Self-Regulated Learning and Executive Function:
Exploring the Relationships in a Sample of Adolescent Males

Abstract

Executive function (EF) is emerging as a construct that is of interest to educators, but its relationship with educationally relevant sets of skills such as self-regulated learning (SRL) are unclear. This study investigated relationships between SRL and EF in a sample of 254 school aged adolescent males. Two hypotheses were tested: that self-reported measures of SRL and EF are closely related within the sample and that as different aspects of EF mature during adolescence, the corresponding components of SRL should also improve, leading to an age-related increase in the correlation between EF and SRL. Two self-report instruments were used: the Strategies for Self-Regulated Learning Survey (SSRLS); and the Behavioural Rating Instrument of Executive Function (BRIEF). Strong correlations between the measures of EF and SRL were found, especially in areas associated with metacognitive processes, suggesting that SRL and EF share a conceptual core based on the efforts that individuals make to monitor their thoughts and actions and to act accordingly to control them. Age-related differences in correlations between EF and SRL were found, with weaker correlations between behavioural regulation and SRL in the younger participants (aged 10.5 to 12.5 years) while the relationship between EF and SRL appears to grow stronger for participants aged 12.5 to 15.5 years even though self-reported levels of EF along with motivation for SRL and important components of SRL such as goal setting and planning were found to decrease with age. Decreasing levels of motivation for learning during adolescence are speculated to moderate the deployment of SRL and EF in a school context.

Keywords:

Self-regulated learning, executive function, adolescence.
Introduction

As adolescents progress through school their academic workloads typically increase and they are required to manage increasingly specialized subject matter, increased levels of homework and more demanding assessment tasks. At the same time, they are expected to be more independent and self-sufficient inside and outside the classroom (Zimmerman, 2002) and to demonstrate increased levels of self-regulatory, adult-like behaviour (Steinberg, 2005).

In the educational literature, the skills necessary for self-regulation in classroom settings have been investigated and described using a variety of rubrics including metacognition, self-regulation (SR) and self-regulated learning (SRL). In the literature, the conceptual boundaries between these terms appear blurred and often entangled (Dinsmore, Alexander, & Loughlin, 2008). The broadest understanding of “self-regulation” refers to the exercise of control over oneself, especially with regard to bringing the self into line with preferred standards (Vohs & Baumeister, 2007). From a psychological perspective, the term self-regulation carries the connotation of regulation of the self by the self through deliberate effort (Vohs & Baumeister, 2007) and can be defined as the self-generated thoughts, feelings, and behaviours that are planned and cyclically adapted based on performance feedback to attain self-set goals (Zimmerman, 1989). Thus, self-regulation requires an individual to activate and monitor thoughts, behaviours and emotions in order to reach goals (Woolfolk & Margetts, 2007).

The focus on self-regulation in academic settings led to the development of self-regulated learning as a field of study (e.g., Butler & Winne, 1995; Pintrich, 2000; Pintrich & De Groot, 1990; Winne & Hadwin, 1998; Zimmerman, 2001; 2008). Self-regulated learners control their learning by actively setting goals, deciding on appropriate strategies, planning their time, organizing and prioritizing materials and information, shifting approaches flexibly, monitoring their learning by seeking feedback on their performance and by making appropriate adjustments

The skills and processes associated with SRL are often couched in terms of metacognition. This term was originally used to describe ‘thinking about thinking’ (Miller, Kessel, & Flavell, 1970) but has subsequently expanded to incorporate knowledge about cognition and a range of self-regulatory mechanisms related to planning, monitoring and evaluating (Baker & Brown, 1984; Brown, 1987; Metcalfe & Shimamura, 1994; Nelson, 1996; Pintrich & DeGroot, 1990; Pintrich & Schunk, 1996). Self-regulated learning has been described as the place where metacognition and motivation intersect (Zimmerman & Moylan, 2009). As such, students can be described as self-regulated to the degree that they are metacognitively, motivationally and behaviourally active participants in their own learning process (Zimmerman, 1986; 2008).

Dinsmore et al. (2008) point out a ‘conceptual core’ which binds the three constructs of self-regulation, self-regulated learning and metacognition together. This conceptual core relates to the efforts that individuals make to monitor their thoughts and actions and to act accordingly to gain some control over them. In other words, the constructs are aligned as a result of the combination of self-awareness and intention to act.

