PSYCHOMETRIC PROPERTIES OF THE SELF-REGULATION AND CONCENTRATION TEST FOR CHILDREN (SRTC) IN A GREEK SAMPLE OF FOURTH GRADE STUDENTS

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Abstract: In the research tradition of self-regulation most of the empirical data have been based on self-reported regulatory skills, which do not necessarily reflect the actual level of students' self-regulatory efficiency. The aim of the present study was to examine the psychometric properties of the Self-Regulation and Concentration Test for Children (SRTC, Kuhl & Kraska, 1992, 1993), a behavioral computerized test for measuring self-regulatory skills, in a sample of Greek students. A total of 88 fourth grade girls ($N = 44$) and boys ($N = 44$) participated in the study from three Greek state primary schools. Participants were asked to complete the SRTC, which examines children's ability to concentrate on a task and resist temptation (distraction). Also, teachers were asked to evaluate children's school performance in language and mathematics. Children were examined individually. The results of the present study provide empirical support for the SRTC's factorial validity and reliability. They support the theoretical assumption that SRTC differentiates between motivational and strategic components of self-regulation. Finally, performance on SRTC was a significant predictor of teachers' evaluations in mathematics.

Key words: Attention, Resistance to temptation, Self-regulation

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INTRODUCTION

The present study aimed at exploring the psychometric properties of the Self-Regulation and Concentration Test for Children (SRTC, Kuhl & Kraska, 1992, 1993), a behavioral computerized test for measuring concentration and self-regulatory skills, in a sample of fourth grade Greek students.

Self-regulation is a volitional process which refers to person's deliberate intention to monitor and control cognition, emotions, behaviour, and environment, in order to accomplish self goals (Efklides, 2008; Efklides, Niemivirta, & Yamauchi, 2002; Kuhl & Fuhrmann, 1998). A core element in this process is action control, that is, the ability to maintain control over one's own action despite the presence of competing action tendencies. The emphasis, thus, is on control processes, which are activated every time a goal-directed activity is either blocked by an obstacle or focussing of attention is required in order to avoid environmental distracters and/or irrelevant thoughts.

Self-regulation has emerged as an important construct in educational research. It refers to the way students initiate, monitor, and exert control over their own learning (for reviews see Boekaerts & Cascallar, 2006; Boekaerts & Corno, 2005; see also Efklides, 2011). Self-regulated students are cognitively, metacognitively, and motivationaly active learners (Schunk & Zimmerman, 1994). While self-regulation efficiency has been found to affect positively school achievement from the first years of primary school till adolescence (Bakracevic-Vukman & Licardo, 2010; Liew, McTique, Barrois, & Hughes, 2008), lack of self-regulation has been related to lower levels of achievement, regardless of students' intellectual ability, motivation, and self-efficacy beliefs (Bakracevic-Vukman & Licardo, 2010; Kadivar, 2003). Although many young children may be highly motivated, some of them fail to self-regulate their behavior in order to complete classroom activities successfully. Self-regulation explains differences in students' commitment on "less interesting" tasks, that is, persist on a task when an attractive alternative is present; in such cases self-regulation is associated with effortful action and action control (Baumann & Kuhl, 2005; Fries, & Dietz, 2007).

The development of self-regulation efficiency in children has been studied within different research traditions, which explain different aspects of child development and particularly self-control in cognitive, emotional, and social life contexts. Behavioral control in young children has been traditionally studied with the delay of gratification paradigm (Mischel, Ayduk, Berman, Casey, Gotlib, et al., 2011; Mischel & Mischel, 1983; Mischel, Shoda, & Rodriguez, 1989). In this paradigm, preschoolers are required to postpone an immediate gratification (a reward e.g., one cookie) in order to get a bigger reward (e.g., two cookies) later on. Mischel and his colleagues investigated whether preschool children were capable of demonstrating effective self-regulation strategies to control their tendency for immediate reward. It is noteworthy that children's ability to delay gratification in

preschool years is predictive of cognitive and self-regulatory skills in adolescence (see Shoda, Mischel, & Peake, 1990).

Performance in this classic delay-of-gratification task is also indicative of preschoolers' ability to control their attention in face of temptation or distracters. A typical situation in which action control occurs is the work-play conflict. Recently there has been growing interest in the strategies used by school children in order to complete their schoolwork and resist temptation from leisure activities (e.g., Fries & Dietz, 2007; Fries, Schmid, Dietz, & Hofer, 2005; Larson & Verma, 1999).

Another line of relevant research is found in giftedness literature in which constructs such as attentional capacity, resistance to inhibition and speed of response have been investigated as manifestations of distracter inhibition that is similar to the delay of gratification. Johnson, Im-Bolter, and Pascual-Leone (2003) as well as Calero, García-Martín, Jiménez, Kazén, and Araque (2007) have argued that high intelligence 6 to 11 years old children have better self-regulatory abilities due to greater conscious control they exert as compared to average intelligence children.

Finally, there is research evidence from the temperament literature. Emotion regulation (Raver, 2002), effortful control (Carlson, Moses, & Claxton, 2004; Rothbart, Ahabi, & Hershey, 1994), distractibility and persistence (Martin, Drew, Gaddis, & Moseley, 1988) are some of the constructs that have been investigated as examples of self-regulated behaviors. Recently there has been an attempt to combine two different research traditions -on self-regulation and attention- as studied in neurocognitive models, in order to reveal the contribution of monitoring and control functions of attention to the emergence of self-regulation skills (see Rueda, Posner, & Rothbart, 2005).

The Self-Regulation and Concentration Test for Children (SRTC)

Kuhl and Kraska (1992, 1993) developed the Self-Regulation and Concentration Test for Children (SRTC), a computerized behavioral test, in order to measure children's ability to concentrate on a task and maintain their commitment to that task while they try to resist tempting distracters. This action control situation is similar to everyday schoolwork-play conflict situations mentioned above.

