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EMPIRICAL RESEARCH

Cognitive Flexibility and Selective Attention's Associations with Internalizing Symptoms in Adolescents: Are they Reciprocal?

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Abstract

Although both executive functions and internalizing symptoms go through important changes during adolescence, the role of executive functions in internalizing symptoms is unclear. Based on developmental cascade models of psychopathology, this study aimed to fill this gap by studying the bidirectional predictive relationship between executive functions (cognitive flexibility and selective attention) and symptoms of depression and social anxiety. A sample of 698 adolescents (40.8% girls) between 12 and 17 years of age ($M = 14.59$, $SD = 1.36$) participated in three waves over 1 year. They completed measures of executive functions and internalizing symptoms. Depressive symptoms predicted deficits in executive functions. Conversely, social anxiety symptoms predicted an improvement in cognitive flexibility. These results suggest that executive function deficits are not a risk factor for the development of depressive symptoms but a consequence of them, and there are specific patterns of associations for depressive and social anxiety symptoms.

Keywords Executive functions · Cognitive flexibility · Selective attention · Depressive symptoms · Social anxiety symptoms · Adolescents

Introduction

During adolescence, there is an increase in the prevalence of internalizing symptoms, such as depression (Merikangas et al., 2010) and social anxiety (Esbjørn et al., 2010). Several studies have found that adolescents with internalizing symptoms exhibit deficits in executive functions (Sommerfeldt et al., 2016). Executive functions include, among others, cognitive flexibility and selective attention, which involve important cognitive processes of attending and interpreting stimuli that are necessary for academic success and solving daily problems (Diamond, 2016). However, there is a gap in the literature regarding the directionality of the associations between symptoms and deficits in executive functions (for an exception, see Brieant et al., 2020). On the one hand, it has been proposed that internalizing symptoms negatively affect adolescents' executive functions (Diamond & Ling, 2016). On the other hand, executive function deficits are proposed risk factors for the development of psychological problems, such as depressive and social anxiety symptoms (Snyder et al., 2019). Thus, associations between executive functions and internalizing symptoms could be bidirectional, as stated in developmental cascade models of psychopathology (Masten & Cicchetti, 2010). These models propose that functioning in one or more domains of behavior influences other domains. Thus, risk and vulnerability factors increase the likelihood of experiencing emotional symptoms, and when the levels of symptoms increase, this in turn increases the likelihood of risk factors worsening, creating a snowball or cascade effect throughout adolescence. While several studies have examined cascade models for the associations between so-called hot cognitions, which involve reactions to the presence of emotional stimuli or states (e.g., cognitive biases and rumination), very few studies have examined these models in relation to so-called cold cognitions, which include information processing that occurs independently of any emotional influence (Ahern et al., 2019). Elucidating the longitudinal relationships between executive functions and internalizing symptoms is important because it can inform the design of both preventive interventions for social anxiety and depression and interventions aimed at improving executive functions in youth. The goal of this study is to address this gap by examining the dynamics between two

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important executive functions (cognitive flexibility and selective attention) and symptoms of social anxiety and depression during a developmental stage in which both executive functions and symptoms are experiencing important changes.

Executive Functions

Executive functions, also referred to as *executive control* or *cognitive control*, are a group of interrelated and top-down psychological processes needed to carry out an action successfully, through concentration and paying attention, to make decisions and face novel situations (Diamond & Ling, 2019). When it comes to executive function relationships with internalizing symptoms, cognitive flexibility is among the most studied executive functions. Cognitive flexibility involves changing one's perspective, solving unexpected problems, and adapting properly to situations. This is necessary for adequate functioning in daily life (Diamond & Ling, 2019). Although less studied, another important executive function is selective attention. Selective attention (also called *executive attention* or *focused attention*) involves staying focused on something and, at the same time, suppressing attention to distractors. Selective attention implies only inhibition at the level of attention and does not involve the inhibition of behavior, thoughts, and memories, which belong to other components of executive functions, such as cognitive inhibition and self-control (Diamond, 2016). This executive function is very important because it involves the mental process carried out in a specific moment to discriminate relevant information (needed to work) from that which is not relevant at that moment. Therefore, selective attention is the basis for carrying out other, more complex psychological tasks.

Executive functions are very vulnerable to environmental influences, such as socioeconomic status (SES), and can be adversely affected in an unfavorable environment (Diamond, 2016). In adolescents, evidence shows that a better SES is positively related to performance in tasks that evaluate cognitive flexibility (Ursache et al., 2016) and selective attention (Mac Giollabhui et al., 2019). One meta-analysis concluded that there is also a positive relationship between SES and executive functions in children and adolescents, with a small-medium effect size (Lawson et al., 2018).

Executive Functions and Depressive Symptoms

Depression is characterized by negative mood (in adolescents the mood can be irritable), decreased interest or pleasure in things, significant weight loss or weight gain, insomnia or hypersomnia, psychomotor agitation or retardation, loss of energy, feelings of worthlessness, decreased ability to concentrate, and suicidal thoughts (American Psychiatric Association, 2013).

The use of executive functions, which already involve an effort for healthy adolescents (Diamond & Ling, 2019), can imply a much greater required effort and sometimes a challenge in adolescents with depressive symptoms. In particular, some depressive symptoms (e.g., apathy, sadness, and tiredness) and their tendency to focus attention on negative thoughts (Levens et al., 2009) can make it difficult for these adolescents to perform tasks that require concentration and attention.

It has been proposed that stress, sadness, and loneliness negatively influence executive functions and the prefrontal cortex (Diamond & Ling, 2016). A unified model of depression (Beck & Bredemeier, 2016) states that the perception of stress can lead to both negative cognitions and autonomic and immune responses. Consequently, a reinforcement of depressive beliefs and neural atrophy in cognitive brain structures can occur (Beck & Bredemeier, 2016). As a result, adolescents with depressive symptoms are left with reduced resources, hampering cognitive tasks and worsening performance. This is consistent with the resource allocation hypothesis (Levens et al., 2009), which holds that difficulties and symptoms associated with depression, such as rumination and negative thoughts, occupy and reduce the available cognitive resources that are necessary to deal with cognitive tasks.