In the psychological and neuropsychological literature, self-regulation and the cognitive processes that serve ongoing, goal-directed behaviours are closely associated with the term “executive function”. Executive function (EF) is an umbrella term (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Chan, Shum, Touloupolou, & Chen, 2008; Meltzer, 2007) that has long been associated with the co-ordination, regulation and optimization of the cognitive processes necessary for formulating goals, planning how to achieve them, and carrying out those plans effectively (Anderson, 2001; Baddeley, 1987; Denckla & Reader, 1993; Lezak, 1982, 1995; Luria, 1966; Moran & Gardner, 2007; Shallice, 1982, 1988; Stuss & Benson, 1986; Wood,
De Luca, Anderson, & Pantelis, 2004). EF has been referred to as the “conductor” which controls, organizes and directs cognitive activity, emotional responses and behaviour (Gioia, Isquith, & Guy, 2001) and descriptions of EF typically include goal setting and planning, cognitive flexibility, attentional control, inhibition of impulses, performance monitoring, and the use of feedback (Anderson, 2001; Shallice, 1988; Stuss & Benson, 1986; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; Wood, De Luca, Anderson, & Pantelis, 2004). EF appears to be a multidimensional construct for which a variety of conceptual frameworks have been formulated (Anderson, 2008; Chan et al., 2008; Lyon & Krasnegor, 1996) from the perspectives of supervisory attention (Norman & Shallice, 1986); working memory (Baddeley, 1987, 2000); problem solving (Zelazo, Carter, Reznick, & Frye, 1997) and volition (Lezak, 1995).

Intuitively, it would appear that EF is also aligned with Dinsmore et al.’s (2008) ‘conceptual core’. The analogy of EF being a conductor of cognitive activity highlights the self-regulatory role that EF performs, however the exact manner in which EF acts as a self-regulatory control system continues to be debated. It has been recognised that different tasks require the contextualized application of a range of executive processes for success (e.g., Anderson, 2002; 2008; Baddeley, 1987; Norman & Shallice, 1986). Barkley (1997; 2001) suggests that self-regulation is the overarching concept which incorporates the key components of EF while others (e.g., Baumeister, 1998; Baumeister, Schmeichel, & Vohs, 2007; Denckla, 1998; Denckla & Reader, 1993; Ylvisaker & Feeney, 2008) view EF as the control processes that overarch all contexts and content domains with self-regulation being subsumed into EF (Denckla, 1998; Denckla & Reader, 1993; Ylvisaker & Feeney, 2008). This perspective suggests a conceptual hierarchy and if this were the case then SRL, with its focus on the context of academic learning, may be viewed as a contextualized application of EF.

Like SRL, EF is often couched in terms of metacognition (e.g., Krause, Bochner, Duchesne, & McMaugh, 2010; Meltzer & Krishnan, 2007; Meltzer et al., 2007; Zimmerman,
1986; 2008; Zimmerman & Moylan, 2009) with many authors blending the terms and understandings of executive function and metacognition together (e.g., Corno, 2001; Krause et al., 2010; McCombs, 2001; Meltzer & Krishnan, 2007; Meltzer et al., 2007; Tobias & Everson, 2009). The descriptions of EF and SRL in the literature suggest that a conceptual link between EF and SRL may be made through the “common ground” occupied by metacognition. EF is of increasing interest to those in the field of education due to the recent emergence of a neurobiological model of adolescent development (Casey, Jones, & Hare, 2008; Casey, Jones, & Somerville, 2011; Dahl, 2004; Spear, 2009; Steinberg, 2005; 2010). This model, described as the first “grand theory” of adolescence to be proposed in the last 50 years (Steinberg, 2010), is based on neuroscientific studies charting the maturation of the brain. These studies have found that the frontal lobe of the brain undergoes substantial reorganization and development during adolescence (Barnea-Goraly et al., 2005; Giedd, 2004; Gogtay et al., 2004; Toga, Thompson, & Sowell, 2005). The frontal lobe has long been associated with EF (Fuster, 2002; Miller & Wallis, 2008; Stuss & Benson, 1986) and as such, it has been speculated that adolescence may constitute a developmentally sensitive period for executive functions (Blakemore & Choudhury, 2006; Giedd, 2004; Giedd et al., 1999; Keating, 2004; Steinberg, 2005).

This speculation raises questions about the relationship between EF, SR, SRL and metacognition during adolescence and the development of the skills that may pertain to the conceptual core that underpins these constructs. Previous research into the development of EF has found that EF skills continue to develop through childhood and into adolescence, with different aspects of EF maturing at different rates and reaching full functionality at different times (Anderson, 2001; Levin et al., 1991; Welsh, Pennington, & Groisser, 1991). Adult levels of ability in EF skills associated with simple planning and attentional set-shifting ability appear to be reached in late childhood or early adolescence (e.g., De Luca et al., 2003; Huizinga, Dolan, &
van der Molen, 2006) while strategic planning and problem solving (Welsh & Pennington, 1988), attentional ability, processing speed and goal setting (Anderson et al., 2001), complex planning and organization (Krikorian & Bartok, 1998), strategic behaviour (Waber & Homes, 1986), processing efficiency (Kail, 1986) and working memory (Huizinga et al., 2006) continue to improve through adolescence, reaching full functionality sometime in late adolescence or early adulthood (Anderson, 2001).

The continued improvements in many EF components during adolescence should allow for greater monitoring and management of cognitive resources. Kuhn and Franklin (2006) argue that the emergence and strengthening of this executive is the single most important and consequential intellectual development to occur in the second decade of life. Empirical studies of the development of self-regulated learning during adolescence are limited, however broader developmental studies have shown that self-regulatory cognitive control develops throughout childhood and into adolescence (Duckworth & Seligman, 2006) with the self-regulatory processes involved in learning appearing to operate under increasing executive control in the years between childhood and adulthood (Kuhn & Pease, 2006).

