Dear future me: behavioral and neural mechanisms underlying self-concept development in relation to educational decision-making in adolescence

Aar, L.P.E. van der

Citation

Aar, L. P. E. van der. (2021, June 15). *Dear future me: behavioral and neural mechanisms underlying self-concept development in relation to educational decision-making in adolescence*. Retrieved from https://hdl.handle.net/1887/3185509

Author: Aar, L.P.E. van der
Title: Dear future me: behavioral and neural mechanisms underlying self-concept development in relation to educational decision-making in adolescence
Issue date: 2021-06-15

Wat wens je jezelf toe voor je Breekjaar?

“MEER ZELFVERZEKERDHEID, ZELFSTANDIGER,
MEER VERTROUWEN EN EEN STUDIEKEUZE!”

Daniel, 18 jaar

Chapter 4

WHAT CHARACTERIZES ADOLESCENTS STRUGGLING WITH EDUCATIONAL DECISION-MAKING? THE ROLE OF BEHAVIORAL AND NEURAL CORRELATES OF SELF-CONCEPT AND SELF-ESTEEM

This chapter is published as:
Van der Aar, L.P.E., Crone, E.A., & Peters, S. (2019). What characterizes adolescents struggling with educational decision-making? The role of behavioral and neural correlates of self-concept and self-esteem. *Mind, Brain, and Education*, *13*, 184 - 197.
doi: https://doi.org/10.1111/mbe.12209

ABSTRACT

Educational decision-making is a complex process where individual factors such as how adolescents think about and evaluate themselves could play an important role. In this study (*N* = 84), we combined behavioral and neural correlates of self-concept and self-esteem to examine what characterizes adolescents who struggle with educational decision-making. We included 38 adolescents (16 – 24 y, *M* = 18.7 y) from "the Gap Year program". This program focuses on personal development for adolescents who have dropped out of higher education or stay undecided after high school. We compared these adolescents prior to the start of the training with 46 peers (17 – 21 y, *M* = 19.4 y) who reported to have successfully chosen a major. The results showed that adolescents struggling with educational decision-making reported lower levels of self-esteem and self-concept clarity. Neurally, higher self-esteem was associated with more self-related activity in the mPFC. Together, these results suggest that healthy self-esteem levels are an important condition for the ability to make a well-suited educational choice.

INTRODUCTION

The transition from general education (e.g. high school) to higher education (e.g. college or vocational education) can be considered to be a major developmental milestone during the period of adolescence (Dietrich, Parker, & Salmela-Aro, 2012; Parker, Thoemmes, & Duineveld, 2015). This transitional period presents a number of challenges such as the need for exploring, selecting, and finally committing to a certain college major that fits with an individual's interests, abilities and career goals (Super, Savickas, & Super, 1996). As this process of educational decision-making can be complex, many adolescents experience difficulties when choosing a major in higher education. For example, these difficulties can be expressed in delaying the need to make a decision (e.g. by taking a gap year), not making a decision at all (career indecision), or making a wrong decision which can result in dropping out or changing programs. In the Netherlands, a growing number of individuals (from 6% in 2015 to 12% in 2017) do not enter higher education directly after high school, but instead take one or multiple gap years (Dutch Ministry of Education, 2018). Additionally, there has been a consistent pattern of about 33% of students who do not finish their first year, because they drop out or change programs (Dutch Ministry of Education, 2018). This is a high-stake societal issue as it has considerable consequences for the well-being of students and is associated with societal costs.

Together, these numbers reflect an alarming trend that highlights the need to understand more about these individuals who experience difficulties with educational decision-making. As adolescence is a phase in which the ability for self-reflection is still developing (Sebastian, Burnett, & Blakemore, 2008), how adolescents thinks about and evaluate themselves could play an important role in explaining why some adolescents encounter problems, drop out or remain indecisive whereas others do not (Lin, Wu, & Chen, 2015; Parker et al., 2012). Therefore, this study investigated behavioral and neural indicators of self-concept and self-esteem to examine what characterizes adolescents who experience difficulties with educational decision-making.

The importance of studying the self in educational decision-making

It has been well established that cognitive factors (e.g. IQ and prior academic achievement) are not the only variables of importance in the transition from high school to higher education (Guo, Marsh, Morin, Parker, & Kaur, 2015). Psychological factors such as motivation (Germeijs & Verschueren, 2007), personality (Klimstra, Luyckx, Germeijs, Meeus, & Goossens, 2012) and academic self-concept (Guo et al., 2015; Parker et al., 2012; Pinxten et al., 2015; Wouters, Germeijs, Colpin, & Verschueren, 2011) have also been found to predict academic adjustment or success after the first year of college. With regard to self-concept, these studies mostly focused on the academic domain specifically (i.e. how one evaluates their academic traits and abilities) and related this to achievement as a measure of academic progress or success (i.e. by GPA scores or completion of the first year). Both academic self-concept and achievement are associated with the (subjective or objective) evaluation of the cognitive abilities of an individual. However, successfully choosing and adjusting to a study program in higher education encompasses more than solely academic skills. For example, one should have a general idea of their traits, strengths and interests in order to find a major that they can enjoy and which fits their interests as well as their abilities (Pinxten et al., 2015). In the literature, less is known about how general descriptions and evaluations of the self contribute to successful educational decision-making. We hypothesize that having a clear, consistent and positive self-concept is crucial for the ability to choose a college major that matches your identity. Therefore, we adopt a dual approach where we investigate both domain-specific and domain-general self-evaluations in adolescents who experience difficulties with educational decision-making.

Two important self-related factors explaining problems with educational decision-making could be related to the structure and positivity of the self: self-concept clarity and self-esteem. Self-concept clarity (SCC) refers to the extent in which individuals generally perceive their self-beliefs to be clear, consistent and stable (Campbell, 1990). SCC increases gradually during adolescence, but shows a temporary dip between 17 – 18 years (Crocetti et al., 2016). Crucially, this is the time that many adolescents face the transition into higher education, but so far no prior research has related SCC to problems with educational decision-making. Self-esteem, on the other hand, has been linked to career decision-making in prior studies. These studies have consistently shown that lower self-esteem is related to career-indecision or low career decision self-efficacy, although they focus on college students rather than high-school students transitioning into higher education (Choi et al., 2012; Gati et al., 2011; Lin et al., 2015).