Likewise, deficits in executive functions could contribute to increased depressive symptoms. In fact, executive functions have been considered as a cognitive risk in the development of depressive symptoms in adolescents (Snyder et al., 2019). If an adolescent perceives that he or she has problems with concentration and attention (i.e., difficulties related to executive functions), which affect coping with academic demands and other changes (e.g., making friends), it can result in feelings of failure, sadness and hopelessness (Hankin et al., 2016).

Nevertheless, evidence regarding the associations between depressive symptoms and executive functions is mixed. At the cross-sectional level, one study (Evans et al., 2016) and two meta-analyses (Snyder, 2013; Wagner et al., 2015) found that impairments in cognitive flexibility are related to depressive symptoms in adolescence and adulthood. In contrast, other studies did not find this relationship in adolescents (Han et al., 2016). Longitudinal studies are scarcer and have reported inconclusive findings about the longitudinal relationship between depressive symptoms and cognitive flexibility. One meta-analysis concluded that greater severity of depressive symptoms predicted greater impairments in cognitive flexibility, among other executive functions, in adults (Snyder, 2013). There is also evidence of the alternative direction of this association. For example, one study found that reduced cognitive flexibility predicted

the first onset of a major depressive episode in adolescents (Stange et al., 2016). Despite these findings, several other studies have failed to find longitudinal associations between cognitive flexibility and depressive symptoms in adolescence and early adulthood (Friedman et al., 2018).

Cross-sectional studies on depressive symptoms and selective attention also show discrepancies. Some studies supported the theory that individuals with depressive symptoms have deficits in selective attention, in samples of both adolescents (Sommerfeldt et al., 2016) and undergraduate students (Wang et al., 2020). Nevertheless, one meta-analysis (Wagner et al., 2015), one systematic review (Vilgis et al., 2015), and other studies (Mac Giollabhui et al., 2019) did not find this association in adolescents.

Finally, very few studies have examined longitudinal associations between depressive symptoms and selective attention. One longitudinal study found that depressive symptoms predicted worse selective attention, but selective attention did not predict either the initial onset of depression or depressive symptoms in adolescents (Mac Giollabhui et al., 2019). Another study did not support the contention that high depressive symptoms predict worse selective attention in adolescents (Connolly et al., 2014).

Executive Functions and Social Anxiety Symptoms

The main characteristic of social anxiety is an intense fear or anxiety in social situations in which the person is exposed to possible evaluation by other people. The anxiety is disproportionate to the actual threat due to the social situation. Additionally, the person is afraid of acting in a certain way or showing anxiety symptoms that can be assessed negatively. Consequently, social situations are avoided or resisted with intense fear or anxiety (American Psychiatric Association, 2013).

Reciprocal influences between executive functions and social anxiety symptoms can also be hypothesized. On the one hand, social anxiety symptoms could negatively affect executive functions. Individuals with social anxiety symptoms are affected by threat-related distractors and, consequently, they can show reduced top-down control and difficulties in selecting important information from the environment (Moriya, 2016), worsening their performance in tasks where executive functions are needed. This is consistent with attentional control theory (Eysenck & Derakshan, 2011), which states that anxiety reduces the goal-directed attentional system's control (associated with prefrontal brain structures) and increases that of the stimulus-driven attentional system (associated with limbic brain structures). Thus, anxiety interferes with the balance between these two attentional systems. These changes, in turn, decrease attentional control and damage cognitive flexibility functions and inhibition (Eysenck & Derakshan, 2011). Attentional control theory can also be transferred to social anxiety (Liang, 2018). Adolescents with social anxiety symptoms must allot a significant portion of their cognitive resources (e.g., concentration and attention) to address the social threat, which thus cannot be used for processes that involve executive functions, consistent with the resource allocation hypothesis of depression (Levens et al., 2009).

On the other hand, the relationship between social anxiety symptoms and executive functions could operate in the other direction. Deficits in these executive functions could worsen social anxiety symptoms, as adolescents could perceive that they are failing in mental tasks and not adapting to different situations, including academic exams and social contexts, which play an important role in adolescence (Schriber & Guyer, 2016). Failures in tasks such as academic exams, where executive functions are involved, could promote feelings of being negatively evaluated and increase social anxiety symptoms.

Studies on the association between social anxiety symptoms or social phobia and cognitive flexibility and selective attention are scarce, and the available studies have been done with adults and reported mixed results. Whereas two studies showed that young adults with social anxiety symptoms (Judah et al., 2013) and with a diagnosis of social phobia (Fujii et al., 2013) had deficits in cognitive flexibility, other research did not find these results, either in individuals with social anxiety symptoms (Liang, 2018) or in those with social phobia (Demetriou et al., 2018). Likewise, one study concluded that young adults' social fear was negatively correlated with their performance on a selective attention task (Tomita et al., 2019), whereas other studies did not find any such association (Wang et al., 2020).

A few studies have examined the association between general anxiety symptoms and cognitive flexibility and selective attention. Regarding general anxiety symptoms, some studies found that anxiety symptoms and cognitive flexibility are negatively related in early adolescence (Mărcuş et al., 2015). Moreover, there is evidence that inducing anxiety impairs performance in cognitive flexibility in undergraduate students (Shields et al., 2016). One longitudinal study concluded that there is a prospective relationship between deficits in cognitive flexibility and anxiety symptoms (Lo et al., 2019). However, another longitudinal study did not find any such association in adolescents (Han et al., 2016). In terms of general anxiety symptoms and selective attention, the evidence is mixed, with some studies supporting the existence of a negative association between anxiety and selective attention in adolescents (Fernández-Castillo & Gutiérrez Rojas, 2009) and others failing to support this association (Yüksel et al., 2018). Based on the review, no studies have examined the

longitudinal relationship between anxiety symptoms and selective attention.