If it can be shown that SRL is a contextualized application of a set of executive functions, perhaps operating through a common conceptual core of metacognitive self-awareness and intention to act, then it may be possible to draw on our understanding of the developmental changes in EF during adolescence to come to a deeper understanding of how SRL develops during this time. Studies of the development of EF have typically taken a laboratory focused approach to the data collection and as such, are devoid of any educational context. Although laboratory research is essential to test and develop theoretical understandings, speculation about developmental changes in educationally relevant skills during adolescence needs to be tested in authentic, ecologically valid contexts. It is understood that intellectual development and social functioning are closely connected to, and cannot be separated from the social contexts in which
they occur (Bandura, 1999; Bronfenbrenner, 2001, 2005; Purdie, Carroll, & Roche, 2004). The awareness of the contextual embeddedness of adolescents is now considered to be an essential element of good research (Brown, 2005).

With this challenge in mind, this study set out to examine the links between EF and SRL within the context of an independent college for boys. Historically, it would seem that males have been largely advantaged in the classroom and in most academic settings (Weaver-Hightower, 2003). However, mounting evidence points to a growing gender gap in classroom functioning and academic achievement (Alloway & Gilbert, 1998; MacCann, 1995; Matthews, Ponitz et al., 2008; Organisation for Economic Co-operation and Development, 2004; Teese, Davies, Charlton, & Polesel, 1995; West, 1996, 1999) with gender differences in self-regulatory skills seen as a possible cause (Duckworth & Seligman, 2006; Matthews et al., 2009). Gender differences in self-regulation have been identified in school aged children (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006; McClelland, Morrison, & Holmes, 2000; Ponitz et al., 2008; Ready, LoGerfo, Burham, & Lee, 2005; Silverman, 2003) with girls consistently perceived by teachers as being more self-controlled and self-disciplined than boys in classroom settings (Beaman, Wheldall, & Kemp, 2006; Humphrey, 1982; Kendall & Wilcox, 1979).

Australia has a long tradition of single-sex schooling. A common argument in favour of this approach is the notion that single-sex schools can more adequately provide learning environments suited to the specific learning needs of each sex (Martino, Mills, & Lingard, 2005). Rowe (2000) found that both girls and boys in single-sex schools perform better and report more positive experiences of schooling than in co-education environments. For boys-only schools, a strong academic ethos is thought to foster a positive approach to boys’ education (Keddie & Mills, 2007) with some schools also introducing programs aimed at promoting self-regulatory behaviour for their male students (Zimmerman, Bonner, & Kovach, 1996).
The context of this study was a large, independent college for boys with a strong academic ethos. The school’s mission statement speaks of the value of good scholarship, the love of learning, independence in thought and action and the readiness to take responsibility for one’s own formation. The learning culture that exists within the school encourages the students to exercise self-regulatory strategies and to develop increasing levels of autonomy. The school has adopted the Dimensions of Learning (DOL; Marzano et al., 1997) as a pedagogical framework for the renewal of teaching and learning with a specific focus on the development of independent, self-directed learners. The establishment of this framework within the school, along with the emerging neurobiological model of adolescent development, has raised questions about the nature of academic self-regulatory development in the students of the school, the application of theoretical models of developing self-regulatory behaviour to the student population and the influences on self-regulation.

This study was developed to test two hypotheses. The first hypothesis arises from the potential sharing of a ‘conceptual core’ between EF and SRL. If this is the case, it would be expected that measures of EF and SRL in a relatively homogeneous sample should be closely correlated. Further, if the understanding of EF as an overarching control process that subsumes self-regulation is true, then SRL could be seen as a contextualized application of a set of executive processes and thus some directionality may be present in the relationship.

The second hypothesis arises from the recognition that different aspects of EF mature at different rates during adolescence. Thus, it is hypothesised that as the different aspects of EF mature during adolescence, the corresponding components of SRL should also improve, leading to an age-related increase in correlation between EF and SRL.

**Method**
**Participants**

Participants in this study were 254 early to school-aged adolescent male students with an age of 10.5 years (126 months) to 17.5 years (210 months). Participants in this study were students of a private boys’ school located in Brisbane, Australia. With an enrolment of approximately 1500 students, the school is set on a well-equipped and pleasant campus and has a strong academic ethos.

The majority of participants in this study were born in Australia (93%) to Australian born parents (74.3%). Of the sample, 1% identify one or more of their parents as having Aboriginal or Torres Strait Islander heritage. While the majority of participants reported living at home with both parents during the school term (73%), a sizeable proportion board at the school (18%) while smaller numbers live with either one of their parents (9%). Only a small proportion of the participants are their parent’s only child (4%) with the majority having either one (35%) or two (35%) siblings. Smaller numbers report being members of larger families of up to five siblings.