SRTC is based on Kuhl's theory of action control (Kuhl, 1984, 1985) and Kuhl and Kraska's (1989) theory of the development of self-regulation. According to Kuhl and Kraska (1989), self-regulation implies effortful action and action control. Lack of self-regulation is evidenced when the person is unable to carry out a deliberate intention because of conflict with another emotionally preferred goal. Self-regulation, thus, comprises processes that are involved in the maintenance of intentions, even when these intentions are "endangered" by competing motivational tendencies. According to the theory, these processes involve attention control (focusing of attention on a central task), emotion control (maintaining positive

affect) and motivation control (thinking the positive aspects of working with the task). One major problem in measuring self-regulation is how to assess shifts in motivation. The SRTC involves assessment of attention, emotion and motivation control. Moreover, it allows the assessment of different components of self-regulation, such as concentration, initial motivation, persistence, deliberate use of regulatory strategies in order to maintain the initial intention, and ability to change the initial intention if necessary.

In SRTC the child is asked to play a computer game and the goal is to earn "gold coins". She/he is instructed to press on the keyboard one key ("S") or another ("L") depending on whether one or two bars appear on the computer screen, respectively. The bars (one or two) appear randomly on the screen. The child's amount of money is raised every time he/she responds correctly and it is displayed on the lower right corner of the screen, so that the child can see it. While the child is working on this task, a distracter appears on the screen –a monkey race between two monkeys on a tree– in the upper right corner of the computer screen. If the "good" monkey wins, gold coin(s) are added to the child's account. In contrast, if the "bad" monkey wins, gold coin(s) are subtracted from the child's account. The child is told that he/she can do nothing to influence the result of the race and watching the race might reduce her/his performance on the main task. So, the child's goal is to earn as much money without being distracted by the monkeys' race. Figures 1a and 1b depict the baseline and one of the distracting conditions, respectively.
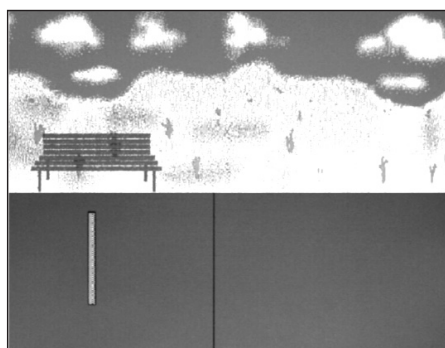

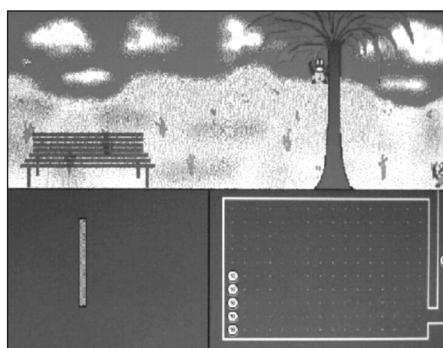**Figure 1a. The Baseline condition in SRTC.**   **Figure 1b. A Distracter condition in SRTC.**

There are four conditions in the game, one *Baseline* condition (BL), that is, a condition with no distracter, and three "distracting" conditions in which the visual and auditory characteristics of the distracter vary as follows: (a) the *Visual* condition (V), where the race is present on the screen without producing any noise, (b) the *Audio-Visual* condition (AV), where the monkeys' race is accompanied by noise, and (c) the *Forced* condition (F), where the race covers up the main task and pressing an

additional key is needed in order to keep working on the initial, main task. According to Kuhl and Kraska (1992, 1993), this kind of variation in distracter characteristics allows the assessment of different self-regulation components: *automatic shielding/intuitive* self-regulation (in the V condition, as the distracter is not salient); strategy use/conscious self-regulation (in the AV condition, since the distracter is more salient and the clicking noise makes the participant aware of the risk of distraction); and *initiative regulation* (in the F condition, where an additional key must be pressed quickly to continue with the task).

This is the main task, which consists of six test blocks, each one with four 15 seconds episodes. In each of the six test blocks, the child works on the episodes of the four conditions (one baseline and three with distracters). The first three test blocks (the 1st half of the task) measure the initial motivation and the other three test blocks (the 2nd half of the task) measure persistence. Moreover, within each of the six episodes, the first half of the episode measures attention and the second half of the episode measures self-regulation.

Following the main task the child has to complete an additional task, in which the instruction is to *stop* working on the main task. The instruction now is the opposite: in order to gain more coins the child must count the number of coins the good monkey adds to the account. This additional task measures the child's ability to change his or her initial intention if the situation requires it (Kuhl & Kraska, 1993).

Self-regulation efficiency is assessed through the *response rate* (speed) and *the variation of inter-response time* (stability) during the temptation episodes. Thus, SRTC provides *relative values* which represent performance declines in response to distracters in the three conditions (Visual, Audiovisual, and Forced) for the 1st (initial motivation) and the 2nd (persistence) half of the task. Moreover, SRTC provides distinct indexes of speed, speed variation and work accuracy for the 1st half of each 15-second test episode (attention phase) and the 2nd half of each test episode (self-regulation phase). Also, the SRTC provides the *percentage of correct responses* as an index of *response accuracy*, since speed comprises not only the correct but the incorrect responses as well.

According to Kuhl and Kraska (1992, 1993), self-regulation assessment through the SRTC has several advantages. To begin with, most children are motivated to do the task, since they usually see it as an exciting computer game. Additionally, individual differences in motivation towards the task and the distracter are controlled, because the task and the distracter are connected to the same motivation source. For example, a child with little interest in gathering coins (main task) should have less interest in the result of the monkey race (distracter) and vice versa. The main advantage of the test, though, is that it differentiates between initial motivation (in the first half of the task) and persistence (in the second half of the task), as well as between attention (first half of each distraction episode) and self-regulation (second half of each distraction episode). Moreover, the SRTC reveals both the strengths and weaknesses of each child

by measuring different components of self-regulation. Specifically, the test differentiates between: (a) deficits in attention and resistance to temptation, (b) fatigue and learning and (c) intuitive self-regulation and/or conscious use of control strategies. Furthermore, SRTC offers information about the child's compensation behavior and possible rigidity in intention changing, when maintenance of an intention becomes by the situation dysfunctional. Finally, the use of a computerized task itself has advantages, since it allows the registration of even the minimal variation in reaction time, permitting, thus, a precise measurement of actual behavior.