Executive Functions and Internalizing Symptoms: Sex and Age Differences

Executive functions—in which prefrontal systems play an essential role—develop during adolescence (Luna et al., 2010). For example, there is a steady growth in cognitive flexibility from ages 12 to 17, with adolescents aged 16 and older showing better cognitive flexibility than those who are 12 years of age (Poon, 2018). Selective attention also shows progressively better performance during preadolescence (Jiménez et al., 2012) and adolescence (Sommerfeldt et al., 2016). However, some studies have not found any associations between age and selective attention in adolescents (Mac Giollabhui et al., 2019). A few studies have analyzed sex differences in adolescents, concluding that there are no sex differences in cognitive flexibility (Lo et al., 2019) or in selective attention (Grissom & Reyes, 2019).

There are important age and sex differences related to internalizing symptoms. The prevalence rates are considerably higher in girls than in boys for both depression (Avenevoli et al., 2015) and social anxiety (Caballo et al., 2014). Furthermore, there are age and sex differences in the trajectories of internalizing symptoms. For instance, depressive symptoms increase for both girls and boys across adolescence, peaking at the ages of 15 and 17 years, respectively (Keyes et al., 2019). In the case of social anxiety symptoms, girls showed higher symptoms that decreased from middle to late adolescence, whereas boys entered middle adolescence with low symptoms that increased slightly or remained stable over time (Ohannessian et al., 2017).

The above-mentioned age and sex differences could affect the dynamics between internalizing symptoms and cognitive flexibility and selective attention. It has been suggested that the early onset of symptoms may be a risk factor for maladaptive executive function development in adolescence (Brieant et al., 2020). At the same time, cognitive abilities encompassed by executive functions are necessary for successful management of negative mood, and so deficits in executive functions could act as vulnerabilities for the appearance of internalizing symptoms, especially in the early phases of adolescence, when these symptoms tend to show a greater increase (Keyes et al., 2019).

Nevertheless, the study of age and sex differences in predictive associations between executive functions and symptoms has been neglected. At the cross-sectional level, only one study was found that examined sex differences in the associations between cold cognitions and psychopathology, finding that better general executive function was related to more anxious symptoms in females (White et al., 2017). In the same study, age moderated the relations between measures of executive and psychopathology symptoms, which tended to be stronger for younger children. However, this study included participants with a broad range of ages (8–21 years) and thus did not allow examining whether age acts as moderator across adolescence.

Additional indirect evidence on the potential differences between boys and girls comes from research on the role of hot cognitions, which include, among others, ruminative styles and cognitive biases (Ahern et al., 2019). For example, many studies have examined the bidirectional relationships between hot cognitions and symptoms of social anxiety and depression, reporting mixed results. In relation to depressive symptoms, some studies found that dysfunctional cognitions including a negative self-vision were more strongly associated with depression in boys than in girls (Calvete et al., 2013) while others have found the contrary effect (Alba et al., 2018). In relation to social anxiety symptoms, more intense associations have been found between dysfunctional cognitions and social anxiety symptoms in girls (De Jong et al., 2012), boys (Glashouwer et al., 2013), or similarly in both (Calvete et al., 2018).

Current Study

The review above indicates a gap in the study of the dynamics between executive functions and internalizing symptoms in adolescence. Clarification of these dynamics is important. If deficits in executive functions predict symptoms, this finding would allow early detection and prevention of internalizing symptoms in youth who have difficulties in executive functions. In the second case, if the symptoms predict a worsening of executive functions, the finding could lead to improvements in interventions for internalizing symptoms and early detection of deficits in executive functions.

Grounded on developmental cascade models of psychopathology, the main aim of this study was to examine the bidirectional predictive relationships between two executive functions (cognitive flexibility and selective attention) and two internalizing symptoms (depressive symptoms and social anxiety symptoms) in adolescents. It was hypothesized that there were bidirectional, long-term, predictive associations between executive functions and internalizing symptoms in adolescents. As executive functions are vulnerable to SES, SES was included in the analyses to control for its potential influence.

A secondary aim was to examine whether the longitudinal associations between executive functions and symptoms were moderated by age and sex. Multigroup comparisons were conducted to examine whether the

bidirectional dynamics between executive functions and internalizing symptoms were invariant for younger (12–14 years) and older youth (15–17 years) and for girls and boys. It was hypothesized that they would be more intense in older youth due to the progressive development of executive functions together with, in the case of social anxiety symptoms, the tendency to decrease in late adolescence. Due to the fact that only one cross-sectional study has examined sex differences in the relationship between executive functions and psychopathology (White et al., 2017) and the mixed results obtained on sex differences in the bidirectional relationships between hot cognitions and internalizing symptoms, the study of sex differences was exploratory, and no specific hypothesis were established.

Methods

Participants

There were 698 participating adolescents (285 girls and 413 boys) who completed at least one of the three waves of the study, which were each separated by 5−6 months: Wave 1 (W1) was at the beginning of the school year, Wave 2 (W2) was 6 months after W1, and Wave 3 (W3) was 1 year after W1. Of the total sample, 12.2% did not participate at W1, 10.3% did not participate at W2, and 15.3% did not participate at W3. Attrition rates were due to not attending class on the days of measurement. Participants were between 12 and 17 years of age ($M = 14.59$, $SD = 1.36$). They were from five high schools (two public and three private) from Bizkaia, Spain. SES was calculated by applying the criteria recommended by the Spanish Society of Epidemiology and Family and Community Medicine (2000): 12.5% of the sample was rated as having low SES, 12.3% as low-medium, 26.4% as medium, 21.5% as high-medium, and 18.8% as high. For 8.6% of adolescents, there was no information on SES.

Measures

Cognitive flexibility

Cognitive flexibility was assessed with the Changes, Cognitive Flexibility Test (Seisdedos, 2004). This performance test is composed of 27 trials. In each trial, the participant is asked to detect changes between three polygons, which can change in the number of sides, size, and color. Between the polygons, there is a circle with specific symbols (arrows, lines, triangles, and/or squares) that determine how the right polygon differs from the left polygon. The meaning of the symbols appears in a table. The participants should choose the option (A, B, C, or D) that indicates whether or not the changes showed by the symbols in the circle have been fulfilled. The participants have 7 min to complete the task by answering as many trials as possible without making mistakes. The reliability of the test was 0.87 (Cronbach's α). Moreover, the test has been shown to have good criterion and construct validity (Seisdedos, 2004). In the present study, the α coefficients were 0.95, 0.94, and 0.89 at W1, W2, and W3, respectively.

