The Motorway Model

Driving pupils fast, but not teaching them to steer

SHORT PAPER

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Abstract

Mind.World short papers present findings from our research studies within a succinct literature context. This paper describes research to measure the effect of a model of education which has been [is?] termed the 'Motorway Model' upon the cognitive development of pupils in relation to their academic outcomes. The Motorway Model is described; key features of high speed and narrowness of pedagogic route are explained. An assessment, CAS Tracking, designed to measure these Motorway characteristics of schools, is described. A method of measuring the Effective Steering Cognition (ESC), which is being developed in pupils in these schools, is described. A study of 16 UK secondary schools measured is reported with data showing the link between road width, speed, school rank and the development of ESC. The results support the idea that high performing schools exhibit motorway characteristics which, in turn, are linked to lower ESC, a skill conjectured to be important for success beyond school in the work place.

Highlights

- Steering Cognition is a means of measuring the relative character of a school's learning road
- Using this measure, high performing schools exhibit narrower learning roads and have pupils making faster decisions
- These characteristics are consistent with the Motorway Model of education
- However, these characteristics are shown to be linked to reduced Effective Steering Cognition (ESC): pupils are driving fast but not learning to steer their minds
- Pupils with high academic outcomes but low ESC may contribute to a growing disconnect between success at school and success in the work place.

Introduction: Education based on a Motorway Model

Walker and Walker have coined the idea of a Motorway Model to describe a model of education which they argue lies behind the current UK secondary school academic assessment framework. The Motorway Model is based on an ideological belief that the quality of education can be measured by the number of pupils, and their distance travelled down an academic road toward narrowly defined publicly examined academic targets.

In the UK, the authors maintain that this model has driven a culture and pedagogy within schools to fulfil these motorway goals. For example, schools have narrowed the educational road by reducing the diversity of styles of pedagogy in the classroom and curricula beyond the classroom; schools have made the teaching experience homogeneous, reducing the number of divergent routes that individuals might wander down in their lessons as well as outside lessons; schools have focused on narrow academic levels, targets and public exams as indicators of their success. Walker and Walker argue that the emergence of a Motorway Model is driven more by government policy than school strategy. Schools seek to deliver educational outcomes within the framework of assessment set by the national government which, they argue, is the highways agency of education, ultimately responsible for what schools aim for, and how pupils are taught. The researchers imply that higher academically performing schools within this assessment framework are likely to exhibit greater Motorway Model characteristics than lower performing schools.

Whilst many educationalists have complained [long argued?] that this approach fails to deliver the broader but essential goals of a rounded education, this study seeks to identify if there are measurable effects on the cognition of pupils educated under the Motorway Model. Do pupils at schools which show Motorway Model characteristics exhibit different *cognitive* features than pupils at schools which show less of those Motorway characteristics?

To investigate this question, the researchers developed first, a method of ranking schools on two relevant Motorway characteristics (speed and road width), and second, a method of measuring the development of kind of cognition hypothesised to be affected by the teaching environment of a school.

1. Measuring the width and speed of the Motorway

Walker and Walker have developed an online pupil assessment, CAS Tracking, to measure characteristics of the Motorway Model exhibited by a school. CAS Tracking measures 'steering cognition', a model of a cognitive executive function which contributes to how we regulate our attention and coordinate our corresponding responses (Walker 2015i). Steering cognition describes how the brain biases attention toward specific stimuli whilst ignoring others, before coordinating responsive actions which cohere with our past patterns of self-representation. According to the Wikipedia article of steering cognition, the analogy of the car is sometimes used to explain steering cognition. As the 'controls of our mind', steering cognition regulates the mind's direction, brakes and gears. Studies have shown that it is distinct from the 'engine' of our mind, sometimes referred to as 'algorithmic processing', which is responsible for how we process complex calculations (Walker 2015i; Stanovich, West 2014, 2008; Stanovich 2011; Evans 2011).

The CAS Tracking assessment measures the effect of the school road on the steering cognition of pupils by taking four comparative readings: first, pupil's instinctive steering cognition, and then second, their steering cognition when engaged in three curriculum subjects on the school road: a maths lesson, a science lesson and an English literature lesson. By comparing the measures, a calculation of the effect of the school road upon the population's steering cognition is made. The method is described in detail by Walker (Walker 2015i).

The CAS Tracking assessment measures the steering cognition patterns of the school population to calculate numerous properties including, first, the relative width of the school road (measured by the total variance of steering cognition shown by the population on the school road) and second, the speed by which pupils are travelling along it (measured by the speed with which pupils make steering cognition adjustments). The researchers conjectured that the width of the school road and the speed of pupils give a representation of Motorway Model characteristics of the school. For example, a school in which pupils exhibited lower steering cognition variance across the population, and travelled faster, would reflect a school with higher Motorway characteristics. A school where pupils travelled slower and showed more variation would reflect a school with lower Motorway characteristics.

CAS Tracking, as a measure of steering cognition, is proposed as a valid means of calibrating the relative characteristics of the school 'road' because it is environmentally primed, or biased, by school-specific characteristics. Unlike IQ, steering cognition is an ecological [I don't' know what that means – can it be 'an ecological something?]; pupils' adjustment of steering cognition is influenced by the specific school environment. For example, schools with formal uniform and more controlling pedagogies have been shown to reduce the variance of steering cognition displayed by the pupils (Walker 2014 h.).

Width and speed of the school road

The width of the school road is a calculation of the population variance for steering cognition scores on the 'school road' compared to that shown instinctively. Population variance can be thought of as a herding quotient: the lower the variance, the tighter is bunched the population of pupils . For example, low variance in the instinctive scores for a pupil population would indicate that the school recruits from a tightly bunched population whose steering cognition is similar. If that population's variance increased on the school road, this would be an indicator that the width of the school road is wider than the instinctive road.

Inter-school road width can be compared by measuring this quotient across sample schools measured using the same method. The relative difference in variance of steering cognition scores indicates the relative narrowness of the school road compared to the wider population of school road widths (Figure 1).