The participants in this study appear to be active and busy young people. 83% of the sample reported participation in competitive school sports involving training and competition outside normal school hours and on weekends. In addition, 58% of the sample group also reported being involved in one or more competitive sporting activities beyond the school. 51% of the participants reported playing a musical instrument and of these, 93% state they have music lessons on a regular basis. Engagement in paid part-time work was reported by 37% of the sample. The younger participants tended to be paid for work around the home, with paid work outside the home becoming more common for participants in older grades.

**Materials**

The fluid and dynamic nature of goal-directed behaviour makes the assessment of EF and SRL challenging. Traditionally, EF research has been from a clinical perspective involving tests of neuropsychological functioning. Current performance based neuropsychological tests attempt
to separate integrated functions into component parts (Burgess, 1997) and assess individual components over a short time frame which may not be relevant to the more complex application of EF in day to day situations (Goldberg & Podell, 2000; Shallice & Burgess, 1991). These issues have led to increased attention to ecological validity in the assessment of EF (Burgess, Alderman, Wilson, Evans, & Emslie, 1996; Kibby, Schmitter-Edgecombe, & Long, 1998; Silver, 2000) and to the development of structured, self-report behaviour rating systems. Self-reports have been successfully used to gather information about executive functioning in adolescents (Hughes, Turkstra, & Wulfeck, 2009; Lee, 2005; Mahone, Zabel, Levey, & Kinsman, 2002). Self-report instruments have been developed to investigate SRL in college students (Pintrich, Smith, Garcia, & McKeachie, 1993; Weinstein, Schulte, & Palmer, 1987) and in school-aged students (Purdie et al., 2004; Purdie & Hattie, 1996).

Dinsmore et al. (2008) urge caution when attempting to use self-report instruments to capture data on the dynamic interplay of person, environment and behaviour that is the hallmark of self-regulation. In this study, self-report instruments were chosen in an attempt to simultaneously capture the student’s own perceptions of SRL and EF use at a particular moment in time. Two self-report instruments were chosen: the Strategies for Self-Regulated Learning Survey (SSRLS) (Purdie, Carroll, & Roche, 2004; Purdie & Hattie, 1996) and the Behavioural Rating Inventory of Executive Function – Self-Report Version (BRIEF-SR) (Guy, Isquith, & Gioia, 2006). The use of two self-report instruments facilitated the comparison of data between the EF and SRL constructs without being confounded by marked differences in the data collection method in relation to both type and timing.

**Strategies for Self-Regulated Learning Survey (SSRLS)**

This instrument has been successfully used to determine self-regulated learning abilities in adolescents by Purdie et al. (2004) and consists of 45 items with five subscales: Goal setting and planning; Self-efficacy for goal achievement; Using Task Strategies; Self-motivation; and
Self-monitoring and Self-evaluation. The numbers of items per scale were 7, 7, 10, 9 and 12 respectively. The five subscales encompass aspects of self-regulated learning that are exemplified by five questions: “What do I have to do?” “How confident am I that I can do it?” “How will I do it?” “How will I keep on task when the going gets tough?” and “How well am I doing?” The participants respond to each item using a 6-point rating scale (1 = not at all true of me; 6 = very true of me). High scores on all subscales indicate high levels of academic self-regulation (Purdie et al., 2004) and a global score for the instrument can also be calculated. Reliability coefficients for the SSRLS subscales, based on Purdie et al. (2004) and the current data, are shown in Table 1. All reliability coefficients (Cronbach’s alpha) were within an acceptable range (Field, 2009) with the exception of the Goal Setting and Planning subscale for the current research ($r_c = 0.63$). This may have occurred because of the small number of items in the scale.

*Behavioural Rating Inventory of Executive Function (BRIEF-SR).*


The BRIEF-SR was developed from the original BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000), which was designed as a rating scale for use with school-aged children (5 to 18 years). The BRIEF is the most well known behavioural checklist for EF (Strauss, Sherman, & Spreen, 2006). The BRIEF-SR was designed to report on self-regulatory functioning from an adolescent’s own perspective in a way that revealed clinically useful, reliable and valid datum (Guy et al., 2004). The self-report version of the BRIEF-SR comprises an 80-item inventory that aims to capture the adolescent's view of his/her own purposeful, goal-directed, problem-solving behaviour. The BRIEF-SR is administered using the BRIEF-SR Rating Form with participants
responding to each item using a three point scale (*never, sometimes, often*). The BRIEF-SR yields information for eight subscales that measure different aspects of executive functioning: Inhibit; Shift; Emotional Control; Monitor; Working Memory; Plan/Organize; Organisation of Materials; and Task Completion. The Inhibit subscale refers to the ability to control impulses and behaviour, for example, being able to appropriately stop and modulate one’s own behaviour at the proper time or in the proper context. The Shift subscale addresses the ability to move from one situation, activity, or aspect of a problem to another as the situation demands. The Emotional Control subscale reports on the manifestation of executive control in the emotional realm and refers to the ability to modulate emotional responses appropriately to suit the situational demand or context. The Monitor subscale represents the awareness of one’s own strengths, weaknesses, behaviour and how one’s own behaviour impacts on others. The ability to self-monitor, that is, to check one’s own actions during or after a task to assure goal attainment, is an important indicator on this subscale.

