of cognitive skills.

Combining the 7th and 9th grade LCA models into the LTA model provided a means to examine whether maturation influences cognitive skill use. Notably, a fair share of youth remained in their respective status over the two-year interval, as indicated by the stability coefficients. However, there was also evidence that an equal amount of youth moved from a lower to a higher skill use status (*augmenting*) or shifted from high to low or high to moderate skill use (*diminishing*). This finding shows that, on the one hand, youth can acquire new skills or apply them in a more varied format in this short time frame. Equally likely, however, is that youth opt for a more constricted set of skills, especially those that moved from a higher to a lower cognitive skill use class.

The effect of discrete dynamic change on self-esteem and drug use

The third research question focused on the relationship between cognitive skill use and self-esteem. The model guiding this study suggests that when youth utilize their cognitive skills successfully, they feel better about themselves, especially if these skills work to enhance their performance. In the Bandura (1997) model, self-efficacy as an expectation is the product of mastery and performance upon self-reflection. Youths who engage in their cognitive skills and see beneficial outcomes will feel better about themselves, leading to a better evaluation of self. In line with this thinking, Kaplan (1978, 1980) suggested that individuals are motivated to strive for positive self-regard, as it has beneficial effects on well-being. Social deviance arises when social comparisons or reflected appraisals result in a loss of self-worth (e.g. Brownfield & Thompson, 2005; Matsueda, 1992). A lack of self-worth undermines social control, weakens bonds to school, and provides a foundation for deviant peer bonds favouring pro-drug norms.

The portion of the analyses that examined differences in the mean levels of self-esteem by mixture group was consistent with these expectations. That is, youth who reported using a full range of cognitive skills and who remained consistent in their application over time reported higher self-esteem than did youth who endorsed fewer skills or whose skill use decreased over time. This protective effect was also observed for members of the moderate skill use class, who augmented their skills and reported higher self-esteem when compared to youth diminishing in their cognitive skill use. This pattern also held for low-skill use youth who were 'augmenters' and reported more varied cognitive skill use over time (i.e. moving from *LCS* to *HCS*), albeit the small cell size precluded this comparison from being significant. Conversely, youth characterized as having diminished cognitive skill use (i.e. *MCS* to *LCS*) reported lower self-esteem, which was significantly different from other status transitions characterized by augmenting cognitive skills.

When the same analytic framework was applied to the drug use intercepts, a consistent pattern also emerged. The stable and augmenting cognitive skills groups reported lower levels of drug use, albeit only one transition was significantly different from zero (*LCS* to *HCS*). Paired comparisons, however, indicated

that youth augmenting their cognitive skill use reported lower drug use than youth diminishing their cognitive skills over time. The final component of the analyses addressed whether the self-esteem–drug use relationship varied based on latent status membership. This analysis addresses whether the acquisition of cognitive skills is associated with higher self-esteem, which in turn protects against drug use. This analysis incorporates both a determinant perspective (cognitive skills contribute to self-esteem) and a consequence effect (self-esteem protects against drug use). This would, in theory, reveal more about the role of self-esteem in either inhibit drug use or facilitate drug use as part of a complex set of developmental risk relations. A third of the nine significant relations capturing transitional statuses showed that self-esteem was protective and associated with less drug use.

Implications for prevention

The findings of this study reinforce the utility of teaching cognitive behavioural 'life skills' (Botvin & Griffin, 2015; Botvin, 2000). A competence-enhancement approach teaches youth to make better decisions, be more planful, and use cognitive–behavioural strategies, including internal self-talk (inner speech), to solve problems and maintain high levels of motivation in the face of challenging tasks. Programmes guided by a life skills approach also teach youth skills to remain calm in the face of adversity, avoid negative or unpleasant thinking when stressed, and maintain attentional focus to improve frustration tolerance. Youth who acquire these skills are more likely to refuse offers to use drugs, resist media and negative peer social influences to use drugs, and more likely to make positive life choices that engender health-enhancing rather than health-compromising behaviours, including the use of alcohol or drugs (e.g. Scheier et al., 2001). Taken as a whole, self-directed, higher-order cognitive skills lend themselves readily to cognitive–behavioural training methods, can be readily practiced in a group or individual setting, and can provide youth with effective coping strategies to address anxiety and stress when confronted with peer pressure to use drugs.

Limitations

There are several limitations associated with this study. First, considerable subject loss occurred between the baseline and follow-up years. To reduce bias from attrition, we controlled for demographic and personality measures, all of which were related to panel loss. We also examined the LCA model separately using the full baseline sample and found that the class structure replicated across samples, suggesting minimal variation in endorsement patterns associated with the longitudinal panel sample. The observation that students lost to follow-up were more likely to smoke cigarettes, drink alcohol and use marijuana, take risks, and have lower self-esteem indicates a loss of relevant variability in the final sample and can limit the generalizability of the findings.

Considerable time elapsed between the 7^{th} and 9^{th} grades and an even longer time frame between deriving transition probabilities and assessing drug use in the 12^{th} grade. Many events can transpire during this time frame, which are consequential to both cognitive skills and drug use. First, the configuration of skills that define class membership in both the 7^{th} and 9^{th} grades can change dramatically and influence students' behaviour. The time frame chosen from the 7^{th} to the 9^{th} grade coincides with the shift to formal operational reasoning; however, even over short time frames, youth can further refine their ability to monitor their thinking skills. The evidence provided by the transition probabilities indicates that youth both adopted and discarded skills. For some of the transitions, the cell sizes were relatively small, which can lead to underpowered comparisons for the proximal and distal outcomes. Mono-method may have influenced the findings, as only a single reporting source was available. Obtaining corollary evidence from teachers or parents would strengthen the measurement component of the model. Entropy was somewhat low, and this can reflect the inability of indicators to form well-separated, homogeneous classes.