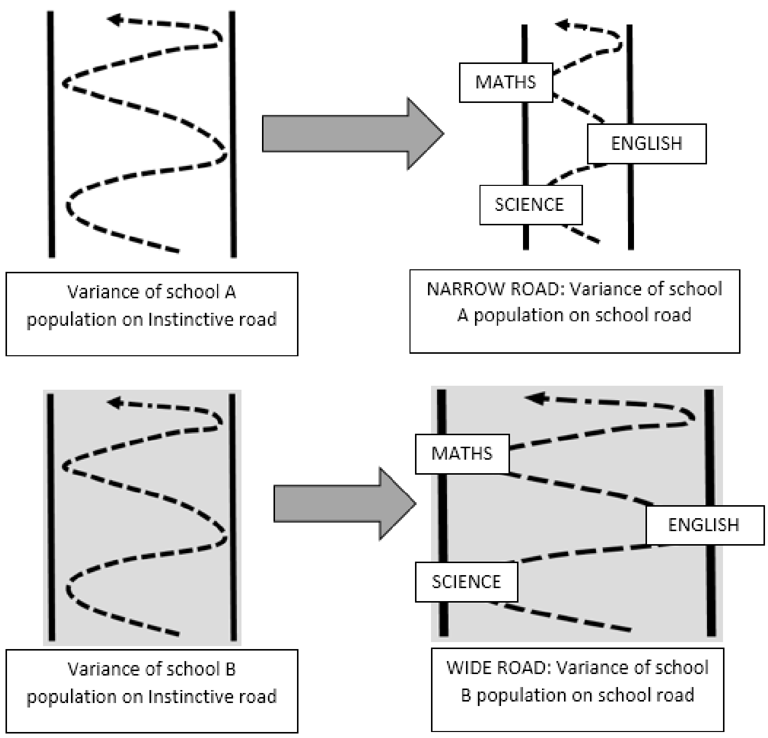


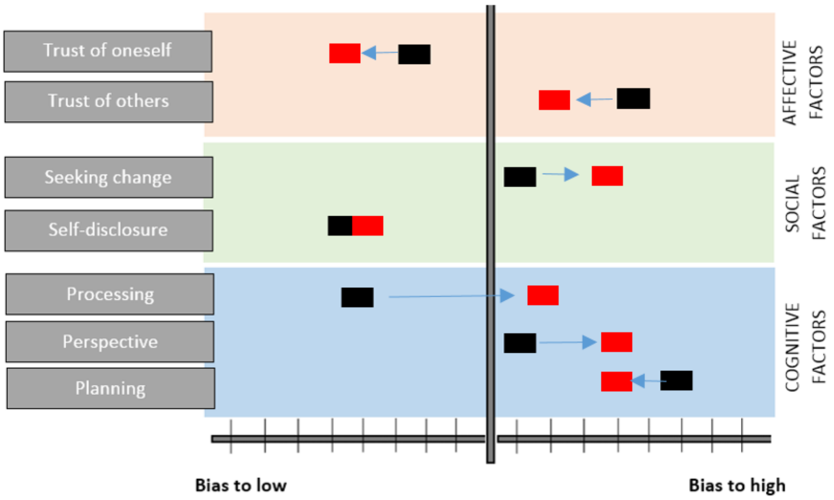
Figure 1. The concept of measuring school road width illustrated by two notional schools, A and B: A exhibiting narrow school road width (low population variance of steering cognition), and B exhibiting wide road width (high population variance of steering cognition)

Speed is a calculation of the time taken for a pupil to make steering cognition adjustments during the assessment. Previous studies have shown that pupils from higher academically ranking schools showed higher speed of response to priming cues than pupils at lower ranking schools. The researchers conjectured that pupils at high ranking schools are not rewarded for investing cognitive load into effortful CAS adjustment. Instead, pupils may deploy cognitive energy into algorithmic, computational tasks (Walker 2015i).

High speed of response was also found to correspond with both low and high pupil CAS variance. High variance + high speed is interpreted as a dysregulated CAS state, which is thought to be effortless and to lead to inaccurate thinking. High speed + low variance is interpreted to be an automatic cognitive state, which is thought to be effortless and quick.

2. Optimal steering cognition for different curriculum subjects

CAS Tracking measures the calibrated adjustment of a pupil's steering cognition to the three curriculum subject-priming stimuli; maths, science and English literature. Relative adjustment from the pupil's instinctive CAS scores indicates the degree, direction and speed of steering cognition self-regulation when faced with the learning environments of each specific curriculum subject (Walker 2015g; Walker 2014 g.; Walker 2015g). Figure 1. shows an illustration of how a pupil's instinctive CAS score may deflect, or adjust, when primed with the subject-specific environment during the CAS Tracking assessment. The 7 factors of adjustment are measured as shown in the figure, and as described elsewhere (Walker 2015i). The pupil's pattern of deflection across these 7 factors can then be compared to any wider population similarly measured using the technology to provide a reliable comparison of the steering cognition response to the three subject stimuli.



Candidate A instinctive CAS score

Candidate A contextually primed (by a maths lesson prime) CAS score

Figure 2. An example of deflections from instinctive to contextual primed CAS for an individual candidate.

Using this methodology, Walker showed in repeated studies that different steering cognition patterns are associated with higher academic performance in each of the curriculum subjects maths, English and science (Walker 2015i, 2014 g.). These can be thought of as the optimal steering cognition patterns to learn most effectively in the specific subject. For example, the optimal steering cognition pattern in science is biased toward a lower trust of oneself and a higher focus on detached evaluative information; by contrast, the optimal steering cognition pattern in English is biased toward a higher trust of oneself and a focus on personal, subjective response.

To understand what steering cognition contributes to a student's learning in the classroom, we can return to our car analogy: steering cognition is enabling the student to steer the most effective route for that particular subject road. Steering cognition controls our attention and orientates our response; so a student with effective steering cognition in a maths lesson is paying attention to the right data, and filtering out the irrelevant data; she is responding to the teacher's instructions, to the learning tasks, to the questions in a way that is more efficient, which means that the data coming into her brain is of higher quality than the data coming into the brain of a student with less effective steering cognition. As a result of that, what she feeds her brain's engine is *better quality data*; she is able to learn more effectively in that lesson, and therefore make more progress and achieve better results.

Figure 2. illustrates the respective optimal steering cognition patterns for each of the three curriculum subjects.