In the last two decades there has been a gradual shift in the conceptualization of self-regulation from a relatively stable individual inclination to respond to various learning situations independently of the context, to inclinations to respond to domain-specific learning situations, and, finally, to an ongoing dynamic activity. Given the emphasis on self-regulation as an activity, there was a subsequent shift in measurement tools as well from aptitude measures (i.e., self-reported regulatory strategies) to measures of self-regulation as an event (as an ongoing activity) (see Boekaerts & Corno, 2005; Turner, 2006; Winne & Perry, 2000). The assumption was that measuring actual self-regulation of behavior has both theoretical advantages for the identification of the mechanism of self-regulation at a micro-level as well as practical advantages for designing intervention programs. The SRTC test is an attempt to measure this aspect of self-regulation.

Research evidence on the use of the SRTC

The test has been already standardized and validated in a sample of 987 German students 6-11 years old (see Kuhl & Kraska, 1992, 1993). Test-retest reliability during a four week interval has provided promising evidence about the test's temporal stability (it ranged from .84 up to .92, $p < .01$ for speed and from .23 up to .57, $p < .01$ for speed variation). Also, the correlations between teachers' ratings of students' self-regulatory behaviors in the classroom –e.g., remembering tasks, resisting temptations, and persisting in long-term school projects– and children's performance mainly in the audiovisual condition were significant and ranged from .35 to .40 ($p < .05$).

There are only few studies that used the SRTC to assess self-regulation efficiency in children. Comparing a group of high-IQ children with an average ability group of primary school children, Calero et al. (2007) found that children with high intelligence performed better on the main task of the SRTC. Also, the SRTC was found to predict differences between hyperactive children and non-hyperactive children. Hyperactive children had significant lower self-regulatory abilities as compared to the non-hyperactive ones (Heise, Zachowski, Gerjets, Kuhl, & Rothenberger, 2003, cited in Calero et al., 2007). Furthermore, it was found to predict differences between children from economically advantaged and disadvantaged families (Howse, Lange, Farran, & Boyle, 2003). Specifically, despite their similar

level of motivation, young children from economically disadvantaged families had lower performance on the SRTC's main task as compared to their schoolmates from high socio-economic background. It is noteworthy that the difference between the two groups was significant only in preschool children and not in second graders. This suggests that SRTC is sensitive to differences of self-regulatory efficiency in very young children. Moreover, performance in the SRTC significantly predicted achievement scores in language only in the group of preschool disadvantaged children as compared to their schoolmates from high socio-economic background. The moderating effect of age on the correlations between performance on the SRTC and school performance was shown in Kuhl and Kraska's (1993) study as well. They found significant correlations between self-regulation indexes provided by the SRTC with performance in language in second graders and in mathematics in fourth graders. Finally, the role of gender in self-regulation efficiency as measured via the SRTC remains unclear since the relevant studies provide contradictory findings (e.g., Calero et al., 2007; Kuhl & Kraska, 1993).

The present study

The present study examined the psychometric properties of the SRTC in a sample of 4th grade Greek pupils. As regards the factorial validity of the instrument, it was expected that response rate (speed) and *variation of inter-response time* (stability) during the temptation episodes (the two basic indexes provided by the SRTC) would load two distinct factors (see also Kuhl & Kraska, 1992, 1993) (Hypothesis 1a). Moreover, speed and speed variation were expected to be negatively and significantly correlated, as a further indication of validity (Hypothesis 1b) (see also Kuhl & Kraska, 1992, 1993).

Also, since the task permits the assessment of different components of self-regulation, it was expected that the scores of the different phases of the SRTC would load different factors that reflect these components. Specifically, four distinct factors were expected: two factors for the initial motivation phase (scores in the first half of the task), that is, one for attention (scores in the first half of each distraction episode) and one for self-regulation (scores in the second half of each distraction episode); two other factors were expected to reflect the persistence phase (scores in the second half of the task), that is, one for attention (scores in the first half of each distraction episode) and one for self-regulation (scores in the second half of each distraction episode) (Hypothesis 2).

As regards the reliability of the SRTC factors, the hypothesis was that the theoretically expected factors would have satisfactory internal consistency (Cronbach's α coefficients) (Hypothesis 3).

As regards the effect of distraction on speed and speed variation, the forced condition was expected to affect speed and speed variation more as compared to the other two conditions (see also Calero et al., 2007). Specifically, lower speed and higher speed variation in the forced condition were expected as compared to the

visual and audiovisual ones (Hypothesis 4). According to Kuhl and Kraska (1993), this is the most distracting condition since it demands initiative for self-regulation in order to continue working on the task.

Further, we examined the effect of the change of the initial intention on response accuracy in the three distracting conditions. Response accuracy was expected to be reduced from the main to the additional task, since the additional task measures the child's ability to change his/her initial intention if the situation requires it (Kuhl & Kraska, 1993). Specifically, on the additional task the child is instructed not to play on the main task but instead to focus on the monkey race (which was previously the distracter), and this is expected to cause a drop in response accuracy (Hypothesis 5).

Finally, we examined the predictive validity of the task for school performance, according to teachers' evaluations. As mentioned above, very few studies have used the SRTC to measure self-regulation efficiency in children and its contribution to school performance. In line with previous evidence (Howse et al., 2003; Kuhl & Kraska, 1989, 1993), it was hypothesized that self-regulation efficiency would predict school performance, especially performance in mathematics, as found in Kuhl and Kraska's (1993) study with 4th graders (Hypothesis 6).

METHOD

Participants

Ninety three 4th grade students (46 boys and 47 girls) participated in the study. They came from three state primary schools of the city of Thessaloniki. The participants were from different socioeconomic status (SES) groups according to their parents' educational level and profession: 22 (25%) from low SES, 23 (26.1%) moderate, and 43 (48.9%) from high SES.

From the initial sample of 93 children, five students were excluded. Four students stopped working for a few seconds on the main task of the SRTC because of irrelevant to the task distracters (e.g., door knocking). These four students produced extreme values on the SRTC's indexes and, consequently, were excluded from the analyses. In addition, one student had been diagnosed with ADHD, according to the teacher. The final sample consisted of eighty-eight children (44 boys and 44 girls). The age range was between 113-124 months, mean age = 118.02, and SD = 3.43.