Selective attention

Selective attention was evaluated with the d2 Test (Brickenkamp, 1962) using a Spanish adaptation (Seisdedos, 2012). The d2 Test is made up of 14 rows, in which the participant should cross out all instances of the letter "d" that have two lines anywhere. The participant has 20 s per row in which to complete the task. The rows also contain "p" and "d" letters with different numbers of lines, which are distractors. The reliability of the test is between 0.71 and 0.98 depending on the study, the sample, the indicator of the test, and the methodology used. The test has good construct validity (Seisdedos, 2012). The test provides a total score (TS) that is a combination of three indicators: the total number of items processed (IP); the error of commission, representing the number of irrelevant items crossed out (CE); and the error of omission, representing the number of relevant items present but not crossed out (OE). The calculation is as follows: $TS = IP - (CE + OE)$. The α coefficients were 0.94, 0.97, and 0.95 at W1; 0.95, 0.97, and 0.94 at W2; and 0.96, 0.96, and 0.91 at W3 for the IP, CE, and OE, respectively.

Depressive symptoms

Depressive symptoms were measured with the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977). The CES-D has 20 items and is rated on a four-point Likert scale ranging from 0 (*practically never*) to 3 (*most of the time*). The higher the score, the higher the depressive symptoms. Some of the items are as follows: "I had trouble keeping my mind on what I was doing" and "I enjoyed life." Previous research with the Spanish version of the scale showed excellent psychometric properties and confirmed its factor structure (Calvete & Cardeñoso, 1999). In the present study, the α coefficients were 0.87, 0.88, and 0.86 at W1, W2, and W3, respectively.

Social anxiety symptoms

Social anxiety symptoms were assessed with the Social Anxiety Scale for Adolescents (SAS-A; La Greca & López, 1998). The SAS-A is composed of 18 items, which are divided into three subscales: fear of negative evaluation

(e.g., "I worry about what others say about me"), social avoidance and distress in new situations (e.g., "I get nervous when I meet new people"), and social avoidance and distress in general (e.g., "I feel shy even with peers I know very well"). The SAS-A is rated on a five-point scale ranging from 1 (*not at all*) to 5 (*all the time*). The Spanish version of the scale has demonstrated good psychometric properties (Olivares et al., 2005). The α coefficients in this study were 0.92 for each of the three waves.

Procedure

First, several high schools in Bizkaia (Spain) were contacted and sent a cover letter with all the information about the research. Five high schools agreed to participate. Parents of adolescents in those schools received the informed consent form and had the option of refusing to allow their children to participate in the three waves of the study (non-participation rate = 1.13%). Moreover, the adolescents were informed that their responses were anonymous and confidential and that participation was voluntary. All of the adolescents consented to participate in the study. They completed the questionnaires in their classrooms during each of the three waves. The questionnaires took about 40 −45 min to complete. The first tests that were administered were Changes and d2. Prior to their administration, participants were informed of the importance of maintaining a quiet environment free from distractions as well as following the instructions of the researcher carefully, as the tests were very demanding and would require concentration and attention. Because Changes and d2 tests are extremely challenging for adolescents, in order to keep them motivated, after completion of these tasks and before the self-report tests they were informed in the three waves that they would participate in a raffle for gift vouchers. The Ethics Committee of the University of Deusto approved this study (ETK-5/18-19).

Data-Analysis Plan

Little's test of Missing Completely at Random (MCAR) was statistically significant (χ^2 (627) = 1512, $p < 0.001$), which indicates that missingness was not random. Thus, the Full Information Maximum Likelihood approach was used with MPLUS 8.1. The general predictive longitudinal model was estimated with path analysis and the MLR (Robust Maximum Likelihood) estimation method. The goodness of model fit was evaluated using the comparative fit index (CFI), the Tucker–Lewis index (TLI), the root-mean-square error of approximation (RMSEA), and the standardized root-mean-square residual (SRMR). Generally, CFI and TLI values of 0.95 or higher show very good fit, and RMSEA and SRMR values lower than 0.08 indicate adequate fit for longitudinal research (Little, 2013). In this study, a cross-lagged panel design was employed. Given the high comorbidity between depression and social anxiety (Epkins & Heckler, 2011), both symptoms were included in the same model in order to identify unique associations between executive functions and internalizing symptoms. The predictive model included both autoregressive and cross-lagged longitudinal paths between variables. Covariance between W1 variables was included as well as covariance between residuals of W2 variables and between residuals of W3 variables. Finally, sex and age differences in the predictive model were examined to assess whether the model was equivalent for girls and boys and for younger (12−14 years) and older (15−17 years) adolescents. ML was used for comparisons between groups.

Results

Descriptive Statistics and Correlation Between Variables

Table 1 shows the descriptive statistics and correlations between the variables of the study. All cross-sectional associations between the two executive functions were positive, with medium-high coefficients, and significant at $p < 0.01$. In the same way, all cross-sectional associations between depressive symptoms and social anxiety symptoms were also positive, with high coefficients, and significant at $p < 0.01$. Only a few correlation coefficients between depressive symptoms and executive functions, particularly cognitive flexibility, were significant. These correlation coefficients were negative and very low. In addition, some correlation coefficients between executive functions and social anxiety symptoms were significant, positive, and very low. These correlations were between social anxiety symptoms at W2 and cognitive flexibility at W1 and at W2 and between social anxiety symptoms at W3 and cognitive flexibility and selective attention at all waves. Age correlated significantly and positively with executive functions with low-medium coefficients ($p < 0.01$) and with social anxiety symptoms at W1 ($r = 0.09$; $p < 0.05$). SES was significantly and positive associated with cognitive flexibility and selective attention in all waves and with very low coefficients ($p < 0.01$) and negatively associated with W2 depressive symptoms ($r = -0.10$; $p < 0.05$).