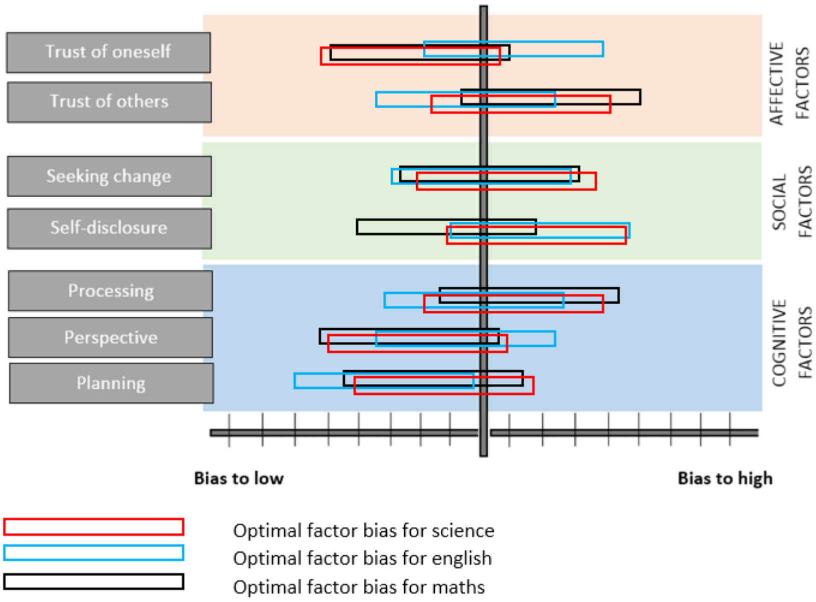


Figure 3. Optimal model for CAS state biases for each of the three subjects maths, English and science for secondary school students.

<u>Measuring Effective Steering Cognition</u>

Effective Steering Cognition (ESC) is a measure of the degree to which a pupil has adjusted their steering cognition from its instinctive pattern, or state, to the optimal pattern required to learn most effectively in the curriculum lesson (Figure 4). ESC has been shown to explain up to 15% of the GCSE grades in maths, science and English that a pupil may achieve (Walker 2015i). ESC is statistically not significantly related to IQ, which is conjectured to rely upon a different function of cognitive processing. Steering cognition has been shown to rely upon associative processing, whilst IQ on algorithmic processing (Walker 2014 g.). To calculate a pupil's overall ESC, the ESC score for each individual subject was first calculated e.g. ESC Maths =

$$\frac{\text{(Instinctive pupil steering cognition - optimal maths lesson steering cognition)}}{\text{(In-lesson pupil steering cognition- optimal maths lesson steering cognition)}}$$

Overall ESC pupil = mean of the pupil ESC individual subject scores.

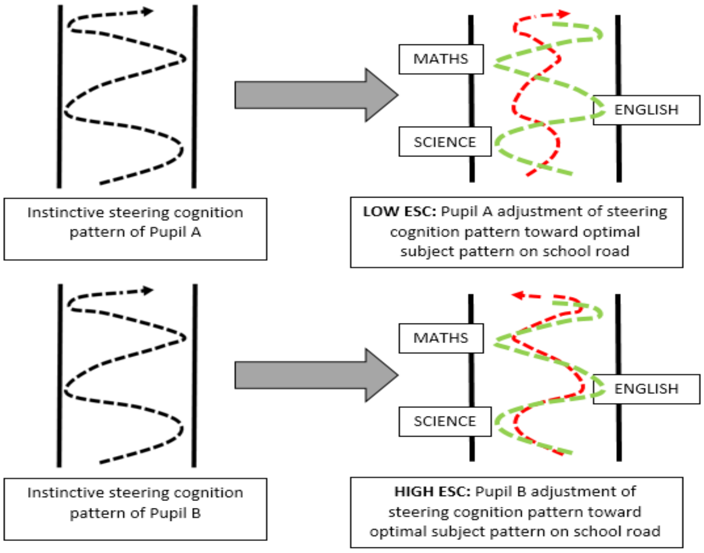


Figure 4. Pupil A exhibits low ESC, compared to Pupil B who exhibits high ESC

ESC is an representation of the conscious effortful metacognitive control a pupil will exert when engaging across a varied curriculum. Importantly, unlike IQ, a pupil's ESC score is not a fixed cognitive quotient that is unrelated to environment. Rather, ESC is a response of the pupil to the learning environment in which they are studying. The analogy of the car is useful: IQ (a measure correlated strongly with working memory, processing speed and long term memory) can be thought of as the mind's mental engine which has a certain power regardless of the terrain on which is it driving. ESC is the mind's effortful steering in response to that environment. The population ESC score across a school will therefore provide an indication of the learning environment over which the minds of pupils are driving.

Specifically, a school's overall ESC score will represent the degree to which pupils are effortfully adjusting their steering cognition from their instinctive patterns to the optimal patterns which have been linked to higher academic performance in that subject. ESC is therefore not an absolute score but a relative score, expressing the relationship between the population's instinctive steering cognition and the optimality of their steering cognition on the school curriculum road.

A pupil with more optimally adjusted steering cognition in their curriculum subjects compared to instinctively (off the school road altogether) would show an ESC score of greater than 1. A pupil with less optimally adjusted steering cognition in their curriculum subjects compared to instinctively (off the school road altogether) would show an ESC score of less than 1. Because ESC is a measure of improvement from a starting point (instinctive score) if that starting point is closer to the optimal, then any improvement will be smaller than if the starting point were further from the optimal. This means that, two populations of pupils who start from different instinctive population score sets could exhibit the same optimality of steering cognition score for maths, science and English lessons but yet show differences in ESC score. The less well regulated population instinctively would show a higher ESC score than the more instinctively well regulated pupil population.

To account for this, the variance from the mean across the population's instinctive steering cognition is measured; this is called the 'driver pool'. The driver pool score provides an indicator of the self-regulatory starting point for that cohort. A wider driver pool indicates more diverse, less well regulated population as a starting point, a lower driver pool score indicates a less diverse, better regulated population as a starting point.
This study measured the CAS Tracking of 6,427 pupils in 17 secondary schools in the UK. Pupil age means were between 14.9 and 15.4 years, with 43% of the same being under 15, 38% between 15 and 16, and 19% between 17 and 19 years of age. 58% were boys and 42% were girls. Of the schools, seven were day and ten were boarding. Schools were selected to represent a distribution of academic ranking from those amongst the highest ranking in the UK, to schools in the mid-lower ranking for academic outcomes. Public exam A Level results from 2012 and 2013 were used to rank schools.

3. Results

Driver pool score

Linear regression was performed to test for relationship between school rank and driver pool. The relationship was not statistically significant. Because data was monotonic, linear and ranked, Spearman ranked correlation was used. The result showed a weak negative relationship was identified (0.23) indicating that, if anything, the driver pool in lower ranking schools was better regulated instinctively than that in higher ranking schools. This should be understood as a measure of the spread of the pool, or the herding of the population instinctively. The effect on ESC score will therefore be small, but would have a small effect in amplifying the ESC of higher ranking schools and suppressing the ESC of lower ranking schools.