Instruments and measures

The Self-regulation and Concentration Test for Children (SRTC). The participants were asked to complete the SRTC (Kuhl & Kraska, 1992, 1993), a behavioral computerized task that measures the ability to carry out a monotonous task in the

presence of distracters, compared to a baseline condition with no distracter. The task has been presented in details in the Introduction section. As has been already reported, the main variables provided by the SRTC are the following: (a) speed (the response rate), (b) speed variation (the variation of inter-response time during the temptation episodes), and (c) work accuracy (the percentage of correct responses). The SRTC provides the above indices for the 1st half of each 15-second test episode (attention phase) and for the 2nd half of each 15-second test episode (self-regulation phase), separately. Moreover, the SRTC provides *relative values* which represent performance declines in response to distracters in the three conditions (Visual, Audiovisual, and Forced) for the 1st (initial motivation) and the 2nd (persistence) half of the task.

School performance. Teachers were asked to evaluate on a 10-(point) scale each student's performance in language and mathematics as compared to his/her classmates.

Procedure

The state elementary schools were randomly selected. The examination took place from April till May, after obtaining the necessary consent of both the school principals and the parents. Students participated voluntarily after being informed about the purpose of the study and assured that no one else, except the researchers, would have access to information on their performance. They were examined individually in a private room in their schools and the examination lasted about 20 minutes. They were given explicit instructions from the beginning. After completing the additional task of the SRTC, children had to answer to the question: "What did you do during the final part of the test", in order to check if they had changed their initial intention or they continued to work on the central bar task of the SRTC during the additional task. Only children could give this kind of information.

In terms of their demographic characteristics, they had only to respond to questions concerning their gender, age, parental educational level and profession and the number of their alphabetical order in the class to be able the researchers to match students' performance with their teachers' ratings. As regards teachers' ratings, they gave their ratings for each student only with a code number, corresponding to the student's alphabetical order in the classroom.

RESULTS

Differentiation between Speed and Speed Variation

The analyses were applied on the relative values given by the SRTC, as recommended

by the SRTC constructors. Specifically, relative values represent differences in performance on conditions with distracters (Visual, Audiovisual, Forced) minus the performance on the baseline condition. Thus, relative values are more representative than absolute values of the declines in performance during the three distracter conditions (Visual, Audiovisual, Forced) with respect to the baseline condition, where the distracter is absent. Relative values for speed and speed variation were computed according to a formula given by Howse et al. (2003). Specifically, the child's number of key presses for each distracter condition was subtracted from the baseline number of key presses. This number was divided by the baseline number of key presses and then multiplied by 100 (Howse et al., 2003, p. 163).

Principal components analysis with promax rotation revealed a two-factor solution. The two factors accounted for a total of 68.6% of the variance for the first half of the task scores and a total of 62.14% of the variance for the second half of the task scores (see Hypothesis 1a). Also, the values of KMO and Bartlett's Test of Sphericity were satisfactory at least for the first half of the test, KMO =.71, Bartlett's Test of Sphericity (15) = 212.19, $p < .001$ for the first half and KMO =.52, Bartlett's Test of Sphericity (15) = 161.86, $p < .001$ for the second half of the test. The factor loadings as well as the reliability coefficients are given in Table 1. While the scores of the first half of the test loaded two clear factors, that is, speed and speed variation, in the second half, two scores loaded on both factors. Specifically, the speed variation in the Audiovisual condition loaded positively (as expected) on the speed variation factor and negatively on the speed factor. The same was the case for speed in the Visual condition. Furthermore, the KMO value for the second half of the test was low (lower than .60). Overall, the results of the present study confirmed the theoretically expected

Table 1. Factor loadings and reliability coefficients of Speed and Speed Variation for the 1st half (initial motivation) and the 2nd half (persistence) of the SRTC

| | Initial Motivation | | Persistence | |
	Speed	Speed Variation	Speed	Speed Variation
Speed				
Visual	.790		.525	-.767
Audiovisual	.929		.885	
Forced	.940		.811	
Speed Variation				
Visual		.887		.944
Audiovisual		.786	-.631	.408
Forced		.484		.452
Eigenvalue	3.04	1.08	2.63	1.10
% of Variance	50.66	17.95	43.87	18.27
Cronbach's α	.87	.57	.71	.41

differentiation between the main test variables: *speed* and *speed variation*. For that reason, the reliability coefficients were calculated for the two theoretically defined factors in both cases. However, only the reliability coefficients of *speed* were above the acceptable level of .70, a finding that will be discussed in the Discussion section.

Pearson correlations were computed to examine the relationship between children's relative *speed* and their relative *speed variation* on the main task of the SRTC. Speed and speed variation were negatively correlated, as expected (Hypothesis 1b). Most of the correlations were significant, especially those referring to the first half of the SRTC. Coefficients ranged from $r = -.29$ to $r = -.43$ (for the first half) and from $r = -.23$ to $r = -.60$ (for the second half of the SRTC). These findings support the validity of the data offered by the SRTC, since high speed and low *speed variation* (high stability) on the SRTC's main phase suggest high self-regulation. On the contrary, low speed and high *variation of speed* is indicative of lack of self-regulation and inability to resist temptation.

Differentiation between components of self-regulation

Two different factor analyses were applied, one on the scores of *speed* and one on the scores of *speed variation* of all task phases. Table 2 shows the factor loadings and reliability coefficients for the variables of *speed* and *speed variation* respectively. The KMO and Bartlett's Test of Sphericity were satisfactory in both analyses: KMO =.67, Bartlett's Test of Sphericity (66) = 471.74, $p < .001$ for the speed variables and KMO =.61, Bartlett's Test of Sphericity (66) = 316.86, $p < .001$ for the speed variation variables. Specifically, scores of work speed loaded on four factors and accounted for 75.81% of the variance. The first factor represented speed in the self-regulation phase of the first half of the task (initial motivation) in the three distracting conditions. The second factor represented speed on the self-regulation phase of the second half of the task (persistence) in the three distracting conditions. The third factor represented speed on the attention phase of the first half of the task in the three distracting conditions. Finally, on the fourth factor loaded the scores of speed in the attention phase of the second half of SRTC. That is, factors 1 and 2 represent possible deficits in resistance to temptation and factors 3 and 4 possible deficits in attention.