Predictive Model

The predictive model included autoregressive paths from the measures at W1 to the same measures at W2 and from the measures at W2 to the same measures at W3 (cognitive flexibility, selective attention, depressive symptoms, and

Table 1 Descriptive statistics and correlation between variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	*M*	*SD*
1. W1 Cognitive flexibility	1														9.82	5.60
2. W1 Selective attention	0.46**	1													411.03	83.40
3. W1 Depressive symptoms	−0.03	−0.06	1												15.95	9.84
4. W1 Social anxiety symptoms	0.03	0.01	0.54**	1											37.56	13.55
5. W2 Cognitive flexibility	0.56**	0.34**	−0.10*	0.08	1										12.10	7.20
6. W2 Selective attention	0.42**	0.75**	−0.07	0.05	0.51**	1									441.23	86.48
7. W2 Depressive symptoms	0.01	−0.03	0.68**	0.43**	−0.06	−0.05	1								15.72	9.53
8. W2 Social anxiety symptoms	0.08*	0.07	0.44**	0.73**	0.13**	0.06	0.52**	1							36.78	13.40
9. W3 Cognitive flexibility	0.40**	0.27**	−0.22**	−0.01	0.52**	0.34**	−0.19**	0.04	1						11.42	8.85
10. W3 Selective attention	0.44**	0.73**	−0.10*	0.05	0.46**	0.83**	−0.06	0.07	0.55**	1					440.45	81.14
11. W3 Depressive symptoms	−0.02	0.02	0.55**	0.32**	−0.08	−0.05	0.62**	0.40**	−0.08	−0.08	1				15.59	9.23
12. W3 Social anxiety symptoms	0.11*	0.10*	0.35**	0.54**	0.11**	0.10*	0.38**	0.68**	0.10*	0.10*	0.54**	1			36.41	13.33
13. Age	0.31**	0.40**	0.01	0.09*	0.26**	0.39**	0.01	0.05	0.13**	0.32**	−0.02	0.07	1		14.58	1.36
14. Socioeconomic status	0.22**	0.18**	−0.06	−0.04	0.26**	0.18**	−0.10*	0.02	0.26**	0.17**	−0.05	0.01	0.27**	1	3.24	1.30

W1 = wave 1; W2 = wave 2; W3 = wave 3

*$p < 0.05$; **$p < 0.01$

social anxiety symptoms). Furthermore, the model included predictive cross-lagged paths from all variables measured at W1 to all variables measured at W2 and from all variables measured at W2 to all variables measured at W3. Finally, age and SES were added to the model to control their potential association with the other variables over time.

The model displayed adequate fit indices (χ^2 (43, $N =$ 698) = 146; RMSEA = 0.059 (90% CI [0.048, 0.069]), p = 0.08; TLI = 0.927; CFI = 0.958; and SRMR = 0.033). Figure 1 displays the main parameters of the final model. The autoregressive paths for all variables were statistically significant ($p < 0.001$) and large (between 0.61−0.78) for all the variables except for cognitive flexibility, which was medium, indicating the stability of these variables over time. Regarding paths from internalizing symptoms to executive functions, depressive symptoms predicted a worsening of cognitive flexibility systematically between W1 and W2 and between W2 and W3 and a worsening of selective attention from W1 to W2. In contrast, social anxiety symptoms predicted higher scores on cognitive flexibility from W1 to W2 and from W2 to W3. Overall, these effects were small. Executive functions did not predict internalizing symptoms, although the predictive path from W2 cognitive flexibility to W3 depressive symptoms was negative and marginally significant ($B = -0.07$ [$SE = 0.04$], $p = 0.07$).

The longitudinal associations between cognitive flexibility and selective attention from W1 to W2 were bidirectional with very low coefficients. From W2 to W3, only selective attention predicted an increase in cognitive flexibility, with a very low coefficient and a marginally significant predictive association of cognitive flexibility to selective attention ($B = 0.07$ [$SE = 0.04$], $p = 0.07$). Social anxiety symptoms predicted a significant increase of depressive symptoms from W2 to W3 with a very low coefficient, and depressive symptoms predicted a marginally significant increase of social anxiety symptoms from W1 to W2 ($B = 0.07$ [$SE = 0.04$], $p = 0.06$). Finally, age predicted a higher increase of selective attention from W1 to W2, whereas SES predicted a higher increase of cognitive flexibility from W1 to W2, both with very low coefficients.

Sex and Age Differences

Table 2 displays the sex and age differences for the variables measured in the study. Girls scored higher than boys on depressive symptoms and social anxiety symptoms in all waves. The effect sizes for these differences were small to moderate. Regarding age differences, older adolescents scored higher than younger adolescents in cognitive flexibility and selective attention in all waves and in SES level, showing moderate to high effect sizes of these differences.