School road width vs school rank

Results showed that in most cases, the school road is wider than the instinctive road, as reflected by the driver pool score (Figure 3). However, the higher the rank of school, the smaller that increase in width. This result was significant [F (1,19) = 5.432, P= 0.018). This result indicates that the relative increase in width of the school road in higher ranking schools is significantly lower than the increase in width of the school road in lower ranking schools. This result occurs when the diversity and spread of steering cognition through the routes their maths, science and English lessons is less in higher ranking schools than lower ranking schools. This result was especially true of the intake of high ranking day schools at the age of 13 and 14, in which the width of the crowd of those younger students was especially tightly marshalled. Because data was monotonic, linear and ranked, Spearman rank correlation was used. Results showed a strong association of 0.63 between high performing schools and road width; high performing schools exhibit narrower school roads than low performing schools.

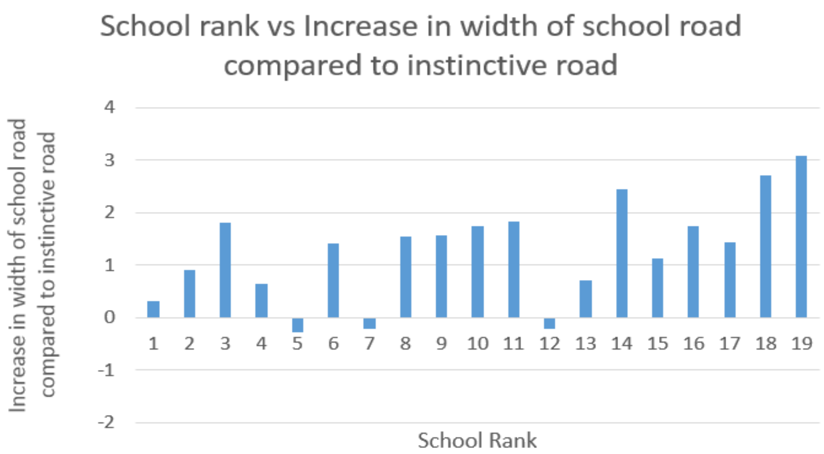


Figure 3. indicating that school road width, as compared to the instinctive road width, increased as school rank decreased. High ranking schools showed lower increase in school road width than lower ranking schools. A negative number indicates that the school road was narrower than the instinctive road.

Speed vs school rank

Figure 4 a. shows the relative speed by which pupils in three school 'buckets' (high performing day schools, low performing day schools and high-low boarding schools) adjusted their steering cognition. As found in previous experiments, pupils in high ranking schools made their adjustments much faster than those in the low ranking schools. The speed of steering cognition response is an indicator of the relative speed of cognitive judgements made by pupils. Analysis of variance across school rank (ignoring school type) proved that the relationship between school and steering cognition speed was statistically significant [F (1,15)= 5.327, P= 0.03), and explained 26% of the variance of school rank (Spearman rho = 0.51) (Figure 4 b.).

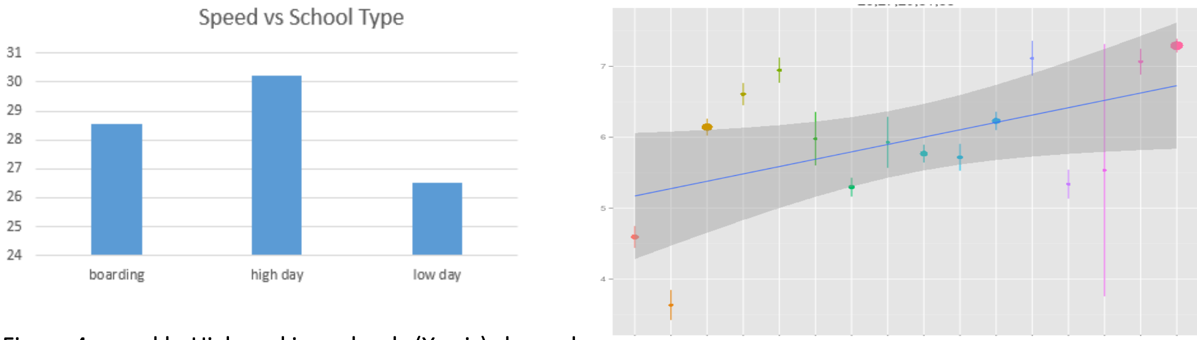


Figure 4 a. and b. High ranking schools (X axis) showed shorter 'time of response to priming cue' (Y axis) than low.

ESC vs school rank

ESC was then correlated with school rank to investigate the relationship between the ESC and school rank. Spearman rank was used to calculate correlation as data was ranked and monotonic. Rho = 0.4 evidencing that an additional 15% of school rank was explained by ESC when the 7 ESC factors were considered separately (Figure 5) i.e. to produce an individual ESC score for each of the 7 ESC factors. The graphs indicated that for the majority of the factors, the relationship between rank and ESC was negative; lower ranking schools exhibited higher ESC scores. However for a minority of factors (P and S factors which represent social and affective steering cognition) the relationship was positive; higher ranking schools were linked to higher ESC scores for those factors.

To confirm the analysis, an overall ESC score for each school for all 7 factors was calculated. When correlated with rank, the overall school's ESC scores showed an Rho = - 0.32. This indicates that overall, ESC is negatively correlated with school rank, with lower performing schools exhibiting moderately better ESC than higher performing schools (see Table 1. appendix for ranked results).