The Working Memory subscale refers to the ability of holding information in mind for the purposes of completing a task. The Plan/Organize subscale focuses on the ability to anticipate future events or consequences, the ability to use goals or instructions to guide behaviour in context and develop steps ahead of time to complete a task in a systematic manner. The Organization of Materials subscale reports on the ability to maintain order during work. This is manifested in the organization of one’s environment and keeping track of belongings. The completion of school work and other tasks in a timely manner is the focus of the last subscale, Task Completion (Guy et al., 2004; Strauss et al., 2006).

Factor analysis by Guy et al. (2004) of the eight scales resulted in a two-factor solution. The first factor consisted of the Inhibit, Shift and Emotional Control and Monitor subscales and was named the Behavioural Regulation Index (BRI). The second factor consisted of the remaining subscales of Working Memory, Plan/Organize, Organization of Materials and Task
Completion and was named the Metacognitive Index (MI). The Metacognitive Index represents the adolescent’s ability to systematically solve problems via planning and organization while sustaining these task completion efforts in active working memory. Together, the BRI and MI yield an overall summary score, the Global Executive Composite (GEC). Low scores indicate high levels of self-reported executive functioning.

Reliability coefficients for the BRIEF subscales, based on Guy et al. (2004) and the current data, are shown in Table 1. All reliability coefficients (Cronbach’s alpha) for the current research were within the acceptable range (Field, 2009), however, the Monitor and Organization of Materials subscales had relatively low reliability ($\alpha = .68$ and .66 respectively).

<Insert Table 1 here>

The BRIEF contains two validity scales: inconsistency and negativity. The inconsistency scale indicates the extent to which the respondent answers similar questions in an inconsistent manner. The scale is formed by computing the absolute value of the difference in scores on pairs of items that are similar (e.g., Item 14: “I have angry outbursts” and Item 32: “I have outbursts for little reason”). A respondent who marks never for Item 14 but often for Item 32 would be scored as having the maximum difference in scores for this pair. Responses can be quantified with never, sometimes and often being coded numerically from one to three and the absolute value of the difference in scores for each of the 10 sets of item pairs calculated and summed to obtain the Inconsistency Score (Guy et al., 2004). Thus, the possible range for the Inconsistency Score is 0 to 20. As only 1% of respondents in the clinical and normative sample scored 9 or higher, this score is taken as the threshold above which the respondent’s data should be treated with suspicion.

The negativity scale measures the extent to which the respondent answers a selection of 10 items in a manner that indicates unusually negative self-perceptions. If a respondent chooses
often for six or more of the 10 items in the negativity scale, the respondent is considered to have an elevated level of negativity and the data should be treated with suspicion (Guy et al., 2004).

**Procedure**

Ethical clearance for this study was obtained from the Social and Behavioural Sciences Ethical Review Committee of The University of Queensland in accordance with the National Health and Medical Research Council’s Statement on Ethical Conduct in Human Research (2007).

The recruitment of students for this project began with the researcher making a short presentation to the students and staff of the school. The goals of the project and the nature of the research were briefly explained and the students were invited to participate. Approximately 1350 letters were distributed and informed consent was received from 259, representing a response rate of approximately 19%. After receipt of consent, the two data gathering instruments were administered to groups of approximately 20 participants in a quiet wing of the school’s library. Each participant was seated at a desk and completed the instruments in silence. The researcher was present at all times and gave instructions consistent with those suggested in the BRIEF-SR Professional Manual (Guy et al., 2004). Each participant was given as much time as was needed to complete the data gathering instruments, with most participants completing both instruments in 20 to 25 minutes.

The participant’s responses to the SSRLS were scored in accordance with the subscales developed by Purdie & Hattie (1996) and successfully used by Purdie et al. (2004). The participant’s responses to the BRIEF-SR were scored in accordance with the BRIEF-SR Professional Manual (Guy et al., 2004). Each participant’s Rating Form was hand scored by the researcher with the resulting scores assessed for validity using the BRIEF’s inconsistency and negativity scales. Two participants who scored above the threshold for either of the validity
scales were not included in the study. Raw scores for each of the eight BRIEF-SR subscales, the two indexes and the overall composite were converted to T scores using normative conversion tables provided in the BRIEF-SR Professional Manual.

All scores were entered into SPSS for analysis of the data. In order to test the first hypothesis, that self-reported measures of SRL and EF are closely related in the sample group, Pearson’s correlation coefficients were calculated to explore the relationships between the BRIEF and SSRLS subscale scores. A simple regression analysis was conducted to test whether EF scores were a better predictor of SRL or vice a versa.

To test the second hypothesis, that an age-related increase in correlation between EF and SRL might exist as a result of the increased EF and SRL component skills during adolescence, the participants were categorized into three groups according to their age. Three groups were formed (Junior: participants aged 12.5 years or less; Middle: participants aged between 12.5 and 15.5 years; and Senior: participants older than 15.5 years). These age ranges were chosen to define the groups as they are a reflection of the three stages of schooling in the sample (upper primary, lower high school and senior high school). The relationships between EF and SRL subscale scores were examined using Pearson’s correlation coefficients and an analysis of variance (ANOVA) was conducted to determine if the mean scores for each of the instrument’s subscales differed significantly between the groups.