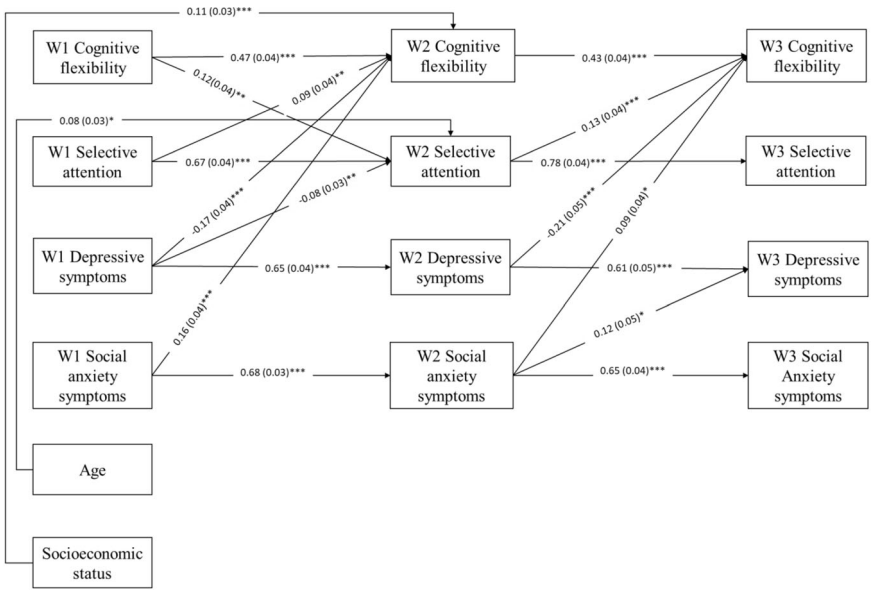

Fig. 1 Predictive model for cognitive flexibility, selective attention, depressive symptoms, and social anxiety symptoms. W1 = wave 1; W2 = wave 2; W3 = wave 3. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Next, it was examined whether the predictive model was invariant for boys and girls. An unconstrained model was estimated, with all the parameters estimated in each sample. This model showed good fit indices (χ^2 (86, $N = 698$) = 225; RMSEA = 0.068 (90% CI [0.057, 0.079]), $p = 0.004$; TLI = 0.925; CFI = 0.958; and SRMR = 0.042). This model was compared with a constrained model in which longitudinal paths were constricted to be equal across both subsamples. This imposition increased the χ^2 value significantly ($\Delta\chi^2$ [36, $N = 698$] = 70; $p < 0.001$), indicating that the model was different for boys and girls. Finally, individual paths were studied to find where the differences were. The path from selective attention at W2 to social anxiety symptoms at W3 was stronger in boys than in girls ($B = 0.02$ [$SE = 0.04$]; $p = 0.01$, vs $B = 0.03$ [$SE = 0.04$], $p = 0.47$; $\Delta\chi^2$ [1, $N = 698$] = 4; $p = 0.04$). In addition, the autoregressive paths for executive functions between W2 and W3 were stronger in boys than in girls: $B = 0.82$ [$SE = 0.03$]; $p < 0.001$, vs $B = 0.62$ [$SE = 0.05$], $p < 0.001$; $\Delta\chi^2$ [1, $N = 698$] = 10; $p < 0.001$ for selective attention and $B = 0.58$ [$SE = 0.06$]; $p < 0.001$, vs $B = 0.43$ [$SE = 0.07$], $p < 0.001$; $\Delta\chi^2$ [1, $N = 698$] = 10; $p = 0.03$ for cognitive flexibility.

A similar procedure was performed to test whether the longitudinal paths between internalizing symptoms and executive functions were invariant for younger (12–14 years) and older youth (15–17 years). The unconstrained model displayed good fit indices (χ^2 (74, $N = 698$) = 199; RMSEA = 0.069 (90% CI [0.058, 0.081]), $p = 0.003$; TLI = 0.930; CFI = 0.962; and SRMR = 0.043). This imposition of invariance for the longitudinal paths increased the χ^2 value significantly ($\Delta\chi^2$ [33, $N = 698$] = 87; $p < 0.001$), indicating that the model was different for both subgroups. Autoregressive paths for selective attention were stronger in the older subgroup, between W1 and W2 ($B = 0.59$ [$SE = 0.05$]; $p < 0.001$, vs. $B = 0.82$ [$SE = 0.04$], $p < 0.001$; $\Delta\chi^2$ [1, $N = 698$] = 14; $p < 0.001$), and between W2 and W3 ($B = 0.63$ [$SE = 0.04$]; $p < 0.001$, vs. $B = 0.86$ [$SE = 0.03$], $p < 0.001$; $\Delta\chi^2$ [1, $N = 698$] = 13; $p = 0.03$). Moreover, the path from SES to W2 cognitive flexibility was stronger in the older group ($B = -0.16$ [$SE = 0.23$]; $p = 0.49$, vs. $B = 1.36$ [$SE = 0.26$], $p < 0.001$; $\Delta\chi^2$ [1, $N = 698$] = 14; $p < 0.001$).

Discussion

Previous research indicates that adolescents with internalizing symptoms exhibit deficits in executive functions. However, there is a gap in the literature regarding the directionality of the association between internalizing symptoms and executive functions in adolescence, a stage in which both experience important changes. Grounded on developmental cascade models of psychopathology (Masten & Cicchetti, 2010), which state that risk and vulnerability factors can increase emotional problems and that these in turn can worsen risk and vulnerability factors, this study tested the bidirectional, long-term, predictive relationship between two important executive functions (cognitive flexibility and selective attention) and internalizing symptoms of depression and social anxiety in adolescents. The relevance of examining these longitudinal relationships lies in the potential to inform the design of preventive interventions for social anxiety and depression and interventions aimed at improving executive functions.

Table 2 Sex and age differences in the variables of the study

	Girls ($n = 285$)		Boys ($n = 413$)					Younger adolescents (12–14 years, $n = 393$)		Older adolescents (15–17 years, $n = 305$)				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*	*M*	*SD*	*M*	*SD*	*t*	*p*	*d*
W1 Cognitive flexibility	9.89	5.21	9.77	5.85	0.27	0.786	0.02	8.35	4.92	11.78	5.85	−7.71	0.000	−0.63
W1 Selective attention	412.54	78.54	410.02	86.58	0.36	0.717	0.03	384.88	81.90	446.40	71.64	−9.59	0.000	−0.80
W1 Depressive symptoms	17.81	10.88	14.67	8.85	3.65	0.000	0.32	16.05	10.22	15.82	9.36	0.27	0.789	0.02
W1 Social anxiety symptoms	39.75	14.69	36.04	12.50	3.09	0.002	0.27	37.12	14.05	38.12	12.90	−0.86	0.392	−0.07
W2 Cognitive flexibility	11.92	6.82	12.23	7.46	−0.54	0.589	−0.04	10.53	6.43	14.19	7.63	−6.57	0.000	−0.52
W2 Selective attention	446.12	87.71	437.83	85.57	1.17	0.243	0.09	414.20	82.21	477.30	78.65	−9.59	0.000	−0.78
W2 Depressive symptoms	17.75	10.37	14.27	8.61	4.38	0.000	0.36	16.09	9.84	15.22	9.09	1.11	0.267	0.09
W2 Social anxiety symptoms	39.75	14.53	34.66	12.12	4.57	0.000	0.38	36.49	14.24	37.16	12.20	−0.61	0.539	−0.05
W3 Cognitive flexibility	11.21	8.44	11.56	9.12	−0.52	0.605	−0.04	9.98	7.97	13.28	9.55	−4.86	0.000	−0.37
W3 Selective attention	440.78	77.36	440.21	83.79	0.08	0.936	0.01	416.82	78.28	472.92	73.57	−8.42	0.000	−0.74
W3 Depressive symptoms	17.91	10.31	13.92	7.99	5.02	0.000	0.43	15.80	9.53	15.31	8.83	0.63	0.532	0.05
W3 Social anxiety symptoms	39.85	14.17	33.93	12.12	5.22	0.000	0.45	35.92	13.77	37.08	12.70	−1.03	0.306	−0.09
Socioeconomic status	3.17	1.25	3.28	1.32	−1.09	0.278	−0.08	2.82	1.26	3.74	1.15	−9.54	0.000	−0.76