We also measured only negative and positive facets of self-esteem at the global level. DuBois and Tevendale (1999) noted that there are differences between global and specific measures of self-esteem. For instance, an individual can have very high self-esteem in one area and low self-esteem in another area as they evaluate their strengths and weaknesses. The latent class indicators were dichotomized based on ordinal-categorical scales. A criticism of dichotomization in a variable-centered framework is the potential to produce biased estimates that accompany loss of variability (DeCoster et al., 2009) and loss of power (Cohen, 1983). However, this is not a concern with person-centered approaches because the emphasis is on the consistency of response patterns (i.e.

agree vs. disagree), not dispersion around the mean (MacCallum et al., 2002). There are many unmeasured confounders that could possibly influence both self-esteem and drug use. This would include socializing agents such as family, peers, and teachers, all of whom can influence cognitive skills, self-esteem, and drug use. Additional factors such as core personality dispositions, including risk-taking and temperament, may also factor into the development of self-esteem and influence drug use (Wills & Ainnette, 2010). Statistical controls for these and other important developmental processes should lead to greater model precision and facilitate further understanding of the complex set of influences that develop in the relationship between self-esteem and drug use. Finally, historical trends may play a role in the rates of drug use. The emergence of vaping, For instance, introduces a form of drug use that was not a focus of the current study. Nevertheless, there is now considerable evidence that the risk factors for adolescent drug use remain quite consistent over time and that the gateway drugs (i.e. alcohol, cigarettes, or marijuana) remain the entry point for most youthful drug use. Changes in the sheer number or patterns of youth drug use do not change the fact that determinants of drug use have remained consistent over time.

Endnotes

1. These types of mental strategies are linked with but are not the same as behavioural self-regulation. Whereas the skills we examine are tied more to decision-making, problem-solving, and self-monitoring (i.e. introspecting on one's interior thought processes), self-regulation is tied more to control of cognitions, affect, and modulation of behavioural action with a specific goal orientation (Baumeister & Vohs, 2004). Thus, while self-regulation can involve reducing cognitive discrepancies (i.e. mentalized comparisons between a current internal standard and future desired state) that interfere with goal achievement (e.g. redirecting attention or response inhibition that occurs with impulse control), self-reflective cognitive skills entail more forethought that guides individual behaviour on how best to achieve a goal (Nigg, 2017).
2. A Data Use Agreement for these secondary data analyses outlined privileges to access the data, which did not include access to the experimental student data. In addition, prior publications reinforce that the intervention worked to decrease drug use in the intervention students (Botvin & Griffin, 2015). Their inclusion would introduce bias because the intervention also changed the mediators (i.e. cognitive skills). Differences in mean levels and likewise in the covariance structure would prohibit being able to examine (free from confounding) normative developmental processes.
3. A latent profile approach with ordinal-categorical response formats could feasibly be tested. However, with a five-point scale, there would be no meaningful reference category to contrast thresholds. In discretizing the Likert scales, we created a meaningful reference comparing 'endorsed' (agree) to 'did not endorse' (disagree) for using the particular skill.
4. Certain technical features of LCA and LTA are required to smooth convergence and assist in model interpretation. For instance, the assumption of local independence stipulates that it is the latent categorical factor causing the association among the observed indicators (i.e. reflecting homogeneous behavioural patterns within classes), which would be unrelated by themselves. We imposed measurement invariance on the conditional response probabilities in logit form between the 7th and 9th grades. This constraint ensures that each status has the same composition and therefore the same meaning at each time point. Moreover, the constraint of measurement invariance also helps to stabilize estimation with a large multiway contingency table and decreases the degrees of freedom (the contingency table increases exponentially from 218 in the LCA to 236 in the LTA, potentially creating the potential for sparse cells). The variances of the different statuses are held invariant, although this constraint can be relaxed to test heteroscedasticity.
5. We used full information maximum likelihood (FIML) to handle missing data in the estimation of the LCA models, which is an appropriate strategy with a planned missingness design. It is a model-based missing data treatment that produces unbiased and accurate parameter estimates when the missing data mechanism is ignored. The FIML procedure qualifies under Rubin (1987) assumptions when data are missing completely at random (i.e. missing data are unrelated to the study variables) and is considered superior to case-deletion and mean substitution approaches (Baraldi & Enders, 2010). The procedure leverages all of the available data, both complete and incomplete, and identifies parameters that have the greatest likelihood of producing the sample data. As the multinomial logistic regression (MLR) is a complete-case analysis, we imputed for the covariates using predictive mean matching with the R MICE package. Predictive mean matching is a model-based imputation method that does not require an explicit specification of missing values distribution, and is fairly robust to the distributional properties of a target variable (van Buuren, 2018).
6. We also tested whether the assigned status was equivalent in the two grades by contrasting a model with freely estimated diagonal values to a model that constrained the diagonal elements of the transition probability matrix to 1 (the remaining elements of the transition probability matrix are constrained to 0). The nested comparison was significant, $\chi^2(6) = 1525.7$, $p < .001$, rejecting the null that the prevalence of latent status membership is identical at the two time points.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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