An important method to increase our understanding of how self-concept variables relate to problems with educational decision-making is by studying the underlying neural mechanisms of self-processing. Questionnaires are sensitive to response bias, and neuroscience research has consistently shown that the neural components of self-concept can be reliably assessed with functional MRI. This research has revealed that the medial prefrontal cortex (mPFC) is important for self-reflection in both adults and adolescents (Denny, Kober, Wager, 2012; Murray, Schaer, & Debbané, 2012; Pfeifer & Peake, 2012; Sebastian et al., 2008; van der Cruijsen, Peters, van der Aar, & Crone, 2018). Altered activity in the mPFC might consequently reflect self-processing deficits. For example, studies investigating self-processing in populations with clinical disorders such as autism or depression have shown atypical patterns of mPFC activity during self-evaluations (Quevedo, Martin, Scott, Smyda, & Pfeifer, 2016; Uddin, 2011). More recently, research has also started to examine brain regions related to self-evaluations in specific domains, such as the physical or academic domain. Although the mPFC is strongly activated for self-evaluations across all domains, these studies have shown that evaluating traits specific to different domains show additional unique activation patterns in the brain. For example, evaluating academic traits was shown to elicit specific activity in the posterior cingulate cortex (PCC) and precuneus which have often been related to memory processes, whereas evaluating physical traits activated regions in the inferior parietal lobe (IPL), which plays a role in mentalizing (Van der Aar, Peters, van der Cruijsen, & Crone, 2019; van der Cruijsen et al., 2018). However, it is still unclear whether atypical engagement of these brain areas could be related to problems with self-processing in these specific domains.

Finally, studies directly relating self-esteem or self-concept clarity to neural activity patterns have been surprisingly sparse. One study by d'Argembeau (2012) linked lower levels of self-certainty to decreased activity in dorsal mPFC, and Yang et al. (2012; 2016) showed that trait self-esteem was positively associated with activation during self-referential processing in orbitofrontal cortex (OFC), but negatively related to activation in dorsal anterior cingulate cortex (dACC). Both of these studies suggest that lower levels of self-concept clarity and self-esteem can be associated with altered activation patterns in different parts of the frontal cortex, but these relations have not yet been examined in adolescents and tested within an educational context.

The current study

The goal of this study was to investigate behavioral and neural correlates of self-evaluations in academic, physical and prosocial domains, and to link these to self-concept clarity, and self-esteem in individuals who experience difficulties with educational decision-making. Therefore, we recruited participants from the Gap Year Foundation. This organization provides structured gap year programs focusing on personal development for adolescents who have dropped out of higher education or stay undecided at the end of high school (www.breekjaar.nl). We compared these participants with adolescents who already successfully transitioned into higher education. Behaviorally, we expected lower scores for participants in the gap year group in the positivity of academic self-evaluations, self-esteem, and self-concept clarity. On a neural level, we expected the gap year group to show altered activity in mPFC during self-evaluations, especially for the academic domain as this domain would be most relevant to problems one could experience with educational decision-making. We additionally tested whether mPFC activity was correlated with individual differences in self-esteem and self-concept clarity. Possibly, continuous changes in these measures will be more valuable than group differences, as they also take into account individual differences within groups (Altman & Royston, 2006).

METHOD

Participants

In collaboration with Foundation Gap Year, we recruited 38 adolescents between 16 – 24 years (M_{age} = 18.73; *SD* = 1.47; 24 females) who were starting the 10-month training program named “the Gap Year Program”. They were tested prior to the start of the program. All participants graduated from high school. 15 participants reported they had tried at least one college major, but dropped out; 23 participants took part in the program directly after high school. As educational decision-making problems are often comorbid with clinical problems (Gati et al., 2011; Scholtens, Rydell, & Yang-Wallentin, 2013), we chose to also include individuals with a clinical diagnosis (*N* = 7, **Table 1**), as long as they were not on medication at the time of testing. We included right-handed (*N* = 33) as well as left-handed participants (*N* = 5) with the criterion that they were able to use the button box with their right hand.

We compared these adolescents with 46 peers (17 – 21 years, M_{age} = 19.38; *SD* = 1.06; 24 females), who were part of a larger study (the Leiden Self-Concept study, *N* = 160, age 11 – 21 years; van der Cruijsen et al., 2018). They were selected from the larger sample based on the following criteria: between ages 16 and 21, and report of an already started major in higher education. This resulted in a sample of 46 participants who were directly comparable to the gap year participants. We assessed the level of commitment, questioning, and rethinking of their current education as an indication of satisfaction with their chosen program using the Utrecht-Management Identity of Commitments Scale (U-MICS; Crocetti, Rubini, Luyckx, & Meeus, 2008). On a 1 – 5 scale, this group scored relatively high on commitment (*M* = 3.73) and low on reconsideration (*M* = 1.83) and these scores differed significantly from the gap year group (commitment: $t(82) = -6.87, p < .001$; reconsideration: $t(82) = 4.53, p < .001$; **Table 1**).

All participants completed two subtests of the WISC-III or WAIS-III (Similarities and Block Design). Estimated IQ scores for the whole group fell between 85 and 132.5 (*M* = 106.99, *SD* = 11.1). The difference between IQ scores between the gap year group (*M* = 104.47) and the control group (*M* = 109.09) was not significant ($t(82) = -1.92$, $p = .058$). Age differed significantly between the groups ($t(82) = -2.34$, $p = .022$). To control for all possible age and IQ differences, these factors were included as covariates in the analyses. More information about both group characteristics and differences can be found in **Table 1**. Written informed consents were provided by the participants themselves or by both parents for minors. Participants were screened for MRI contra-indications, had normal (or corrected to normal) vision, were fluent in Dutch, had no neurological impairments, and were not taking psychotropic medication. The study was approved by the University Medical Ethics Committee.

Table 1.
Group characteristics

	Gap year (*N* = 38)			Control (*N* = 46)		
	Range	Mean	SD	Range	Mean	SD
Age (years)*	16.6 – 24.7	18.73	1.47	17.02 - 21	19.38	1.06
IQ	85 – 127.5	104.47	9.5	85 – 132.5	109.08	11.98
Commitment school**	1 - 5	2.52	.91	1 - 5	3.73	.71
Reconsideration school**	1 – 5	3.01	1.35	1 – 5	1.83	1.02
Clinical diagnoses		*N*			*N*	
ADHD		2			1	
ADD		3				
ASS		1				
Depression		1				

Note: * = p < .05; ** = p < .001.
Commitment and Reconsideration for school were measured with the U-MICS (Crocetti et al., 2008).