**Results**

It was hypothesised that self-reported measures of SRL and EF are closely related in the sample and so Pearson’s correlation coefficients were calculated in order to examine the relationship between the subscale scores of the BRIEF and SSRLS instruments (Table 2).

<Insert Table 2 here>

Many correlations were found between the self-reported measures of SRL and EF. This finding supports the intuitive idea that the two instruments are measuring a common theoretical
notion or similar elements of a broader conceptual framework. The strongest correlations (defined as having Pearson correlation coefficients greater than .5 (Field, 2009)) were all found to be related to the BRIEF Metacognitive Index (MI) and its subscales. As lower scores on the BRIEF represent higher levels of self-reported executive functioning, the negative correlation coefficient for the BRIEF’s Global Executive Composite and the SSRLS Global Score indicates that as the self-reported levels of EF increased, so did the self-report levels of SRL.

A standard regression analysis was conducted to further investigate the relationship between the SSRLS Global Score and the BRIEF GEC. It was found that the BRIEF GEC significantly predicted SSRLS Global Scores ($b = -1.38$, $t(235) = -7.37$, $p < .001$). The BRIEF GEC also explained a significant proportion of variance in SSRLS Global Scores ($R^2 = .188$, $F(1, 235) = 54.30$, $p < .001$). The SSRLS Global Score was also a predictor of the BRIEF GEC, but in this case, the unstandardized coefficients was reduced ($b = -.14$), indicating that the GEC score was a better predictor of SSRLS Global Score than the SSRLS Global Score was of the GEC score.

In order to investigate which of the BRIEF subscale scores were the best predictors of the SSRLS score, a standard regression analysis was conducted with each of the BRIEF subscales entered as independent variables (Table 3). This analysis pointed to the BRIEF’s Shift and Plan/organize subscales as being the best predictors of the SSRLS global score for this sample.

This study also tested the hypothesis that the nature of EF and SRL may be age-dependent and result in changes to the relationship between self-reported levels of SRL and EF during adolescence. In order to examine these possible age-related differences, the participants were categorized into three groups according to their age (refer to Table 4).
The correlations between the SSRLS and BRIEF subscale scores were found to be subtly different for each of the age groupings (Table 5).

<Insert Table 5 here>

The junior group was found to have the fewest statistically significant correlations between SSRLS and BRIEF subscales (19 of 66) compared to the middle group (53 of 66) and the senior group (38 of 66). The correlations that were found for the junior group were clustered around the BRIEF’s Metacognitive Index and its’ Working Memory and Plan & Organize subscales. It was noted that for the junior group, the Behavioural Rating Index and its’ subscales contained only one significant correlation with the SSRLS subscales. Likewise, the SSRLS Task Strategies subscale was devoid of correlations with any aspect of the BRIEF.

For the middle group, numerous correlations were found across almost all aspects of the BRIEF and SSRLS with the only exception being the BRIEF’s Shift and Emotional Control subscales. In the senior group, the number of correlations decreased compared to the middle group, with the BRIEF’s Inhibit, Shift and Emotional Control subscales being largely devoid of correlations.

To further interpret these findings, the correlation coefficients were converted using Fisher’s Z-transformation and a Z-test conducted to determine if the differences between the correlation coefficients for each group were statistically significant (Table 6).

<Insert Table 6 here>

By convention, Z-test scores of greater than 1.96 and 2.58 are considered significant ($p < .05$ and $p < .01$ respectively). A number of significant differences were found between the junior and middle groups and between the middle and senior groups. In each case, the middle group had a stronger correlation coefficient than either the junior or senior group.
To further investigate possible age-related changes in EF and SRL, the mean scores for the BRIEF and SSRLS subscales were calculated for each age group (Table 7) and the differences were explored using a one-way between groups analysis of variance.

A significant difference was found between groups for the BRIEF GEC scores ($F(2, 242) = 6.79, p < .001$). The effect size, calculated using eta squared, was .05. Bonferroni corrected post hoc tests revealed differences between the senior group and the junior group (mean difference = 4.00, $p < .05$) and between the senior group and the middle group (mean difference = 4.57, $p < .001$). In both cases the senior group self-reported lower levels of executive functioning than the younger groups. It was noted that the sample size for the middle group was much larger than the junior and senior groups. Since the eta squared measure of effect size may be influenced by differences in group size, Cohen’s $d$ was calculated and used as an indication of the effect size for the post hoc comparisons. In both cases, Cohen’s $d$ was found to be 0.49, indicating a medium sized effect.