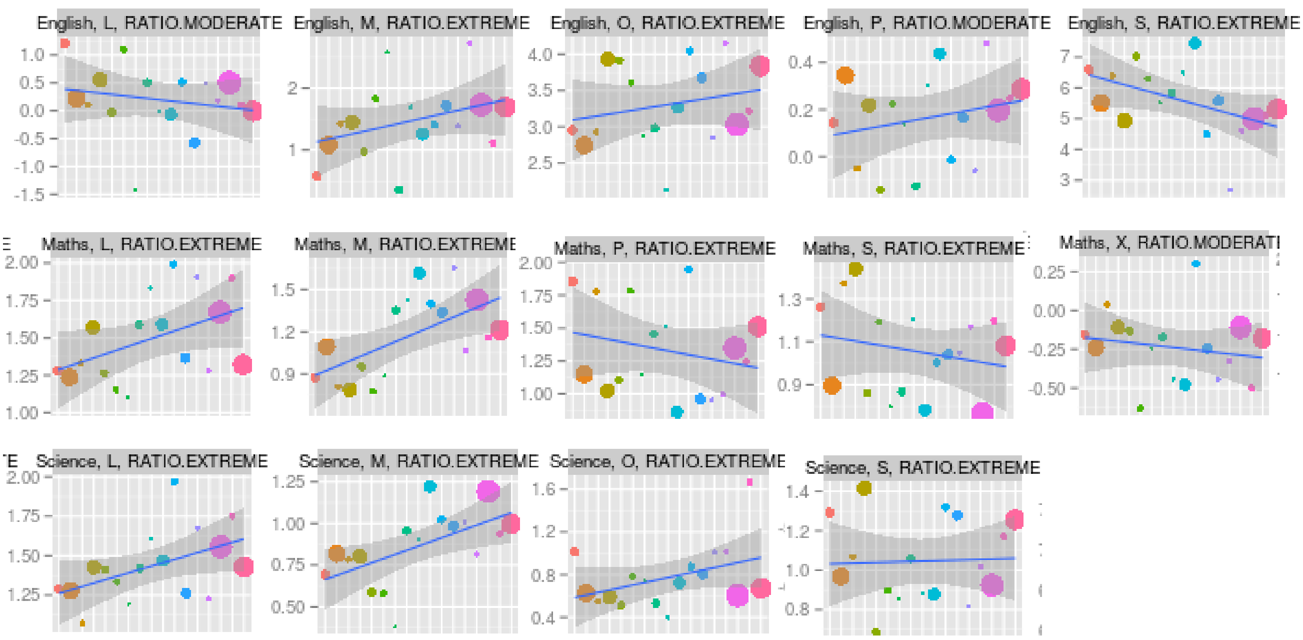


Figure 5. The majority of factors showed that low ranking schools (right on X axis) had higher, therefore, better EC CAS lessons than high ranking schools (left on X axis).

Effective steering cognition vs school road width and speed

Rankings for width and speed were assigned to each school. Spearman ranked correlation was performed to identify the relationship between ESC and speed and road width. The analysis with both boys and girls together resulted in a weak correlation between *speed and ESC* (rho = 0.21), with lower speeds linked to higher ESC and a moderate correlation between *width and speed* (0.49), with narrower roads linked to higher speed. The relationship between speed and width was significant [F (1,15) = 1.94, p= 0.04]. The relationship between ESC and width was not significant.

Finally, schools were grouped into three 'buckets' according to their school road width; narrow (population variance on the school road <14) (n= 4 schools), medium (population variance on the school road between 14 - 15) (n= 7 schools) and wide (population variance on the school road >15) (n = 4 schools). Mean ESC scores, speed and school rank were calculated for each of the three buckets. A t-test assuming unequal variances was conducted. A significant difference was found between ESC wide road schools and ESC narrow road schools (mean 117.5, 172, t critical 1.94, p = 0.03) meaning that wide road schools exhibited statistically better ESC than narrow road schools. Results are shown in Figure 6.

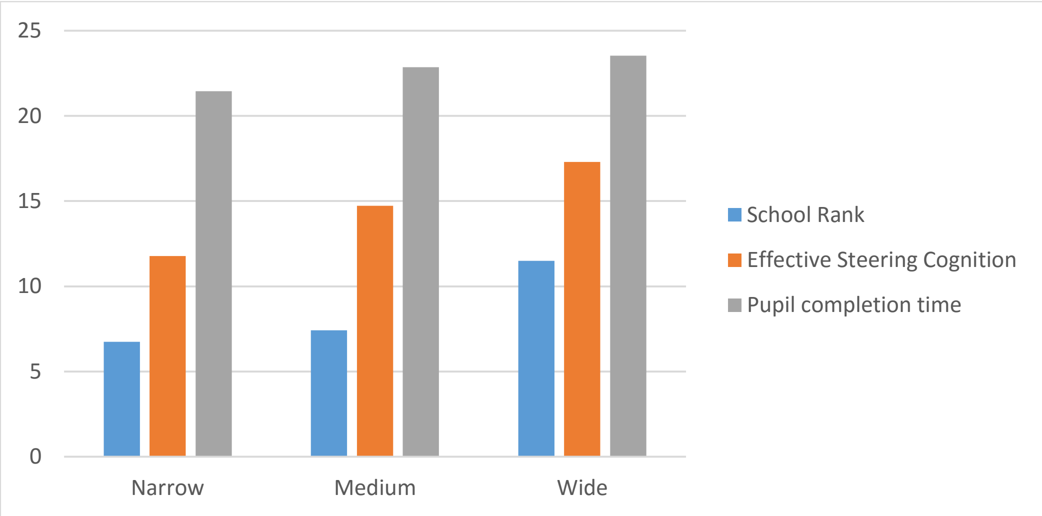


Figure 6. showing the three buckets of schools, grouped by 'school road width'- narrow, medium and wide, against school rank, ESC mean school score and pupil completion time of CAS Tracking responses

4. Discussion

High performing Motorway Schools

These results support Walker and Walker's idea that high performing schools exhibit characteristics of the Motorway Model. A strong and significant association (0.62) indicates that high performing schools exhibit narrower school roads than low performing schools; pupils drive along in tighter groups with less variation between them. They also show less variation across a range of curriculum subject lessons suggesting that pedagogy is more uniform and focused upon progress rather than exploration.

A strong and significant association (0.51) indicates that pupils at higher performing schools also show higher speed of steering cognition adjustment. Walker conjectures that increased steering cognition adjustment speed may provide pupils' with the ability to deploy more cognitive resources to their algorithmic cognition, which underpins IQ and is central to school academic assessment, than to their self-regulation of their affective-social-cognitive attention (Walker 2015i).

Lower ESC in higher performing schools

Pupils at lower ranking schools, driving on wider school roads, exhibited higher ESC than pupils at higher ranking schools. ESC is a cognitive skill which enables pupils to adjust their attention and their responses when faced with a wide range of varied and unpredicted learning environments. This result evidences that pupils at lower ranking schools exhibit greater effortful adjustment of ESC when engaging in their lessons than their equivalent peers at high ranking schools.

This result suggests that, whilst pupils at high academically performing schools are well equipped to succeed in tasks which are familiar, clearly marked and of a consistent social, emotional and cognitive nature, they are less effective at managing varied, novel, ad hoc, complex, emergent and socially unfamiliar contexts of learning.

The results indicate that pupils at high performing schools are learning in narrower social and emotional environments in which the need for them to adjust their steering cognition is diminished. Instead, they appear to rely upon their mind's algorithmic engine to travel fast over their learning landscape. Because their school environments are more socially homogeneous, the curriculum is narrow and tightly defined, and because assessments are predictable and test memory, repeated procedures and processing speed, they are able to succeed against these criteria.