Experimental Task

All participants performed an fMRI task in which they were presented with short sentences that described positively or negatively-valenced traits or competencies in the domains of academics (e.g. 'I am smart'), prosocial skills ('I share with others'), and physical appearance (e.g. 'I am unattractive'). Each domain consisted of 20 stimuli, ten with positive valence and ten with a negative valence, making a total of 60 trait sentences (for more information and validation of the traits, see (van der Cruijsen et al., 2018) . In the Self condition, participants indicated to what extent the trait applied to them on a scale from 1 ('not at all') to 4 ('completely'). In the Control condition, participants categorized other traits relating to the same three domains (e.g. 'solving fights') into one of four categories: (1) school, (2) social, (3) physical appearance, or (4) I don't know. This condition contained 20 trait sentences in total, again equally divided in valence.

The Control and Self conditions were presented in separate runs and were counterbalanced across participants. The stimuli were presented in a optimized pseudorandomized order using Optseq (Dale, 1999) and were separated with a jittered black screen (0 - 4400ms). Each trial started with a 400ms fixation cross. Subsequently, the stimulus was presented for 4600ms, consisting of the trait sentence and response options (1 – 4) (**Figure 1**). Within this timeframe, participants could respond by pressing buttons with the index to little finger of their right hand after which the number of their choice turned from white to yellow for the remaining stimulus time. If the participant failed to respond within 4600ms, they were shown the phrase 'Too late!' for 1000ms. These trials were modeled separately and were not included in the analysis. They occurred in 0,5% of the Self condition and in 0,3% of the Control condition. To obtain one positivity score per domain in the Self condition, scores on negative traits were recoded and combined with scores on the positive traits.

Questionnaires

Self-esteem: Self-esteem was measured using a Dutch translation (Veldhuis, Konijn, & Seidell, 2014) of the well-validated Rosenberg self-esteem scale (Rosenberg, 1965). This 10-item questionnaire measures global self-worth by determining both positive and negative feelings about the self. Example of items are, 'On the whole I am satisfied with myself', and 'I certainly feel useless at times'. Answers were scored on a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The scale had high internal consistency (Cronbach's alpha = .91). After recoding the five counter-indicative items, higher scores indicated higher self-esteem.

Self-concept clarity: Self-concept clarity was measured with a Dutch translation of the Self-Concept Clarity Scale (Campbell, 1990; Crocetti et al., 2008). This 12-item questionnaire measures the extent to which individuals describe their self-concept as clear, stable, and internally consistent. An example of an item is "My beliefs about myself often conflict with one another". Answers were given on a 5 point Likert scale from 1 ("strongly disagree") to 5 ("strongly agree"). The scale was reliable (Cronbach's alpha = .85). Mean scores were computed such that higher scores indicate higher self-concept clarity.

Procedure

Participants were familiarized with the MRI-procedure with a mock scanner. Before scanning, participants received instructions about the tasks and performed 9 practice trials for each condition. Anonymity was emphasized and participants were encouraged to honestly describe how they thought about themselves.

MRI data acquisition

MRI data were collected using a Philips 3T MRI scanner with a standard whole-head coil. Functional scans were collected in two runs with T2*-weighted echo-planar imaging (EPI). The first two volumes were discarded. Volumes covered the whole brain (TR = 2200 msec, TE = 30 msec, sequential acquisition, 37 slices of 2.75 mm, FOV = 220 x 220 x 111.65 mm). After the functional scans, a high-resolution 3D T1scan was obtained (TR = shortest msec, TE = 4.6 msec, 140 slices, voxel size = 0.875 mm, FOV = 224 x 178.5 x 168 mm). Sentences were projected on a screen behind the scanner and could be viewed through a mirror attached to the head coil. Head movement was restricted with foam inserts.

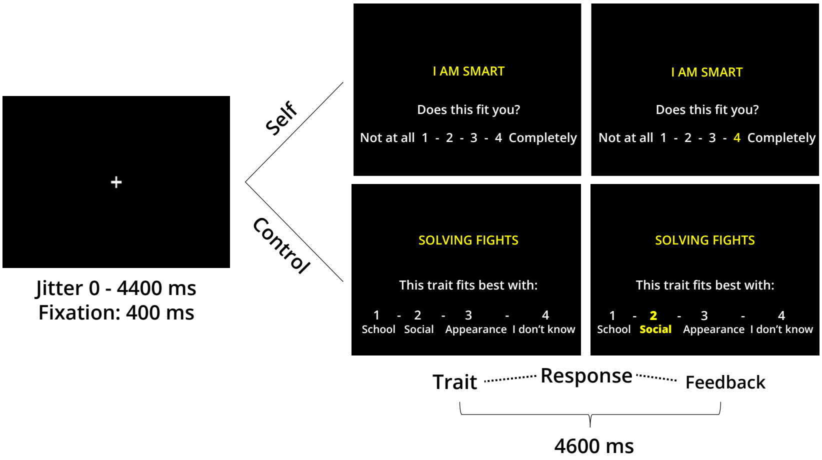

Figure 1. *Example of a trial in the Self and the Control condition. Each trial started with a black screen with a jittered duration between 0 and 4400ms. Subsequently, a fixation cross was shown for 400ms after which the stimulus was presented. In the Self condition, participants rated on a scale of 1 to 4 to what extent the traits fit themselves. In the Control condition, participants categorized the trait sentences into one of four options. The stimulus was shown for 4600ms. If participants responded within this timeframe, the number of their choice would turn yellow. If participants failed to respond within this timeframe, a screen with the phrase 'Too Late!' was shown for an additional 100ms after which the next trial would start.*

MRI data analyses

MRI data were preprocessed and analyzed with SPM8 (Wellcome Department of Cognitive Neurology, London). Images were corrected for slice-timing acquisition and differences in rigid body motion. All structural and functional volumes were spatially normalized to T1 templates. The normalization algorithm used a 12-parameter affine transformation together with a nonlinear transformation involving cosine basis functions, and resampled the volumes to 3 mm cubic voxels. Templates were based on the MNI305 stereotaxic space (Cocosco, Kollokian, Kwan, Pike, & Evans, 1997). Functional volumes were spatially smoothed with a 6 mm full-width at half-maximum (FWHM) isotropic Gaussian kernel.