For the SSRLS scores, the ANOVA revealed a significant difference between the groups for the SSRLS Goal Setting and Planning ($F(2, 251) = 4.29, p = < .05, \eta^2 = .03$) and Self-motivation subscales ($F(2, 251) = 10.82, p < .001, \eta^2 = .08$). Post hoc tests revealed that the junior group self-reported levels of Goal Setting and Planning were higher than the middle group (mean difference = 2.39, $p < .05$), but the effect size was small (Cohen’s $d = .10$). The junior group was found to have a higher Self-motivation mean score compared to the middle group (mean difference = 3.09, $p < .05$) and the senior group (mean difference = 5.44, $p < .001$) with the mean score for Self-motivation decreasing with increasing age across the three groups. The effect size, calculated using Cohen’s $d$, was found to be .79 and .37 respectively.

Standard regression analysis was conducted to investigate the relationship between the BRIEF’s GEC score and the SSRLS Global Score for each age grouping. In the first instance,
the SSRLS Global Score was entered as the dependent variable and the BRIEF GEC score entered as the predictor for each age group. The results are shown in Table 8.

<Insert Table 8 here>

In each case the BRIEF GEC was found to be a predictor of the SSRLS Global Score. The middle group had the strongest R square value of the three groups, although the R square values are all modest. The middle group was also found to have the strongest beta coefficient (-.497) indicating a medium sized effect.

In order to test if the SSRLS Global Score was a better predictor of the BRIEF GEC score, a standard regression analysis was then conducted with the BRIEF GEC score entered as the dependent variable and the SSRLS Global Score as the predictor for each age group (Table 9).

<Insert Table 9 here>

While the R square and effect sizes remained the same as the previous analysis, the unstandardized b co-efficients were smaller in this case (-.07, -.15 and -.16 respectively) indicating that the GEC score was a more useful predictor of SSRLS Global Score than the SSRLS Global Score was of the GEC score.

Discussion

The skills necessary for self-regulation in educational settings have been described using a variety of rubrics including metacognition, self-regulation and self-regulated learning. In the literature, the conceptual boundaries between these terms appear blurred and often entangled (Dinsmore et al., 2008). The emergence of executive function as a conceptualization of interest to educators has the potential to cloud the picture further. This study was designed to investigate the relationships between self-reported measures of SRL and EF within the context of a sample group of school-aged, adolescent male students.
The first hypothesis tested in this study was that the self-reported measures of SRL and EF should be closely related within the context of a sample of adolescent school students. This hypothesis was supported by the number of statistically significant correlations between the subscale scores of the two instruments used in this study. Further, as self-reported levels of SRL increased, so did self-reported levels of EF. Not surprisingly perhaps, the majority the metacognitive aspects of EF correlated well with the measures of SRL. In broad terms it would appear that the self-report SSRLS instrument, designed to capture data about SRL, was also measuring many goal focused and metacognitively orientated aspects of EF. This finding lends support to descriptions of SRL and EF that are couched in terms of metacognition (e.g., Corno, 2001; Krause et al., 2010; McCombs, 2001; Meltzer & Krishnan, 2007; Meltzer et al., 2007; Tobias & Everson, 2009; Zimmerman, 1986; 2008; Zimmerman & Moylan, 2009) and gives rise to the notion that metacognition occupies the conceptual “middle ground” between EF and SRL. It would appear, for this sample at least, that EF shares the ‘conceptual core’ described by Dinsmore et al. (2008) as the efforts that individuals make to monitor their thoughts and actions and to act accordingly to gain some control over them.

The self-reported level of EF, as measured by the BRIEF’s Global Executive Score, was found to be a predictor of self-reported SRL. This finding, limited as it was by the nature of a regression analysis using data from single educational context and sample group, suggests a degree of directionality in the relationship between EF and SRL with EF being a stronger predictor of SRL than SRL was of EF. In a small way, this supports the formulation of SRL as being a contextualized application of EF.

The second hypothesis to be tested in this study focused on the possibility that as the different aspects of EF mature during adolescence, the corresponding components of SRL should also improve and lead to an age-related increase in correlation between EF and SRL. The analysis of the data from this sample group indicted that the self-reported levels of EF and SRL
did concurrently improve with age. The self-reported levels of EF in the Senior group were found to be lower than the Middle of Junior groups and the levels of self-reported goal setting and planning, a common descriptor of both EF and SRL, were found to be highest in the Junior group. In addition, the SSRLS Self-motivation scores were found to decrease with increasing age. This last finding brings a focus to the potential role that motivation plays in the application of skills that contribute to Dinsmore et al.’s (2008) conceptual core which binds the constructs of self-regulation, self-regulated learning, metacognition and executive function together.

Motivation can be thought of as an internal process that energises, directs and maintains behaviour over time (Krause et al., 2010) which in an educational context, refers to a student’s energy and drive to learn, work effectively and achieve to their potential (Martin, 2003). The role that motivation plays in self-regulated learning has been discussed (e.g., Zimmerman & Schunk, 2008) with Zimmerman and Moylan (2009) describing self-regulated learning as the place where motivation and metacognition meet.