One way to understand the cognitive basis of this result is to consider how steering cognition and algorithmic cognition compete for mental resources. Miyake and Friedman's theory of executive function proposes that updating, inhibition, and shifting are central tasks of executive function, each of which relates to the capacity to adapt one's cognition to the task in hand (Halloran 2011; Miyake et al. 2000; Fernandez-Duque et al. 2000).. Updating is defined as the continuous monitoring and quick addition or deletion of contents within one's working memory. Inhibition is one's capacity to supersede responses that are prepotent in a given situation. Shifting is one's cognitive flexibility to switch between different tasks or mental states. Bull and Scerif have identified that inhibition and shifting are predictors of children's mathematical ability (Bull, Scerif 2001) and effective learning (St Clair-Thompson, Helen L, Gathercole 2006). Studies on mental state switching have shown that processing speed is slowed when learners are required to switch from one mental task to another (Derakshan 2010; Mayr, Keele 2001; Monsell 2003).

The ability to effortfully adjust one's steering cognition, evidenced in a higher ESC score, necessarily involves reducing processing speed to steer more accurately. Similarly, deploying all one's resources to high processing speed will reduce the available resources to steer optimally. The study provides evidence that high ranking schools have become engineered for the latter rather than the former, with narrower school roads, upon which pupils travel faster, exhibiting characteristics of being an educational motorway rather than a broader educational road. The results suggest that the focus on academic attainment, which is underpinned by the development of analytical or algorithmic cognition, may come at a previously hidden price: *the relative reduction in the development of the ability to self-regulate one's steering cognition.*

This result suggests that high performing schools may be missing out on an untapped educational dividend. Walker has evidenced that about 15% of academic outcomes at secondary school are attributable to steering cognition as opposed to IQ. Better steering cognition need not come at a price of worse academic outcomes. Teaching pupils to 'drive' will improve their overall ability to be resourceful, metacognitively aware and exhibit strong self-efficacy, which have been evidenced as being critical for academic success (Hattie 2009; Ainley 2006; Alter et al. 2007; Boström, Lassen 2006; Education Endowment Fund 2013). Indeed, a study with first year undergraduates at a UK university evidenced that academic outcomes were improved by coaching students to improve their steering cognition through personal feedback and signposts (Walker 2015h).

Narrow, fast roads are linked to poor self-regulation and wellbeing risks

Poor steering cognition has been shown to be reliable indicator mental health and welfare risks due to reduced self-regulatory control, lower emotional functioning, lower social competencies (Walker 2015i). Jo Walker has claimed that pupils with poor steering cognition are less likely to reach out for help when they need it, are more likely to seek self-soothing strategies which are unhealthy, are more likely to engage in controlling or socially risk taking behaviours (Walker 2015a, 2015d, 2015c, 2015f, 2015e) .

Jo Walker argues that the self-regulation of steering cognition is a factor explaining lower pupil welfare and mental health. Walker J. has identified both fixed steering cognition bias, dysregulated bias and over-regulated bias as causes of self-regulatory problems (Walker 2015g, 2015a, 2015b).

Self-regulation has been defined as the ability to flexibly activate, monitor, inhibit or adapt one's non conscious, automatic affective-social strategies in response to direction from internal cues, environmental stimuli or feedback from others, in order to bring about an intended outcome (Rothbart et al. 2000a; Demetriou 2000; Eisenberg N. et al. 2006). As such, it is often effortful, volitional, conscious and purposeful (Eisenberg et al. 2000; Eisenberg et al. 2010; Hofer et al. 2010; Rothbart, Bates 2007; King et al. 2013, Bauer, Isabelle, M., Baumeister, Roy, F. 2011, 2011), and is sometimes described as effortful control. Research into the development of self-regulation in children and adolescents has grown exponentially over the last fifteen years. A swathe of evidence identifying self-regulation as a foundational developmental skill which underpins future affective, social and academic competence (Vohs et al. 2008); in contrast, poor self-regulation has been found to correlate with a wide range of internalising and externalising difficulties (Eisenberg et al. 2000; Blair 2002; Trentacosta,C.J., & Shaw, D.S. 2009; Tangney et al. 2004).

Pupils with *less steering cognition bias* are more likely to *read* the particular situation, encounter or context; they notice extrinsic and intrinsic cues which lead them to purposefully choose a particular affective-social response (Rothbart et al. 2000b; Eisenberg et al. 2000; Halberstadt et al. 2001; Tangney et al. 2004) i.e. exhibit greater self-regulation. By contrast, pupils who develop a *polar steering cognition bias* are less likely to notice those extrinsic and intrinsic cues; they tend to iterate the same self-strategies again and again which further reinforces their bias. These pupil can be said to have poor self-regulation; poor self-regulation predisposes them to a number of incipient risks (Eisenberg et al. 2003; Sallquist et al. 2009; Simonds et al. 2007).

Over-achieving and over-regulating: precursors to a crash

One explanatory theory of mental health risks in high performers is proposed by Jo Walker who has described the *over-regulation* of steering cognition as a precursor to dysregulation of attentional steering biases (Walker 2015b). Walker highlights that self-regulation is effortful and depletes personal resources, making poor decision making more likely (Baumeister et al. 1998; Baumeister, Vohs 2004).

Walker cites anecdotal evidence from longitudinal coaching work conducted with pupils in schools in which pupils with over-regulated steering cognition exhibit sudden, unexpected veering, or dysregulation as well as dysfunctional behaviours. Walker notes that often such pupils are high performers, motivated, conscientious and responsible, often in position of leadership or responsibility for others. The subsequent, sudden dysregulation is often unpredicted and without forewarning and manifests in behaviours which may be self and socially destructive. One such example, whose steering cognition was tracked over 18 months, illustrates the sudden dysregulation that occurred at a trigger point, after the sustained over-regulation of the previous 15 months (Figure 6).

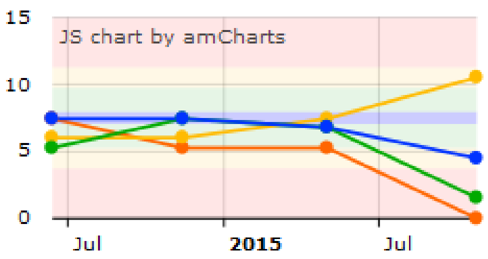


Figure 7. showing the tracked steering cognition for a single pupil (as measured by four factors shown in blue, green, yellow and red). The close regulation of scores from May 2014-May 2015 indicate over-regulation, followed by sudden dysregulation after that.

Walker argues that such sudden dysregulation is akin to a driver over-concentrating on a road, taking notice of all the road signs, the other road users, trying not to make a mistake and get anything wrong, who suddenly reaches a point of self-regulatory depletion where they cannot control their driving any more. A small and apparently trivial trigger can then cause them to disproportionately veer off, and crash.