Individual participants' data were analyzed using the general linear model in SPM8. The fMRI time series were modelled as a series of zero duration events convolved with the hemodynamic response function (HRF). Modelled events of interest for the Self condition were: "Academic-Positive", "Academic-Negative", "Physical-Positive", "Physical-Negative", "Prosocial-Positive", and "Prosocial-Negative". For the Control condition, we used one event of interest ("Control") that was collapsed across domains and valences. The events were used as covariates in a general linear model. Six motion regressors were added to the model. The resulting contrast images, computed on a subject-by-subject basis, were submitted to group analyses.

At the group level, we first performed whole-brain one sample *t*-tests for the contrasts Self > Control (collapsed across domains), Academic > Control, Physical > Control, and Prosocial > Control for both groups combined (*N* = 84). Next, we performed follow-up two-sample *t*-tests to compare activity in these four contrasts for the gap year group with the control group. In addition, we performed whole-brain regression analyses for the total sample to examine overall associations between self-related neural activation and individual differences in self-esteem and self-concept clarity. All analyses were FDR cluster-corrected at $p < .05$, at an initial uncorrected threshold of $p < .001$, as implemented in SPM8 (Woo, Krishnan, & Wager, 2014). Finally, we used the MarsBar toolbox to extract ROIs from the whole-brain contrasts to further illustrate individual differences in self-esteem and self-concept clarity.

RESULTS

Behavioral results

To investigate group differences in self-concept measures we performed a series of ANOVAs, corrected for age and IQ, on general self-evaluation positivity scores as well as per domain separately. These analyses yielded no group differences in positivity scores for self-evaluations per domain or across domains.

Additional ANOVAs for measures of self-esteem and self-concept clarity showed significant group differences for self-esteem ($F(1,80) = 27.00$, $p < .001$, $\eta_p^2 = .25$), and self-concept clarity ($F(1,80) = 13.06$, $p < .001$, $\eta_p^2 = .14$), with lower scores in the gap year group compared to the control group. Descriptive statistics can be found in **Table 2.**

Table 2.
Descriptive statistics of self-concept measures in the gap year group and control group

	Gap year (*N* = 38)			Control (*N* = 46)		
	Range	Mean	SD	Range	Mean	SD
Self positivity general	2.2 - 3.6	2.9	.36	2.5 – 3.6	3.1	.26
Academic positivity	1.7 - 4.0	2.6	.55	1.9 – 3.9	2.9	.46
Physical positivity	1.6 - 3.8	2.9	.56	2.2 – 3.8	3.0	.43
Prosocial positivity	2.3 – 4.0	3.2	.42	2.3 – 4.0	3.2	.37
Self-esteem**	1.3 – 4.3	2.8	.88	2.4 – 4.6	3.7	.61
Self-concept clarity**	1.7 – 4.1	2.7	.55	2.0 – 4.6	3.3	.70

Note: * = $p < .05$; ** = $p < .001$.

fMRI results

Whole-brain analyses

To examine which brain regions were generally involved in self-evaluations, we computed a whole-brain one-sample t-test for the contrast Self > Control for both groups combined. This resulted in significant clusters of activation in cortical midline structures; spanning from (ventral)mPFC, to the anterior-, middle-, and posterior cingulate cortex and bilateral precuneus. Additionally, the contrast Self > Control resulted in activation in right inferior frontal gyrus (IFG), bilateral SMA, and bilateral TPJ (**Figure 2** and **Table 3**). When examining the contrast Self > Control for the groups separately using a one-sample t-test, results for the control group showed increased activation in mPFC, ACC, right IFG, bilateral SMA and bilateral TPJ, and the gap year group showed activity in the ACC and vmPFC (see **Figure 2** and **Table 4**). To test for differences in the contrast Self > Control between the gap year- and control group, we conducted a two-sample t-test. There were no differences that survived FDR-cluster correction at $p < .05$.

We repeated these analyses for the domains separately. For the groups combined, the whole-brain contrast Academic > Control resulted in activation in vmPFC, PCC and precuneus, as well as in right IFG and right TPJ (**Figure 2**). The contrast Physical > Control resulted in similar activity in the mPFC, ACC, MCC, and PCC, as well as in right IFG, TPJ and bilateral SMA (**Figure 2**). Finally, the contrast Prosocial > Control resulted in activity in the mPFC, ACC and right TPJ (**Figure 2** and **Table 5**). When examining these contrasts for both groups separately, the gap year group only showed activity in mPFC and TPJ that survived FDR-cluster correction at $p < .05$ for the contrast Physical > Control (**Table 6**). However, two-sample t-tests for all three domain specific contrasts did not yield any significant differences in activation between groups.

Whole-brain regressions

Next, we examined relations with questionnaire self-concept measures by means of whole-brain regression analyses. For the whole-brain contrasts Self > Control, Academic > Control, and Physical > Control, higher self-esteem was associated with increased activation in the mPFC for evaluating self traits (**Table 3 and Table 5**). To further explore this relation for both groups, we extracted an ROI of this region activated in each whole-brain contrast. The results are visualized in **Figure 3** and indicate that individuals with higher self-esteem recruited the mPFC more during self-reflection than individuals with lower levels of self-esteem. As a follow-up analysis, we conducted an ANOVA for mPFC-activity with group as between-subjects factor and age and IQ as covariates. For the mPFC ROI extracted from the Self > Control contrast, we found a significant effect of group ($F(1,80) = 5.25$, $p = .025$, $\eta_p^2 = .06$), in which the gap year group showed lower averaged mPFC activity ($M = 0.65$) compared to the control group ($M = 1.55$). We found similar group effects for the mPFC ROI extracted from the Academic > Control contrast ($F(1,80) = 8.26$, $p = .005$, $\eta_p^2 = .09$; $M_{gap\ year} = 0.28$, $M_{control} = 1.17$) and the Physical > Control contrast ($F(1,80) = 9.65$, $p = .003$, $\eta_p^2 = .11$; $M_{gap\ year} = 0.79$, $M_{control} = 2.08$). However, it should be noted that these ROIs were extracted from the whole-brain contrasts with self-esteem as regressor, therefore results could be biased towards the behavioral findings of differences in self-esteem between groups.