Motivation is in part a matter of personality and involves habitual patterns of thought and action that develop over time (Csikszentmihalyi, Rathunde, & Whalen, 1993). Motivation is thus reflected in the patterns of activity and in the use of time. For many young people, adolescence is a time for increased independence, responsibility and social awareness (De Luca & Leventer, 2008). These changes are evidenced for many in the more focused involvement in sports and hobbies, the establishment of a part-time job and an increased interest in the opposite sex. The emergence of these interests and commitments may compete for the adolescent’s time and attention and result in a decrease in interest and motivation for the academic aspects of school. Decreases in the self-reported levels of EF with increasing age may also be a result of the participants becoming more adept and well practiced in executive processes that are required for day to day life at school as they get older. As a result, the executive processes become increasingly automatic and consequently the participants become less aware of them (van der
The difference in motivation between the participants in the Junior and Senior groups may also be a result of the younger students being typically naively confident about their future success whereas older students are more aware of their own limitations and thus more pragmatic.

Subtle, age-related differences in the relationship between self-reported levels of EF and SRL were found in this sample. For example, it appears that for the younger students in this study, the aspects of EF that are associated with the BRIEF’s BRI are not as strongly correlated to SRL as they are for the older groups. The BRI represents the adolescent’s ability to maintain appropriate regulatory control of his or her behaviour and emotional responses and it is thought that appropriate behavioural regulation is likely to be a precursor to the successful deployment of metacognitive processes (Guy et al., 2004). In the case of the young students in this study, it would seem that behavioural regulation, as measured by the BRI, may be playing less of a precursory role for the metacognitive strategies measured by the SSRLS than in the older groups. This may be because younger students have less advanced behavioural regulation skills compared to the older students and that the younger students may be reliant on external regulatory frameworks imposed by parents and teachers to a greater degree than the older students.

The Middle group was found to have the greatest number of correlations between the measures of EF and SRL and the Z-tests revealed that many of the correlation co-efficients were stronger for the Middle group compared to the Junior of Senior groups. For this sample, it appears that between the ages of 12.5 and 15.5 years, the relationship between EF and SRL grows stronger even though key processes such as goal setting and planning are lower than in the Junior group. It is possible that the differences in group size may have influenced the data that informed these findings, but the effect sizes, calculated using Cohen’s d which is not influenced by group size, lends some weight to their veracity. It has been suggested that early to mid
adolescence may represent a period of vulnerability to impulsive, risky, sub-optimal choices (Casey et al., 2008; Steinberg, 2005; 2010). This period of life is one where young people may be able to exercise increasing levels of independence and personal choice, but may also feel confused over competing interests and at risk of failure or rejection. As a result academic goal setting, prioritizing and planning may be less of a priority. In addition, it has been recognized that the transition to high school involves a complex renegotiation of student’s social relationships with both teachers and peers (Gillock & Reyes, 1996; Langenkamp, 2010). As Zimmerman (1998) suggests that teachers and peers are key social sources of SRL experiences, this transition to high school may be related to a temporary decline in achievement following the transition (Barone, Aguirre-Deandris, & Trickett, 1991; Eccles et al., 1993; Lucey & Reay, 2000; Reyes, Gillock, Kobus, & Sanchez, 2000).

This research represents a small study into aspects of a very large field. The findings of this research and their significance therefore need to be tempered by this knowledge. Limitations also exist by virtue of the scope and methodological restrictions. The sample for this study was composed of school-aged, adolescent male students drawn from a single school. This school was a large, independent boy’s school, with a particular ethos and culture which may not be representative of other schools. The culture of the school may be reflected in the socio-economic background of the parents who choose this school for their son and by the expectations that are placed on the student by the parents and the school. Together, these factors may influence the way these young men approach their learning. A future goal of the researchers is to extend this current study into a wider range of schools and social contexts. The inclusion of female students would allow for the examination of any potential gender based differences in the relationships between EF and SRL to be explored.

Self-report survey instruments were used to gather the data for this research. This approach was advantageous for data collection from a large sample group, but it does rely on
accurate self-reflection and reporting by the participants. In addition, the use of multiple self-report instruments could be viewed as a potential weakness of this study as the correlations could be inflated due to shared method bias. It would be interesting to see if the results of this study could be replicated with other types of instruments and this is a future aim of the researchers.

This study shows that EF and SRL are related with EF appearing to share in the ‘conceptual core’ identified by Dinsmore et al. (2008) that binds the constructs of SR, SRL and Metacognition. However, even apparently closely related constructs such as SRL and EF may be subject to differing, age-related changes during the adolescent period. The conceptualizations of EF and SRL, and that of adolescence itself, are not static and continue to develop. Further research is needed to better define and explore the developmental trajectories of EF and SRL, patterns of deployment, the links between them and influential developmental factors. Other types of evidence, such as that which is longitudinal in nature to track the development of the relationship between the constructs or which includes other sources, such as problem-solving manipulations or psychological measures, beyond self-report data, would be beneficial for teasing out the potentially nested nature of these constructs. The establishment of a clearer, empirical link between EF and educationally relevant sets of skills such as those associated with SRL would allow the hypothesised developmental, cognitive changes during adolescence, often couched in terms of EF, to be examined within an educational context.
References