If Walker is right, this study suggests that the narrow, fast Motorways of high performing schools may be associated with increased steering cognition patterns of not coping with pressure and self-harming, as a direct causal consequence. The pressure to over-regulate in order to drive on the straight, narrow fast road, leads to a subsequent consequence of dysregulation due to depletion.

The evidence from this study suggests that the so-called Motorway Model of education is linked to schools seeking to narrow the road and push pupils to drive faster. These characteristics are most apparent in high performing schools as one would expect in a public educational governance system which rewards characteristics which 'fit' the model. Whilst pupils at such schools develop the ability to drive fast and straight, using the kind of algorithmic cognition which underpins IQ and public examinations (Walker 2015i), this study evidences that there is a corresponding cost to their development of good self-regulation. The specific, lower ability to appropriately regulate steering cognition is linked to pupils from high performing schools with narrow, fast roads. Patterns of steering cognition associated with increased risks of self-harm and not coping with pressure are evidenced on these roads.

Because steering cognition has been shown to be a largely independent cognitive function to algorithmic cognition, it appears that an overly narrow focus on the latter has had an unintended cost to the former. Like drivers being taught to drive fast on motorways, pupils' minds are not being developed to change gear, low down, steer and cope with the more varied, difficult, unpredictable complexities beyond the academic environment. Minds driving fast and straight show increased vulnerabilities and lower protective factors, failing to seek support and engaging in patterns of behaviour which are self-harming or unhealthy.

Conclusion: Beyond the Motorway Model of Schools

The Motorway Model of school has come at a price. Schools can be engineered to build narrow, fast roads and to accelerate the progress of their pupils accordingly. However, there appears to be a cost. The question is whether the benefit makes the cost worthwhile. The answer may depend on whether education is seen as a means to get pupils as far down an academic road as possible, or whether it is a context to teach them how to steer their minds.

Other analysis of this data has highlighted the mental health costs associated with the Motorway Model. Poor self-regulation of steering cognition, associated with narrow fast school roads, shows increased risks of self-harm and not coping with pressure. This current relatively large population study indicates that the Motorway Model has negative consequences for *learning,* especially in relation to the ability to adjust to novel, varied and unpredictable tasks and environments. Whilst these classroom consequences are relatively small, though not insignificant, for the academic outcomes of pupils at school (accounting for up to 15%), they may have larger consequences beyond school in the professional world.

There is an increasingly acknowledged disconnect between the qualities developed during education and those required by employers. Consistently employers cite the ability to work in a team, problem solve, be resourceful in decision making and communicate well. In a recent survey 30% of employers complained that recruits with strong academic qualifications lack these generic business skills required in the working world (Archer, Davidson 2008). As a result, apprenticeships and internships have become an increasingly necessary finishing school for graduates whose 16 years of formal education have been largely disconnected from the actual requirements of industry. David Sproul, Senior Partner of Deloittes, recently announced that the company would no longer be asking applicant CV information on school and university (Economia 2015). Demography is irrelevant, he claims, in relation to talent. More radically, they are jettisoning the metric of applicants' prior educational qualifications, preferring to design their own tests. Ernst and Young have also abandoned consideration of degree results, stating there is no relationship between them and success in professional assessments, as have the book publisher Penguin (TES 2015). One possibility is that steering cognition may play a very significant role in the cognitive skills required to succeed in the varied, unpredictable and socially flexible world of the work place. If this were the case, it may help to explain the disconnect between high performing students who are successful at school but in the workplace are not found by employers to be successful.

Finally, one obstacle to schools' investing in the development of broader cognitive functions than those currently assessed has been the lack of a reliable measure by which to calibrate relative skills in them. The measure of ESC provides an interesting potential measure of a comparative quotient of cognitive development not currently measured by schools. As such, it may open up an opportunity to quantify a previously unmeasured property of educational outcome.

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Appendix

Table 1

ALL ages and genders			**Girls all ages**			
Sch Rank	Speed	ESC	Sch Rank	width road	Speed	ESC
1	20	120	1	11.7	18	113
2	24	101	2	13.7	25.5	137
3	20	156	3	14.8	21.9	115
4	22	178	4	14.2	22	253
5	23	76	5	14.3	24	54
6	24	146	6	16.1	24.3	146
7	22	109	7	14.3	21.6	170
8	22	134	8	14.5	22.2	138
9	24	152	9	15.8	23.5	135
10	23	107	10	13.6	21.8	103
11	21	117	11	15.4	22.2	41
12	23	127	12	14.7	24.6	107
13	24	116	13	14.9	24	194
14	22	107	14	13.6	20.5	118
15	25	167	15	15.1	23	171
16	24	222	16	17.4	23.3	240

Publication bibliography

Ainley, Mary (2006): Connecting with Learning: Motivation, Affect and Cognition in Interest Processes. In *Educ Psychol Rev* 18 (4), pp. 391–405. DOI: 10.1007/s10648-006-9033-0.

Alter, Adam L.; Oppenheimer, Daniel M.; Epley, Nicholas; Eyre, Rebecca N. (2007): Overcoming intuition: Metacognitive difficulty activates analytic reasoning. In *Journal of Experimental Psychology: General* 136 (4), pp. 569–576. DOI: 10.1037/0096-3445.136.4.569.

Archer, Will; Davidson, Jess (2008): Graduate Employability. What do employers think and want? The Council for Industry and Higher Education. UK. Available online at http://www.brunel.ac.uk/services/pcc/staff/employability/?a=92718.

Bauer, Isabelle, M.; Baumeister, Roy, F. (2011): Self Regulatory Strength. In : Handbook of Self Regulation. Research, Theory and Applications, pp. 64–78.

Baumeister, Roy F.; Bratslavsky, Ellen; Muraven, Mark; Tice, Dianne M. (1998): Ego depletion: Is the active self a limited resource?, Vol 74(5), May 1998, 1252-1265. In *Journal of Personality and Social Psychology* 74 (5), pp. 1252–1265.

Baumeister, Roy F.; Vohs, Kathleen D. (Eds.) (2004): Handbook of self-regulation. Research, theory, and applications. New York: Guilford Press.

Blair, Clancy (2002): School readiness. Integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. In *The American psychologist* 57 (2), pp. 111–127.

Boström, Lena; Lassen, Liv M. (2006): Unraveling learning, learning styles, learning strategies and meta-cognition. In *Education + Training* 48 (2/3), pp. 178–189. DOI: 10.1108/00400910610651809.

Bull, R.; Scerif, G. (2001): Executive functioning as a predictor of children's mathematics ability: inhibition, switching, and working memory. In *Dev Neuropsychol* 19 (3), pp. 273–293. DOI: 10.1207/S15326942DN1903_3.