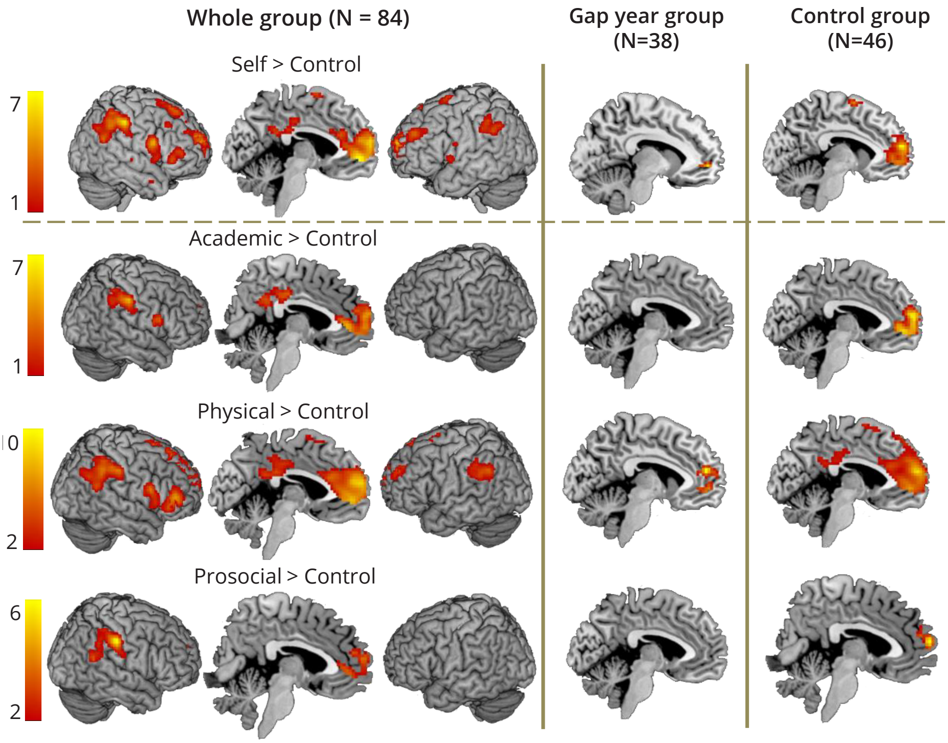

***Figure 2**: Activity for the whole-brain contrasts Self > Control, Academic > Control, Physical > Control, and Prosocial > Control for both groups combined (N =84), and for the gap year group (N = 38) and the control group (N = 46) separately.*

To test whether the relation between self-esteem and mPFC activity was present in both groups, or was only found because self-esteem differs for the two groups, we calculated partial correlations between mPFC and self-esteem while controlling for group membership. This analysis showed that the relation between self-esteem and mPFC activity when thinking about self was still significant for all three contrasts (Self > Control: $r = .36$, $p = .001$; Academic > Control: $r = .43$, $p < .001$; Physical > Control: $r = .33$, $p = .002$), indicating a general relation between mPFC and self-esteem across participants in both groups.

Finally, we conducted similar whole-brain regression analyses with self-concept clarity as regressor variable, but this did not result in significant clusters of activation.

Table 3.
Regions activated for the contrast Self > Control for both groups combined (*N* = 84)

Region		BA	Coordinates			Cluster Size	T
Self > Control							
Frontal cortex/ subcortical	L Mid Orbital Gyrus (mPFC)	32	-3	50	-5	1025	7.09
	L Superior Medial gyrus	10	-6	59	13		6.61
	R Anterior Cingulate Cortex	32	3	41	4		6.09
	R Inferior Frontal Gyrus (IFG)	44	57	11	22	106	5.73
	R Inferior Frontal Gyrus	44	54	14	4		3.60
	R Inferior Frontal Gyrus	45	48	32	1	55	4.20
	R Inferior Frontal Gyrus	46	48	41	10		4.10
	L Suppl Motor Area (SMA)	6	-6	2	67	104	4.59
	R Superior Medial Gyrus	6	12	26	58		4.56
	R SMA	6	9	11	64		3.99
	R Middle Cingulate Cortex	23	3	-22	37	90	4.46
Parietal cortex	R SupraMarginal Gyrus (TPJ)	40	60	-25	46	353	6.68
	R Inferior Parietal Lobe	40	54	-46	40		4.89
	R Angular Gyrus	39	60	-52	25		4.75
	L SupraMarginal Gyrus (TPJ)	39	-60	-43	34	91	4.29
	L Inferior Parietal Lobe	40	-57	-37	46		4.19
	L Inferior Parietal Lobe	40	-54	-31	37		3.89
	L Posterior Cingulate Cortex (PCC)		0	-43	25	70	4.09
	R Precuneus	23	9	-52	31		4.09
	L Precuneus	31	-9	-55	31		3.55
Self > Control with self-esteem as positive regressor (N = 84)							
Frontal cortex	R Superior Medial Gyrus (mPFC)	10	6	59	7	66	4.37

Note: Names were based on Automatic Anatomical Labeling (AAL) atlas.

Table 4.
Regions activated for the contrast Self > Control for both groups separately

	Region	BA	Coordinates			Cluster Size	T
Self > Control *Control group (N = 46)*							
Frontal cortex/ subcortical	L Superior Medial Gyrus (mPFC)	10	-6	59	16	927	7.57
	L Anterior Cingulate Cortex	32	-3	50	-2		6.59
	L Superior Medial Gyrus	10	-9	59	7		5.92
	R Inferior Frontal Gyrus (IFG)	44	57	11	22	167	5.77
	R Rolandic Opperculum	6	54	5	16		4.76
	R Inferior Frontal Gyrus	44	51	14	1		4.11
	L SMA	6	-6	2	67	106	5.42
	R Superior Medial Gyrus	8	12	29	55		4.21
	R SMA	6	9	11	64		4.19
Parietal cortex	L Inferior Parietal Lobe (TPJ)	39	-57	-46	37	90	4.81
	L Inferior Parietal Lobe	40	-57	-37	46		4.10
	L Supramarginal Gyrus	40	-57	-31	31		4.06
	R Inferior Parietal Lobe (TPJ)	40	57	-46	40	128	5.80
	R Angular Gyrus	39	60	-52	25		4.27
	R Angular Gyrus	39	42	-52	31		4.25
	R Supramarginal Gyrus (TPJ)	40	57	-28	46	57	5.81
Self > Control Gap year group (N = 38)							
Frontal cortex/ subcortical	R Anterior Cingulate Cortex (ACC)	32	6	41	-2	59	5.18
	L Mid Orbital Gyrus	10	-9	53	-2		4.93

Note: Names were based on Automatic Anatomical Labeling (AAL) atlas.