Likewise, the analysis of scores of *speed variation* produced a four-factor solution similar to the one mentioned above. The four factors accounted for 67.41% of the variance.

At a next step we examined the latent structure of the SRTC speed and speed variation values via two Confirmatory Factor Analyses (CFA) by using the EQS Version 6.1 software (Bentler, 2005). Given that the normalized estimate of multivariate Kurtosis and Mardia's coefficient indicated non-normality, the Satorra-Bentler scaled χ^2 and the Robust estimation procedure were used in both analyses. Specifically, the normalized estimate of multivariate Kurtosis was 18.38 for speed and

Table 2. Factor loadings and reliability coefficients of Speed and Speed Variation for the two halves (initial motivation and persistence) and the two phases (attention and self-regulation) of the SRTC

	Speed				Speed Variation			
	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
	S-R	S-R	A	A	S-R	S-R	A	A
Self-regulation								
1st half / V	.897				.788			
1st half /AV	.879				.843			
1st half / F	.902				.768			
2nd half / V		.748				.731		
2nd half / AV		.906				.793		
2nd half / F		.874				.808		
Attention								
1st half / V			.835				.896	
1st half /AV			.889				.892	
1st half / F			.838				.894	
2nd half / V				.747				.711
2nd half / AV				.812				.781
2nd half / F				.873				.755
Eigenvalue	3.09	2.73	1.99	1.29	2.79	1.89	1.82	1.58
% of Variance	25.73	22.72	16.59	10.76	23.26	15.74	15.21	13.20
Cronbach's α	.86	.82	.82	.74	.60	.69	.87	.60

Note: V = Visual condition; AV = Audiovisual condition; F = Forced Condition; S-R = Self-regulation; A = Attention.

19.19 for speed variation and the respective Mardia's coefficients were 71.83 and 74.99.

The four-factor theoretically predicted solution (attention and self-regulation for the first part of the test and attention and self-regulation for the second part) was confirmed in both cases (speed and speed variation) with no modifications. The indices for speed were: scaled $\chi^2(54) = 65.27, p > .05$, robust NNFI = .911, robust CFI = .927, and robust RMSEA = .049. The respective indices for the speed variation were: $\chi^2(54) = 58.39, p > .05$, robust NNFI = .964, robust CFI = .970, and robust RMSEA = .031. The above results suggest that the SRTC's indices as computed for different time intervals and different test phases assess different components of self-regulation (see Hypothesis 2).

Means and standard deviations of the factors that corresponded to different components of self-regulation are given in Table 3.

Table 3. Descriptive statistics (M and SD) of the relative values of Speed and Speed Variation

Variables	Relative Speed		Relative Speed Variation	
	M	SD	M	SD
Attention/Initial Motivation	.014	.092	.000	.169
Attention / Persistence	.029	.076	.051	.103
Self-regulation/ Initial Motivation	-.003	.063	.018	.202
Self-regulation / Persistence	-.003	.065	.021	.081
Initial Motivation (1st half)	-.001	.076	.015	.173
Persistence (2nd half)	.008	.059	.033	.074
Attention	.022	.060	.026	.092
Self-regulation	-.002	.043	.013	.062

Reliability coefficients

Only the internal consistency coefficients of speed were above the acceptable level of .70 in all the factors extracted in the factor analyses, confirming thus partly the respective prediction (Hypothesis 3).

The effect of distraction on speed and speed variation

Four repeated measures ANOVAs were applied on the mean scores of speed and speed variation with the three conditions (Visual, Audiovisual, and Forced) as within subjects factors. Specifically, the main effect of condition was found significant in both phases (the initial motivation phase and the persistence phase) and in speed and speed variation. Because the Mauchly's test of sphericity were significant in three out of four cases, the corrected F values are presented for these cases. The indices were: $F(1.75, 152.57) = 34.14$, $p < .001$, partial $\eta^2 = .28$ (for speed in the initial phase); $F(1.77, 153.68) = 14.66$, $p < .001$, partial $\eta^2 = .14$ (for speed variation in the initial phase); $F(2, 174) = 51.33$, $p < .001$, partial $\eta^2 = .37$ (for speed in the persistence phase), and $F(1.26, 109.73) = 7.96$, $p < .005$, partial $\eta^2 = .08$ (for speed variation in the persistence phase). According to the Bonferroni multiple comparison test, the difference between the Forced and the other two conditions in both phases was significant (ranging from $p < .05$ to $p < .001$). Speed was significantly reduced and speed variation was significantly increased in the Forced condition as compared to the other two conditions (Hypothesis 4).

Response accuracy in the main and the additional task of SRTC: Changing the initial intention

Response accuracy in the main phase was compared to that of the additional task of the SRTC. In particular, four ANOVAs were applied, one for each work-condition (Baseline, Visual, Audiovisual, Forced), with independent variable the test phase (main - additional) and dependent variables the percent of correct responses on the four conditions. The respective means and standard deviations are given in Table 4.

Table 4. Descriptive statistics (M and SD) for Response Accuracy on the main and the additional task of the SRTC

Conditions	Main task		Additional Task	
	M	SD	M	SD
Baseline	.887	.067	.913	.063
Visual	.889	.084	.857	.171
Audiovisual	.887	.078	.859	.144
Forced	.900	.070	.850	.142

Children tended to work more accurately on the main task than on the additional task. This was expected, since, contrary to the main phase of the test, on the additional task the child is instructed not to play on the main bar task but instead to focus on the monkey race (which was previously the distracter). The difference in response accuracy between these two tasks reached, however, significance only in the Forced condition, $F(1, 76) = 11.34$, $p = .001$, partial $\eta^2 = .13$. Also, children worked more accurately on the baseline condition (no distracter) in the additional task than on the main task baseline condition, $F(1, 86) = 15.28$, $p < .001$, partial $\eta^2 = .15$.