W1 = wave 1; W2 = wave 2; W3 = wave 3

The results indicated that depressive symptoms predicted lower cognitive flexibility over the course of 1 year, which is consistent with the findings of one meta-analysis (Snyder, 2013). In contrast, cognitive flexibility did not act as a risk factor for the development of depressive symptoms, although there was a marginally significant path from W2 cognitive flexibility to W3 depressive symptoms, indicating a possible trend. In the same way, greater depressive symptoms predicted lower selective attention (only from W1 to W2), but selective attention did not predict depressive symptoms, which is consistent with some studies (Mac Giollabhui et al., 2019). These findings indicate that depressive symptoms impair cognitive flexibility and selective attention strategies. These symptoms could hinder these executive functions through tiredness, sadness, and stress, among other symptoms, steadily damaging their use over time (Diamond & Ling, 2016). Another explanation is based on the resource allocation hypothesis (Levens et al., 2009), which theorizes that depressive symptoms occupy and reduce resources that are necessary to face executive function tasks.

Regarding social anxiety symptoms, the results were contrary to what was hypothesized. Social anxiety symptoms were positively associated with cognitive flexibility at the cross-sectional level at all waves and with selective attention at W2 and W3. Moreover, social anxiety symptoms predicted systematic increases in cognitive flexibility ability over time, both from W1 to W2 and from W2 to W3. These unexpected findings are inconsistent with the results of other studies (e.g., Kashdan & Rottenberg, 2010) and with theoretical proposals, such as attentional control theory (Eysenck & Derakshan, 2011). Nonetheless, this theory also proposes that individuals with high anxiety usually use compensatory strategies (e.g., make more effort) to increase their level of performance (Eysenck & Derakshan, 2011). Adolescents with social anxiety symptoms may perceive themselves as less valid because of their social difficulties and try to compensate for them with greater effort, which in this case might result in better cognitive flexibility. This explanation is related to the close association between social anxiety and perfectionism in adolescents (Flett et al., 2012). Perfectionism can indirectly contribute to the improvement of cognitive flexibility because adolescents with social anxiety might invest more effort when they feel evaluated by others. In fact, in this study most of the correlation coefficients between social anxiety symptoms and measures of cognitive flexibility were significant and positive. Another tentative explanation is that adolescents with social anxiety symptoms are very active at the cognitive level in relation to social situations. They develop a greater capacity to analyze social situations and, on many occasions, avoid them. Their continued use of creative safety responses and behaviors to avoid social situations could lead them to develop better cognitive flexibility. Thus, social anxiety symptoms might improve this executive function rather than worsen it. Future research should replicate this finding and examine potential mediating mechanisms to explain how adolescents high in social anxiety symptoms activate cognitive flexibility processes. For instance, a higher use of safety behaviors could imply a higher use of these cognitive

processes. Finally, contrary to the hypothesis, cognitive flexibility did not predict social anxiety symptoms, and there were no longitudinal predictive relationships between selective attention and social anxiety symptoms, except in boys, as discussed below.

Overall, the findings of the present study are partially consistent with the developmental cascade models of psychopathology (Masten & Cicchetti, 2010). According to the results, deficits in cognitive flexibility and selective attention would be outcomes of depressive symptoms but not clear risk factors for the development of depressive symptoms. These results are consistent with those obtained in a previous study (Brieant et al., 2020), in which initial levels of internalizing and externalizing symptomatology were associated with lower executive functions over time, but initial levels of executive functions did not predict changes in internalizing and externalizing symptomatology. However, in that study, composite measures of internalizing symptoms and executive functions were used, and thus no specific conclusions regarding different internalizing symptoms and executive functions were obtained. In fact, in the current study, the patterns of associations with the executive functions assessed are very different for social anxiety symptoms and depressive symptoms. Here, symptoms of social anxiety seem to predict improvements in cognitive flexibility, whereas depressive symptoms predict worsening cognitive flexibility. Thus, the findings of this study do not support the idea that executive functions act as transdiagnostic risk factors for the development of internalizing symptoms in adolescents (Snyder et al., 2019). Indeed, the findings suggest that only internalizing symptoms influence executive functions. This could indicate that, even though executive functions are used daily, a deficit or difficulties in them do not imply a change in symptomatology.

A secondary aim of the study was to examine whether the longitudinal associations between executive functions and internalizing symptoms were moderated by age and sex. This is important because executive functions, as well as internalizing symptoms, experience relevant changes in youth, and there are notable sex differences in the developmental trajectories of depressive and social anxiety symptoms (e.g., Ohannessian et al., 2017). In relation to age, the results showed that, at the cross-sectional level, older adolescents had better cognitive flexibility and selective attention in all waves. Furthermore, the stability of selective attention was higher among older adolescents, consistent with the established hypothesis as well as with other studies (Brieant et al., 2020). The results also showed that SES, which was positively associated with measures of executive functions, was more predictive of increases in W2 cognitive flexibility in older adolescents than in younger adolescents. However, this result should be considered with caution since in this study older adolescents displayed higher SES, and a meta-analysis could not confirm that age was a moderator of the SES–executive functions relationship (Lawson et al., 2018).