Table 5.
Regions activated during the domain contrasts for both groups combined (*N* = 84)

	Region	BA	Coordinates			Cluster Size	T
Academic > Control							
Frontal cortex	L Mid Orbital Gyrus (vmPFC)	10	-9	56	-2	672	7.06
	L Superior Medial gyrus	10	-6	62	10		6.02
	R Anterior Cingulate Cortex	32	6	38	7		5.88
	R Inferior Frontal Gyrus (IFG)	44	57	11	22	70	5.08
Parietal cortex	R SupraMarginal Gyrus (TPJ)	40	60	-25	46	201	5.98
	R SupraMarginal Gyrus	40	48	-40	43		4.09
	R Inferior Parietal Lobe	40	51	-43	55		3.97

Table 5.
Continued

	Region	BA	Coordinates			Cluster Size	T
	L Posterior Cingulate Cortex	23	0	-46	31	246	4.77
	L Precuneus	23	-6	-55	25		4.65
	R Middle Cingulate Cortex	31	3	-22	37		4.58
Physical > Control							
Frontal cortex	L Superior Medial Gyrus (mPFC)	10	-6	56	16	1773	10.25
	L Anterior Cingulate Cortex	32	-3	50	-2		7.46
	L Superior Medial Gyrus	10	-9	59	1		7.14
	R Middle Frontal Gyrus	46	45	41	10	410	6.26
	R Inferior Frontal Gyrus	44	57	11	22		5.93
	R Inferior Frontal Gyrus	47	48	29	-2		4.82
	R Superior Medial Gyrus	8	12	29	55	176	4.84
	R SMA	6	6	17	61		4.79
	L SMA	6	-6	2	67		4.69
Parietal cortex	R Inferior Parietal Lobe (IPL)	40	57	-46	40	342	6.17
	R Supramarginal Gyrus	40	57	-28	46		5.61
	R Middle Cingulate Cortex (MCC)	23	6	-28	31	192	4.72
	L Posterior Cingulate Cortex		0	-40	25		4.23
	R Middle Cingulate Cortex	23	3	-22	37		4.17
Prosocial > Control							
Frontal cortex	L Anterior Cingulate Cortex	32	-3	50	-2	296	5.59
	R Superior Medial Gyrus	10	6	53	19		4.76
	L Superior Medial Gyrus	10	-12	56	13		4.65
Parietal cortex	R Supramarginal Gyrus (TPJ)	40	60	-25	46	239	6.63
	R Angular Gyrus	39	60	-52	25		4.36
	R Inferior Parietal Lobe	40	48	-40	46		4.05
Whole-brain regressions with self-esteem							
Academic > Control							
Frontal cortex	L Superior Frontal Gyrus (mPFC)	10	-18	65	16	95	4.90
	R Superior Medial Gyrus	10	6	59	7		4.12
	L Superior Medial Gyrus	10	-6	65	19		4.05
Parietal cortex	L Postcentral Gyrus	1	-48	-40	58	63	5.31
	L Postcentral Gyrus	1	-39	-43	64		4.70
	L Superior Parietal Lobe	7	-33	-55	64		3.33

Table 5.
Continued

Region		BA	Coordinates			Cluster Size	T
Physical > Control							
Frontal cortex	R Superior Medial Gyrus (mPFC)	10	3	59	10	113	4.60
	R Superior Medial Gyrus	10	12	50	4		3.68

Note: Names were based on Automatic Anatomical Labeling (AAL) atlas.

Table 6.
Regions activated during the domain contrasts for both groups separately

Region		BA	Coordinates			Cluster Size	T
Control group (N = 46)							
Academic > Control							
Frontal cortex	L Mid Orbital Gyrus (vmPFC)	10	-9	59	-2	534	5.92
	L Superior Medial Gyrus	10	-6	59	16		5.87
	L Superior Medial Gyrus	10	-9	59	7		5.64
	L Superior Frontal Gyrus (dlPFC)	10	-21	53	28	72	5.29
	L Middle Frontal Gyrus	10	-30	47	31		4.11
	R Inferior Frontal Gyrus (IFG)	44	57	11	22	75	5.09
	R Rolandic Operculum	6	54	5	16		4.43
	R Rolandic Operculum	4	57	-4	16		3.58
Parietal cortex	L Inferior Parietal Lobe (IPL)	40	-54	-28	37	86	4.38
	L Inferior Parietal Lobe	39	-60	-46	37		4.15
	L Inferior Parietal Lobe	40	-57	-37	46		3.93
Physical > Control							
Frontal cortex	L Superior Medial Gyrus (mPFC)	10	-6	56	16	1773	10.25
	L Anterior Cingulate Cortex	32	-3	50	-2		7.46
	L Superior Medial Gyrus	10	-9	59	1		7.14
	R Middle Frontal Gyrus	46	45	41	10	410	6.26
	R Inferior Frontal Gyrus	44	57	11	22		5.93
	R Inferior Frontal Gyrus	47	48	29	-2		4,82
	Right Superior Medial Gyrus	8	12	29	55	176	4.84
	Right SMA	6	6	17	61		4.79
	Left SMA	6	-6	2	67		4.69
Parietal cortex	R Inferior Parietal Lobe (IPL)	40	57	-46	40	342	6.17
	R Supramarginal Gyrus	40	57	-28	46		5.61

Table 6.
Continued

	Region	BA	Coordinates			Cluster Size	T
	L IPC		-57	-55	40		5.85
	Left Inferior Parietal Lobe	39	-57	-46	37	149	5.47
	Left Supramarginal Gyrus	40	-57	-31	31		3.94
	Right Middle Cingulate Cortex	23	6	-28	31	192	4.72
	Left Posterior Cingulate Cortex		0	-40	25		4.23
	Right Middle Cingulate Cortex	23	3	-22	37		4.17
Prosocial > Control							
Frontal cortex	L Superior Medial Gyrus (mPFC)	10	3	62	13	135	5.19
	L Superior Medial Gyrus	10	-6	59	16		4.43
	R Superior Medial Gyrus	9	12	56	25		3.85
Gap year group (N = 38)							
Physical > Control							
Frontal cortex	L Superior Medial Gyrus (mPFC)	10	-6	50	16	195	5.67
	R Anterior Cingulate Cortex	32	6	41	-2		5.23
	L Mid Orbital Gyrus	10	-9	53	-2		4.76
Parietal cortex	R Supramarginal Gyrus (TPJ)	40	48	-43	43	66	4.61
	R Inferior Parietal Lobe	40	57	-37	52		3.90
	R Supramarginal Gyrus	40	63	-25	43		3.55

Note: Names were based on Automatic Anatomical Labeling (AAL) atlas.