As regards the number of children who did not change their initial intention after the main task, 11 children (12.9%) of 88 reported that during the additional task they continued to work on the main task. Further, from this group of children, 10 out 11 children (90.9%) failed to count correctly the number of coins the good monkey gave them. Practically, these 10 children failed at the additional task, which measures the ability to switch between different goals when required. It is interesting, though, that many more children than the 11 failed to count the coins the good monkey gave them during the additional phase. Specifically, 46 children (52.27%) out of 88 failed to answer correctly to the examiner's question about the number of coins the good monkey gave them. Furthermore, according to teachers' ratings the children who didn't manage to complete the additional task successfully ($n = 46$) tended to have lower mean performance in language ($M = 8.93$, $SD = 1.14$) and in mathematics (M $= 9.27$, $SD = 1.01$) compared to those ($n = 42$) who completed the additional task successfully ($M = 9.06$, $SD = 1.12$ and $M = 9.42$, $SD = 0.87$, in language and

mathematics, respectively). However, the differences did not reach significance, $t = -.526$, $p > .05$, for language and $t = -.692$, $p > .05$, for mathematics.

Self-regulation and school performance

In order to examine the contribution of self-regulation efficiency to school performance we conducted a series of linear regression analyses with independent variables the factors provided by the factor analyses mentioned above (see Table 3) and dependent variables school performance in language and mathematics. Specifically, in each of the first four regressions the independent variable was one of the following: Attention, Self-regulation, Initial Motivation (1st half of the task), and Persistence (2nd half of the task), respectively. In each of the next four regressions the independent variable was: Attention in the Initial Motivation phase, Attention in the Persistence phase, Self-regulation in the Initial Motivation phase, and Self-regulation in the Persistence phase, respectively. The above mentioned regressions were conducted separately for school performance in language and mathematics. None of the above variables was significant predictor of school performance.

At a next step, we conducted the same analyses using as independent variables speed and speed variation in the three distracting conditions. Results showed that changes in children's work speed due to the presence of the audiovisual distracter significantly predicted their performance in mathematics, $R^2 = .061$, $t = 2.42$, $p = .023$, *beta* = .25. Specifically, decreased speed on the audiovisual condition as compared to the baseline condition was related to low performance in mathematics (Hypothesis 6).

DISCUSSION

The present study aimed at exploring the psychometric properties of the Self-Regulation and Concentration Test for Children (SRTC, Kuhl & Kraska, 1992, 1993) in a sample of fourth grade Greek students. The main advantage of the SRTC is that it is a behavioral computerized task for measuring children's ability to self-regulate their action and to concentrate on a monotonous task in the presence of attractive distracters. The majority of the current empirical studies on self-regulation in children have been based on self-reported or significant others' reported measures, which do not necessarily reflect the actual level of students' self-regulatory efficiency in various achievement settings. Given the emphasis during the last decade on measuring self-regulation as an event or an ongoing activity (see Boekaerts & Corno, 2005; Turner, 2006; Winne & Perry, 2000), SRTC is a very promising instrument towards this direction. Moreover, it is an instrument that despite the claim that it assesses different components of self-regulation, such as concentration, initial

motivation, persistence, as well as the ability to change the initial intention if it is necessary, there is sparse empirical research using it. As far as we know, only two studies (Calero et al., 2007; Howse et al., 2003) have used SRTC, apart from Kuhl and Kraska (1993), who constructed it. There is, therefore, need for further investigation of its psychometric properties in children from different cultural and/or educational backgrounds.

In general, the results of the present study add to the SRTC's validity and they are in accordance with previous evidence. Specifically, in agreement with the theoretical assumptions concerning the SRTC (Kuhl & Kraska, 1989, 1993), the results confirmed the expected differentiation between the main test variables (work speed and speed variation) (Hypothesis 1a) as well as between the different phases of the SRTC (Hypothesis 2), providing, thus, empirical support for the SRTC's factorial validity as a measure of children's ability to concentrate on a task and to resist temptation. The studies of Calero et al. (2007) and Howse et al. (2003) did not provide any information about the SRTC's factorial validity according to theoretical assumptions.

Specifically, the SRTC measures the child's self-regulation efficiency through response frequency (speed) and variance of inter-response times (stability). The results of the present study suggest that work speed and variance of inter-response times represent two different variables which are closely related. The significant negative correlations between speed and speed variation that have been found in the present study confirmed the theoretical assumption about the desirable relation between these two variables, adding, thus, to SRTC's validity (see also Hypothesis 1b). According to the test constructors, on the one hand, the combination of high work speed rates and low variation of inter-response times indicates high self-regulation efficiency. On the other hand, the combination of low speed rates and high fluctuation in key pressing, suggests a self-regulatory deficit and an inability to ignore the distracter in order to complete a monotonous task. To assess the child's actual self-regulated behavior, work speed and speed variation must be taken into account, because the variable of work speed includes correct as long as erroneous key pressings. According to Kuhl and Kraska (1989, 1993), the variation of inter-response time is a more sensitive index than speed, because it reflects the child's compensation efforts. The low reliability coefficients found in the present study in the speed variation factors may be due to the sensitivity of this measure. It seems that this index is affected more by the characteristics of the different distracter conditions and the different phases of the SRTC. In the validation study of the SRTC in German population, Kuhl and Kraska did not report coefficients of the reliability of the instrument. As has been already mentioned, in order to understand reliability issues concerning this instrument, we have to keep in mind that SRTC is constructed to show possible instabilities in various testing phases, especially in the speed variation variable. Namely, scores from the first half of the test offer information as to whether

a child's self-regulation efficiency is endangered when the child is suddenly confronted with sources of temptation. A rise in the child's self-regulation efficiency from the first to the second half indicates the child's ability to make up for drops in efficiency. Likewise, a decrease in efficiency from the first to the second half probably indicates the child's difficulty to maintain existing self-regulation efficiency over a longer period of time. Thus, the low reliability indices only in speed variation are not surprising. Further investigation is needed.