As in previous research, girls displayed higher scores on both depressive symptoms and social anxiety symptoms than boys (e.g., Avenevoli et al., 2015). However, in general the longitudinal associations between executive functions and internalizing symptoms were very similar in boys and girls, although a few differences emerged. In boys, but not in girls, W2 selective attention predicted an increase of W3 social anxiety symptoms. This result is contrary to previous findings indicating that, at a cross-sectional level, better general executive functions were related to more anxious symptoms in females (White et al., 2017). In any case, this association consisted of a very small effect size. Additionally, boys displayed stronger autoregressive paths for executive functions (cognitive flexibility and selective attention) between W2 and W3 than girls. This finding indicates that boys have more stable executive functions over time. A tentative explanation is that boys, who display lower depressive symptomatology than girls, are less exposed to the negative influence of symptoms in their level of cognitive flexibility and selective attention. In contrast, girls are more exposed to these symptoms, acting as risk factors for the impairment of executive functions.

Finally, the results showed that SES was positively correlated with cognitive flexibility and selective attention in all waves, according to previous studies (e.g., Ursache et al., 2016). However, in this study these results could be biased by the overlapping between SES and age. SES was also correlated, although negatively, with W2 depressive symptoms, highlighting the importance of a good environment during the developmental period of adolescence (Mac Giollabhui et al., 2019).

Some limitations should be mentioned. First, the present study only focused on cold executive functions; that is, non-emotional processes that require critical analysis and work in neutral contexts in which there are no rewards or punishments (Zelazo & Carlson, 2012), such as looking for instances of "d" letters with different numbers of lines in the d2 Test. Future research could replicate this work with other types of tasks to assess hot executive functions, in which there are emotional and motivational situations involved (Zelazo & Carlson, 2012; e.g., reward sensitivity and delay discounting in the Iowa Gambling Task). It is important to analyze the differences between these two executive function types using the present study's model because they exhibit different development patterns during adolescence and different associations with internalizing symptoms, with hot executive functions being more associated with behavioral and emotional difficulties (i.e., emotional problems, conduct problems, hyperactivity, and peer problems) than

cold executive functions (Poon, 2018). Second, two executive function performance tasks were employed. Considering the suggestion of another study (i.e., Mullin et al., 2020), it is recommend that future studies add subjective self-report measures for the evaluation of these executive functions to evaluate the difference between conditions in long-term associations with internalizing symptoms, as some studies have concluded that they have different relationships (e.g., Reinholdt-Dunne et al., 2013). Finally, this study used a nonclinical sample, focusing on symptoms and not on the disorder level. Hence, future studies should apply the present study's model to clinical samples of adolescents with depression and social anxiety disorders. Depressive symptoms and social anxiety symptoms could be risk factors for the development of depressive and social anxiety disorders, respectively (Epkins & Heckler, 2011), in which case their relationships with executive functions could be closer and more damaging.

Despite these limitations, this study also has several strengths. First, it used a cross-lagged panel longitudinal design with three waves, each one separated by a period of 5−6 months. This design allows for a bidirectional study exploring how executive functions and internalizing symptoms are related to each other in the long term. Second, performance tasks were utilized to evaluate executive functions in all three waves of the study, and around 600 participants took part in each wave. This sample size is larger than those commonly used in studies that evaluate executive functions through performance tasks. Third, the longitudinal design contributes to the understanding of the role of social anxiety symptoms with cognitive flexibility and selective attention in adolescents through non-emotional performance tasks, which is an apparent gap in the literature; moreover, it increases the understanding of the relationship between depressive symptoms and these executive functions. Finally, the results offer opportunities for new studies. In particular, future research could examine the role of potential mediating mechanisms to explain some of the longitudinal associations found in this study. For example, increased rumination and cognitive biases could mediate the predictive association between depressive symptoms and decreased executive functions, and higher use of safety behaviors could have an impact on the association between social anxiety symptoms and increased cognitive flexibility.

Conclusion

Previous research indicates that adolescents with internalizing symptoms exhibit deficits in executive functions. However, there is a gap in the study regarding the directionality of the associations between symptoms and deficits in executive functions. Over the course of 1 year, the current study examined the relationships between two important executive functions (cognitive flexibility and selective attention) and internalizing symptoms (depressive symptoms and social anxiety symptoms) in youth. The results indicated that greater depressive symptoms predicted lower cognitive flexibility over the course of 1 year and lower selective attention from W1 to W2. These results support proposals that difficulties and symptoms associated with depression can reduce available cognitive resources and negatively affect executive functions (Levens et al., 2009). In contrast, greater social anxiety symptoms predicted higher cognitive flexibility over the course of 1 year. Moreover, except in boys, measures of executive functions did not predict changes in internalizing symptoms. Thus, the findings do not support the notion that executive functions act as transdiagnostic risk factors for the development of internalizing symptoms in adolescents (Snyder et al., 2019). These results are important because they have implications for youth interventions. Specifically, they suggest the importance of evaluating the negative impact that depressive symptoms can have in several areas of adolescents' lives in which they need to use executive functions successfully. Future studies should investigate whether interventions targeting depressive symptoms can improve cognitive functioning, as some authors suggest (Diamond & Ling, 2016), or if specific training for the improvement of executive functions is necessary for adolescents with high depressive symptoms.

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Authors' Contributions A.M. collaborated with the design of the study, analyzed the data, wrote the paper, prepared the tables, and revised the references; E.C. designed the study, collaborated with the writing of the study, analyzed the data, and wrote part of the results. All authors approved the final version of the manuscript for submission.

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Data Sharing and Declaration This manuscript's data will be deposited at OSF (https://osf.io/K6ZAE).

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Ethical Approval The procedures of this study have been approved by the institutional research committee of the University of Deusto and have been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Informed Consent Informed consent was obtained from all individual participants included in the study and their parents/guardians.

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