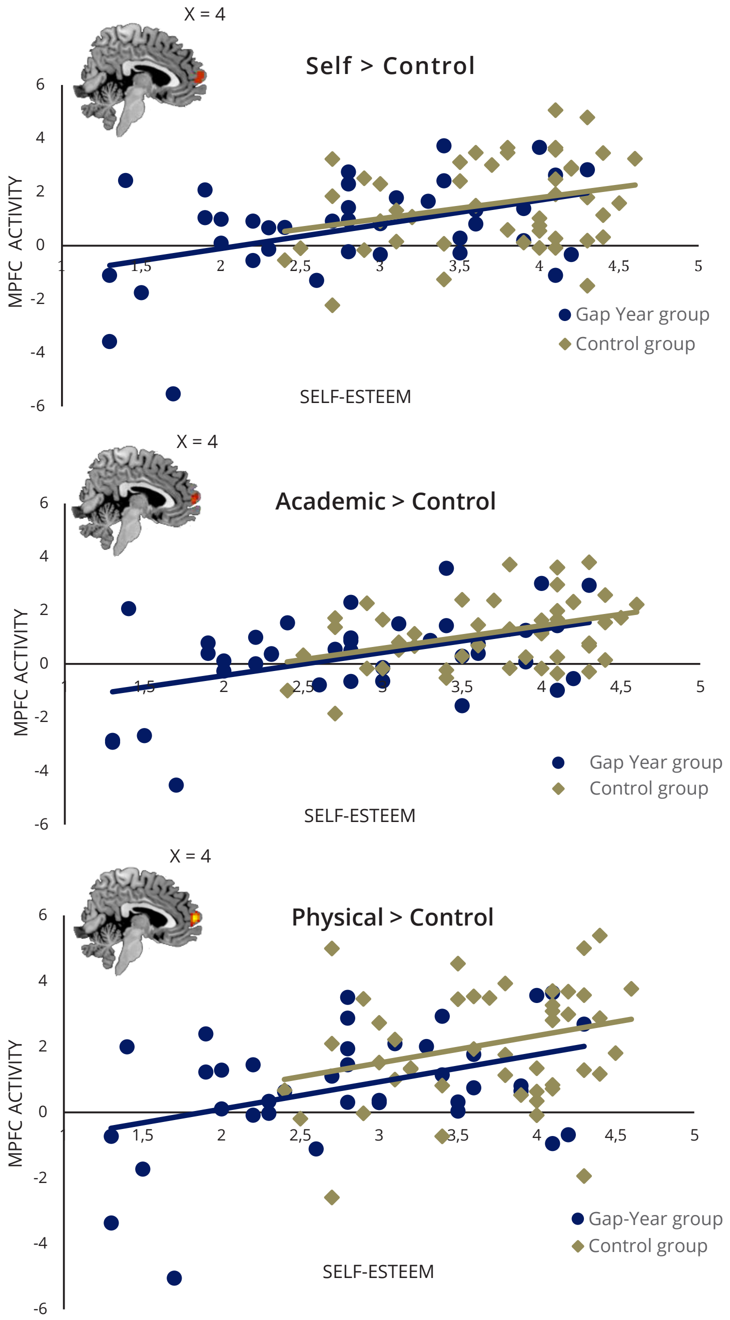

Figure 3: *mPFC shows increased activity for increased self-esteem in the contrasts Self > Control, Academic > Control, and Physical > Control.*

DISCUSSION

In this study, we investigated behavioral and neural correlates of self-concept and self-esteem in individuals who experience problems with educational decision-making. We compared adolescents who were struggling with the educational decision-making process and were at the start of a structured gap year program (gap year group) to adolescents who already successfully transitioned into higher education (control group) on measures of domain specific self-evaluations, self-concept clarity and self-esteem. Results revealed two key findings. First, adolescents struggling with educational decision-making reported lower levels of self-esteem and self-concept clarity compared to a control group, but did not differ in their self-evaluations specific to domain. Second, lower self-esteem was associated with less self-related activity in the medial prefrontal cortex, especially for evaluating academic and physical traits. These findings will be described in more detail in the following paragraphs.

Differences in behavioral self-concept and self-esteem

Our first aim was to investigate characteristics related to self-evaluation in individuals who experience difficulties with educational decision-making compared to a control group. In line with our expectations, individuals who were struggling with educational decision-making scored significantly lower on self-concept clarity and self-esteem compared to their already-decided peers. Regarding self-esteem, these results are consistent with other studies relating self-esteem to career indecision and career decision-making self-efficacy (Choi et al., 2012; Creed, Prideaux, & Patton, 2005; Gati et al., 2011; Germeijs & De Boeck, 2002; Lin et al., 2015). Self-esteem could contribute to greater efficacy in decision-making as individuals with more self-esteem possess more positive attitudes, value the self more and therefore might engage more often in exploring and prioritizing their interests (Lin et al., 2015). Self-esteem could also function as a mechanism encouraging more goal-directed behavior (e.g. choosing a major based on own intrinsic interests and personal goals, not influenced by parental expectations) and could contribute to the confidence needed to make the final decision.

As predicted, we also found group differences in self-concept clarity. This is unsurprising as individuals with higher self-esteem are often also more confident in their self-judgments, and those self-judgments tend to be more stable and consistent (Campbell, 1990). These results could also be interpreted in the context of decision-making. For example, research has indicated that individuals who hold their self-beliefs with more certainty are also more likely to use self-knowledge to guide their decisions (Setterlund & Niedenthal, 1993; Story, 2004). Not having a clear sense of who you are could therefore also interfere in the process of deciding for a suitable major. For example, individuals with low self-concept clarity might be less confident that their strengths and weaknesses at the time of deciding for a college major will be the same in the future, and might anticipate regretting their decision. This could negatively influence their motivation to explore different options, and increase the chance of remaining undecided. Future studies should test these hypotheses in more detail using longitudinal designs to examine the temporal relation between self-esteem, self-concept clarity and educational decision-making.

Interestingly, we did not find any group differences in domain-specific self-evaluations. Contrary to our expectations, the gap year group did not evaluate themselves more negatively on academic traits. These results suggest that it is not necessarily their academic abilities that the gap year individuals are insecure or more negative about. Instead, their lack of a clear self-concept and low self-esteem are possibly a greater hindering factor for finding a future major that fits their identity. It is possible that they are confident that they have the academic potential to succeed in higher education, but lack the self-insight or self-esteem needed to choose a suitable major.