Moreover, the results of the present study confirmed the theoretically expected differentiation between the different phases of the SRTC and, consequently, the different components of self-regulation (Hypothesis 2). Namely, the SRTC seems to be a promising behavioral measure for discriminating motivational (first half of the test) and strategic components of self-regulation (second half of the test, where the main task becomes less interesting and children tend to get tired). Further, the SRTC seems to be a valid instrument for distinguishing children's ability to pay attention to a task (in the first half of 15-seconds intervals) from their self-regulation efficiency (in the second half of 15-seconds intervals).

As regards the effect of distraction on speed and speed variation, the expected patterns of performance were found (see Hypothesis 4). That is, lower speed and higher speed variation were found in the most distracting Forced condition as compared to the other two conditions (Visual and Audiovisual) (see also Calero et al., 2007; Kuhl & Kraska, 1993). According to Kuhl and Kraska (1993) the Forced condition is the most distracting since it demands the child to *initiate self-regulation* in order to continue working with the task.

The expected patterns of performance were also found in the analysis of children's response accuracy on the main and on the additional task of the SRTC. Specifically, children worked more accurately during the main phase than on the additional task of the SRTC (see Hypothesis 5). This difference, though, reached significance only in the case of the Forced distracter condition. During the additional task, the child has to focus exclusively on the monkey race. Consequently, since the child counts coins on the right side of the computer screen, it is more difficult (and unnecessary) to work accurately on the main bar task, which is taking place on the left side of the computer screen (or covered by the forced distracter). On the contrary, children worked more accurately on the baseline condition (no distracter) of the additional task than on the main phase baseline condition. This is also an expected pattern of performance, since, in the baseline condition (where the distracter is absent), the child has the opportunity to play with the bar task. Moreover, the increase of response accuracy in the additional task could be attributed to the child's previous experience with the bar task (during the main phase), reflecting thus a learning effect (see also Kuhl & Kraska, 1989, 1993).

The additional task was constructed to assess children's disengagement from their initial intention (completing the bar task) and their commitment to a new one

(watching the monkey race), in order to earn coins. According to the results of the present study, large proportion of children failed at the additional task of the SRTC. These children had lower school performance than those who completed this part of the test successfully, although the difference did not reach significance. This finding could be an indication of a possible relation between children's ability to switch between different goals, when required, and their school performance. However, further investigation is needed with a larger and more diverse group of children as regards their intellectual ability and/or school performance. Also, future research should focus on examining children's monitoring accuracy, in cases they report they changed their initial intention but, nevertheless, failed in the new goal, as well as children's motivation not to change their initial intention, even though it is required by the environment.

As regards the relation between self-regulation and school performance, it has been already recognized that self-regulation significantly contributes to school performance (e.g., Bakracevic-Vukman & Licardo, 2010; Liew et al., 2008; Howse et al., 2003). In line with previous findings (see also Kuhl & Kraska, 1989, 1993), work speed in the audiovisual condition predicted performance in mathematics (Hypothesis 6). Comparing SRTC's work conditions, the audiovisual condition is more sensitive because it is closer to the real school class environment (Kuhl & Kraska, 1993). On the contrary, self-regulation efficiency did not predict school performance in language. In a previous study, which was conducted by Howse and his colleagues (2003), self-regulation efficiency of 5-8 years old children predicted their performance in language. The lack of a predictive path from performance on SRTC to performance in language may be due to children's age. In the present study, as well as in Kuhl and Kraska's study, performance in the audiovisual condition was found to predict only performance in mathematics in fourth graders. Moreover, the SRTC was constructed to be used with young children from first to fourth grade. Given that the sample in the present study was only fourth graders, there was small variance in their responses in SRTC, as the task may be easy for them.

In summary, the results of the present study, although preliminary, provide empirical support for the SRTC's factorial validity and reliability (at least for the speed variable) in a sample of fourth grade Greek students. SRTC measures the ability to concentrate on a task and resist temptation. Moreover, our findings provide evidence for the SRTC's predictive validity, at least in the case of school performance in mathematics in fourth grade.

Self-regulation is a multifaceted ability which is developing gradually in the first years of school life (Eigsti, Zayas, Mischel, Shoda, Ayduk, et al., 2006), affecting school achievement. Given that young children's ability to self-regulate and control their impulsive action has been found to predict aspects of cognitive and social competence later in life (Mischel et al., 1989), diagnosis of possible self-regulation deficits during the first years of school life could be very helpful for designing

intervention programs to facilitate the development of self-regulation efficiency. SRTC seems to be a promising computer-based instrument for assessing different aspects of children's ability to concentrate on a task in the presence of an attractive alternative, at least in a Greek sample of fourth grade students. We believe that normative data for the Greek population could make the SRTC a useful and practical tool for the measurement of various processes involved in school children's self-regulation efficiency. Thus, further empirical research is needed with a larger sample of children from grade one to at least grade four, in order to evaluate the usefulness of SRTC as a diagnostic tool for educational interventions in self-regulation. Finally, in future research, it would be interesting to use the SRTC in order to explore the relationships between measures of different cognitive functions (e.g., attention, memory, attention switching) and children's actual self-regulation efficiency, and to determine the role of more stable personality characteristics (e.g., cognitive styles) in the development of self-regulation efficiency.

REFERENCES

Bakracevic-Vukman, K., & Licardo, M. (2010). How cognitive, metacognitive, motivational and emotional self-regulation influences school performance in adolescence and early adulthood. *Educational Studies, 36*(3), 259-268.

Baumann, N., & Kuhl, J. (2005). How to resist temptation: The effects of external control versus autonomy support on self-regulatory dynamics. *Journal of Personality, 73*, 443-470.

Bentler, P. M. (2005). *EQS 6.1*. Encino, CA: Multivariate Software.

Boekaerts, M., & Cascallar, E. (2006). How far have we moved toward the integration of theory and practice in self-regulation. *Educational Psychology Review, 18*(3), 199-210.

Boekaerts, M., & Como, L. (2005). Self-regulation in the classroom: A perspective on assessment and intervention. *Applied Psychology: An International Review, 54*, 199-231.

Calero, M. D., García-Martín, M. B., Jiménez, M. I., Kazén, M., & Araque, A. (2007). Self-regulation advantage for high-IQ children: Findings from a research study. *Learning and Individual Differences, 17*, 328-343.