Differences in neural correlates of self-concept and self-esteem

An important way to clarify the underlying mechanisms of self-concept and educational decision making is by using neuroimaging measures as they may provide additional information about the networks underlying the process of making self-evaluations (Denny, Kober, Wager, 2012; Pfeifer & Peake, 2012). A second aim of this study was therefore to compare neural activity patterns in participants who struggle with educational decision-making to peers without such problems, and to examine whether activity was dependent upon individual differences in self-esteem and self-concept clarity. As anticipated, across all participants we found increased activity in cortical midline areas (such as mPFC) during self-evaluations across domains compared to a control task. This is consistent with studies investigating neural correlates of self-processing in adults as well as in adolescents (Flagan & Beer, 2013; Northoff & Bermpohl, 2004; Pfeifer & Berkman, 2018; Romund et al., 2017).

To examine how this neural activity differed between participants struggling with educational decision-making versus those who did not experience difficulties, we directly compared the groups to each other. In contrast to our expectations, a direct comparison did not result in neural differences between the groups for domain-general - nor for domain-specific self-evaluations. However, because the two groups differed in self-esteem, we also tested for self-related brain regions that co-varied with individual differences in self-esteem. Using self-esteem as a continuous measure could be more valuable than comparing at a group level, as this also takes into account individual differences within groups (Altman & Royston, 2006). We observed that individuals with higher levels of self-esteem recruited the mPFC more during self-reflection than did individuals with lower levels of self-esteem. This relationship was present for the evaluation of academic as well as physical traits. This indicates that self-esteem dependent individual differences in mPFC-recruitment are reflected in multiple domains. Thus, we found no whole-brain group differences in neural activity, but the groups differed on self-esteem and lower individual levels of self-esteem were associated with reduced self-related mPFC activity. These results highlight the importance of using an individual differences approach to examine the neural characteristics of individuals struggling with educational decision-making.

Prior studies have also observed relations between brain activity and self-esteem in comparable paradigms, such that individual differences in self-esteem were related to processing of self-referential items in dACC and OFC (Yang et al., 2012, 2016). This study, in contrast, observed that specifically the central part of the mPFC correlated with self-esteem. Differences between these results and our findings can possible be explained by the valence of the items as well as the choice of control condition. For example, Yang and colleagues (2016) reported a positive relation between OFC activity and self–esteem during self-evaluation of positive traits only, and these were contrasted against evaluation of traits of others, instead of the more basic semantic control condition used in our study. These design differences could have contributed to the relatively more ventral PFC regions being activated in Yang et al., which are regions known for supporting affective processing and have been related to more positive as well as more self-relevant self-descriptions (D'Argembeau, 2013; Moran, Lee, & Gabrieli, 2011), while in our study self-esteem was related to more central mPFC activation for thinking about the self in general compared to a more basic control task. In addition, Yang and colleagues (2016) did show a positive relation between mPFC activity and self–esteem, but only during evaluation of positive descriptions from others about the self. Together, these results suggest that self-esteem could serve as an important condition to help individuals in mentalizing about the self as well as about opinions of others about the self. Given that we found that individuals who struggled with educational decision-making scored lower on self-esteem, it would be an interesting future direction to investigate how self-esteem interventions could influence the content and valence of these self-appraisals and related neural activity.

The lower self-related mPFC activity which we found in individuals with lower self-esteem has also consistently been found in individuals with autism or alexithymia who are known for their deficits in self-awareness and impairments in mentalizing (Moriguchi et al., 2006; Pfeifer et al., 2013; Uddin, 2011). However, in our study it would be more likely to expect to find this relation with self-concept clarity, as this construct is more closely related to lower self-awareness. Interestingly, we did not find any neural activity related to individual differences in self-concept clarity, A prior study by

D' Argembeau did show that higher self-certainty was reflected in increased dmPFC activation (D'Argembeau et al., 2012). Possibly, these differences in findings are related to a difference in measures. Whereas self-certainty measures certainty of possessing traits related to specific domains, self-concept clarity reflects general stability and internal consistency of the self-concept (Campbell, 1990). Future studies are needed to unravel the interplay between self-certainty, self-concept clarity, self-esteem and self-processing on a behavioral and neural level.

Limitations, Future directions and Conclusions

In this study we compared a specific group of adolescents struggling with educational decision-making with adolescents who did not. Although this method increased our understanding of the behavioral and neural self-related characteristics of this specific group, results should be interpreted in light of several limitations. First, the experience of educational decision-making problems can be confounded with other difficulties (e.g. in the clinical range). Therefore it is inherently difficult to find a control group that precisely matches the gap year group, as they might differ in more areas than just educational decision-making. Larger samples in which various individual difference factors are controlled for can possibly provide more insight into these specificities.

Second, in this study we only investigated differences in self-concept measures between groups and did not test direct relations between self-concept and specific educational decision-making problems (e.g. differentiating between educational indecision or deciding but stopping in the first year). Therefore, we were not able to draw conclusions about what self-concept variables are better predictors for certain educational decision-making problems. Future studies should take these distinctions into account in order to increase our understanding of predictors of these various problems.

Additionally, future research would benefit from using larger samples and randomized control trials or longitudinal designs to separate cause and effect. For example, future studies should investigate whether individuals have lower self-esteem as a result of their difficulties with educational decision-making (perhaps by not conforming to the societal norm of pursuing a college degree, lacking structure or clear future life goals, or the feeling of lagging behind compared to their peers), or whether low self-esteem holds back self-exploration thereby hindering them from making an informed decision for a future major that fits their identity (Lin et al., 2015).

Despite these limitations, our results add to an increasing understanding of characteristics of individuals struggling with choosing a future major or career, and stress the importance of investigating non-cognitive, psychological factors in the decision-making process, as well as their underlying neural mechanisms. Moreover, as we did not find any differences in self-evaluations specific to domain, our results suggest that general factors relating to the structure and positivity of the self are possibly of greater relevance in the process of educational decision-making rather than domain-specific self-evaluations, such as how one evaluates their academic abilities. Our behavioral and neural results regarding differences in self-esteem especially highlight that healthy levels of self-esteem could be an important condition for the ability to make a well suited educational choice. These findings have important implications for future interventions, and emphasize the need for more attention to personal development in high-school in order to increase the possibilities for adolescents to find a major that fits their interests, abilities and goals.