Carlson, S. M., Moses, L. J., & Claxton, L. J. (2004). Individual differences in executive functioning and theory of mind: An investigation of inhibitory control and planning ability. *Journal of Experimental Child Psychology, 87*, 299-319.

Efklides, A. (2008). Metacognition: Defining its facets and levels of functioning in relation to self-regulation and co-regulation. *European Psychologist, 13*(4), 277-287.

Efklides, A. (2011). Interactions of metacognition with motivation and affect in self-regulated learning: The MASRL model. *Educational Psychologist, 46*, 6-25.

Efklides, A., Niemivirta, M., & Yamauchi, H. (2002). Introduction: Some issues on self-regulation to consider. *Psychologia: An International Journal of Psychology in the Orient, 45*, 207-210.

Eigsti, I. M., Zayas, V., Mischel, W., Shoda, Y., Ayduk, O., Dadlani, M. B., Davidson, M. G., Aber, J. L., & Casey, B. J. (2006). Predictive cognitive control from preschool to late adolescence and young adulthood. *Psychological Science, 17*(6), 478-484.

Fries, S., & Dietz, F. (2007). Learning in the face of temptation. *The Journal of Experimental Education, 76*(1), 93-112.

Fries, S., Schmid, S., Dietz, F., & Hofer, M. (2005). Conflicting values and their impact on learning. *European Journal of Psychology of Education, 20*, 259-74.

Heise, E., Zachowski, K. P., Gerjets, P., Kuhl, J., & Rothenberger, A. (2003). I*nterference control deficits with motivational relevant distracters in ADHD*. Unpublished manuscript. University of Göttingen, Germany.

Howse, R. B., Lange, G., Farran, D. C., & Boyle, C. D. (2003). Motivation and self-regulation as predictors of achievement in economically disadvantaged young children. *Journal of Experimental Education, 71*, 151-174.

Johnson, J., Im-Bolter, N., & Pascual-Leone, J. (2003). Development of mental attention in gifted and mainstream children: The role of mental capacity, inhibition, and speed of processing. *Child Development, 74*, 1594-1614.

Kadivar, P. (2003). The role of self-efficacy beliefs, self-regulation and intelligence in school performance among secondary school first grade students. *Journal of Education and Psychology, 10*(1-2), 45-58.

Kuhl, J. (1984). Volitional aspects of achievement motivation and learned helplessness: Toward a comprehensive theory of action control. In B. Maher & W. Maher (Eds.), *Progress in experimental personality research* (Vol. 13, pp. 99-171). New York: Academic.

Kuhl, J. (1985). Volitional mediators of cognition-behavior consistency: Self-regulatory processes and action versus state orientation. In J. Kuhl & J. Beckmann (Eds.), *Action control: From cognition to behavior* (pp. 101-128). New York: Springer.

Kuhl, J., & Fuhrmann, A. (1998). Decomposing self-regulation and self-control: The Volitional Component Inventory. In J. Heckhausen & C. S. Dweck (Eds.), *Motivation and self-regulation across the life span* (pp. 15-49). Cambridge, UK: Cambridge University Press.

Kuhl, J., & Kraska, K. (1989). Self-regulation and metamotivation: Computational mechanisms, development and assessment. In R. Kanfer, P. L. Ackerman, & R. Cudack (Eds.), *Abilities, motivation and methodology* (pp. 343-374). Hillsdale, NJ: Erlbaum.

Kuhl, J., & Kraska, K. (1992). *Der Selbstregulations-und Konzentrationstest für Kinder* (SRKT-K) [The Self-Regulation and Concentration Test for Children]. Göttingen, Germany: Hogrefe.

Kuhl, J., & Kraska, K. (1993). Self-regulation: Psychometric properties of a computer-aided instrument. *The German Journal of Psychology, 17*, 11-24.

Larson, R. W., & Verma, S. (1999). How children and adolescents spend time across the world: Work, play, and developmental opportunities. *Psychological Bulletin, 125*(6), 701-736.

Liew, J., McTique, E. M., Barrois, L., & Hughes, N. (2008). Adaptive and effortful control and academic self-efficacy beliefs on achievement: A longitudinal study of 1st through 3rd graders. *Early Childhood Research Quarterly, 23*(4), 515-526.

Martin, R. P., Drew, K. D., Gaddis, L. R., & Moseley, M. (1988). Prediction of elementary school achievement from preschool temperament: Three studies. *School Psychology Review, 17*(1), 125-137.

Mischel, W., Ayduk, O., Berman, M. G., Casey, B. J., Gotlib, I. H., Jonides, J., Kross, E., Teslovich, T., Wilson, N. L., Zayas, V., & Shoda, Y. (2011). Will power over the life span: Decomposing self-regulation. *Social Cognitive & Affective Neuroscience, 6*(2), 252-256.

Mischel, H. N., & Mischel, W. (1983). The development of children's knowledge of self-control strategies. *Child Development, 54*, 603-619.

Mischel, W., Shoda, Y., & Rodriguez, M. L. (1989). Delay of gratification in children. *Science, 244*, 933-938.

Raver, C. C. (2002). Emotions matter: Making the case for the role of young children's emotional development for early school readiness. *Social Policy Report, Society for Research in Child Development, 16*, 3-18.

Rothbart, M. K., Ahadi, S. A., & Hershey, K. L. (1994). Temperament and social behavior in childhood. *Merrill-Palmer Quarterly: Journal of Developmental Psychology, 40*(1), 21-39.

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2005). The development of executive attention: Contributions to the emergence of self-regulation. *Developmental Neuropsychology, 28*(2), 573-594.

Schunk, D. H., & Zimmerman, B. J. (1994). *Self-regulation of learning and performance: Issues and educational applications*. Hillsdale, NJ: Erlbaum.

Shoda, Y., Mischel, W., & Peake, P. K. (1990). Predicting adolescent cognitive and self-regulatory competencies from preschool delay of gratification: Identifying diagnostic conditions. *Developmental Psychology, 26*, 978-986.

Turner, J. C. (2006). Measuring self-regulation: A focus on activity. *Educational Psychology Review, 18*, 293-296.

Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 531-565). San Diego, CA: Academic.