Demetriou, A. (2000): Organisation and development of self-understanding and self-regulation. In M. Zeidner (Ed.): Handbook of Self-Regulation. San Diego: CA:Academic, pp. 209–251.

Derakshan, Eysenck (2010): Emotional states, attention, and working memory. A special issue of cognition & emotion. Hove: Psychology Press (Cognition & emotion. Special Issue).

Economia (2015): Social Mobility to Drive Deloittes Hiring Policy. Economia. UK. Available online at http://economia.icaew.com/news/september-2015/social-mobility-to-drive-deloitte-hiring-policy, updated on 2/16/2016.

Education Endowment Fund (2013): Teaching and Learning Toolkit. EEF and Sutton Trust. Available online at http://educationendowmentfoundation.org.uk/uploads/toolkit/Teaching_and_Learning_Toolkit_(Spring_2013).pdf.

Eisenberg, N.; Fabes, R. A.; Guthrie, I. K.; Reiser, M. (2000): Dispositional emotionality and regulation: their role in predicting quality of social functioning. In *Journal of Personality and Social Psychology* 78 (1), pp. 136–157.

Eisenberg, Nancy; Spinrad, Tracy L.; Eggum, Natalie D. (2010): Emotion-related self-regulation and its relation to children's maladjustment. In *Annual review of clinical psychology* 6, pp. 495–525. DOI: 10.1146/annurev.clinpsy.121208.131208.

Eisenberg, Nancy; Valiente, Carlos; Fabes, Richard A.; Smith, Cynthia L.; Reiser, Mark; Shepard, Stephanie A. et al. (2003): The relations of effortful control and ego control to children's resiliency and social functioning. In *Dev Psychol* 39 (4), pp. 761–776.

Eisenberg N.; Damon w.; Lerner. (Eds.) (2006): Handbook of Child Psychology. New York: Wiley.

Evans, Jonathan. (2011): Dual-process theories of reasoning: Contemporary issues and developmental applications. In *Developmental Review* 31 (2-3), pp. 86–102. DOI: 10.1016/j.dr.2011.07.007.

Fernandez-Duque, Diego; Baird, Jodie A.; Posner, Michael I. (2000): Executive Attention and Metacognitive Regulation. In *Consciousness and Cognition* 9 (2), pp. 288–307. DOI: 10.1006/ccog.2000.0447.

Halberstadt, Amy G.; Denham, Susanne A.; Dunsmore, Julie C. (2001): Affective Social Competence. In *Social Development* 10 (1), pp. 79–119. DOI: 10.1111/1467-9507.00150.

Halloran, Roberta Kathryn (2011): Self-regulation, executive function, working memory, and academic achievement of female high school students. In *ETD Collection for Fordham University*, pp. 1–139. Available online at http://fordham.bepress.com/dissertations/AAI3452791.

Hattie, John (2009): Visible learning. A synthesis of over 800 meta-analyses relating to achievement. London, New York: Routledge.

Hofer, Claire; Eisenberg, Nancy; Reiser, Mark (2010): The Role of Socialization, Effortful Control, and Ego Resiliency in French Adolescents' Social Functioning. In *J Res Adolesc* 20 (3), pp. 555–582. DOI: 10.1111/j.1532-7795.2010.00650.x.

King, Kevin M.; Lengua, Liliana J.; Monahan, Kathryn C. (2013): Individual differences in the development of self-regulation during pre-adolescence: connections to context and adjustment. In *Journal of abnormal child psychology* 41 (1), pp. 57–69. DOI: 10.1007/s10802-012-9665-0.

Mayr, Ulrich; Keele, Steven W. (2001): Changing internal constraints on action: The role of backward inhibition. In *Journal of Experimental Psychology: General, Vol 134(3), Aug 2005, 343-367.* 129 (1), pp. 4–26.

Miyake, A.; Friedman, N. P.; Emerson, M. J.; Witzki, A. H.; Howerter, A.; Wager, T. D. (2000): The unity and diversity of executive functions and their contributions to complex \"Frontal Lobe\" tasks: a latent variable analysis. In *Cogn Psychol* 41 (1), pp. 49–100. DOI: 10.1006/cogp.1999.0734.

Monsell, Stephen (2003): Task switching. In *Trends in Cognitive Sciences* 7 (3), pp. 134–140. DOI: 10.1016/S1364-6613(03)00028-7.

Rothbart, M. K.; Ahadi, S. A.; Evans, D. E. (2000a): Temperament and personality: origins and outcomes. In *J Pers Soc Psychol* 78 (1), pp. 122–135.

Rothbart, M. K.; Ahadi, S. A.; Evans, D. E. (2000b): Temperament and personality: origins and outcomes. In *J Pers Soc Psychol* 78 (1), pp. 122–135.

Rothbart, Mary K.; Bates, John E. (2007): Temperament. In William Damon, Richard M. Lerner (Eds.): Handbook of Child Psychology. Hoboken, NJ, USA: John Wiley & Sons, Inc.

Sallquist, Julie Vaughan; Eisenberg, Nancy; Spinrad, Tracy L.; Reiser, Mark; Hofer, Claire; Zhou, Qing et al. (2009): Positive and negative emotionality: trajectories across six years and relations with social competence. In *Emotion* 9 (1), pp. 15–28. DOI: 10.1037/a0013970.

Simonds, Jennifer; Kieras, Jessica E.; Rueda, M. Rosario; Rothbart, Mary K. (2007): Effortful control, executive attention, and emotional regulation in 7–10-year-old children. In *Cognitive Development* 22 (4), pp. 474–488. DOI: 10.1016/j.cogdev.2007.08.009.

St Clair-Thompson, Helen L; Gathercole, Susan E. (2006): Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. In *Q J Exp Psychol (Hove)* 59 (4), pp. 745–759. DOI: 10.1080/17470210500162854.

Stanovich, Keith E. (2011): Rationality and the reflective mind. New York: Oxford University Press.

Stanovich, Keith E.; West, Richard F. (2008): On the relative independence of thinking biases and cognitive ability. In *Journal of Personality and Social Psychology* 94 (4), pp. 672–695.

Stanovich, Keith E.; West, Richard F. (2014): What Intelligence Tests Miss. In *The Psychologist* 27 (2), pp. 80–83.

Tangney, June P.; Baumeister, Roy F.; Boone, Angie Luzio (2004): High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. In *Journal of Personality* 72 (2), pp. 271–324.

TES (2015): Ernst-and-young-drops-degree-classification-threshold-graduate-recruitment. In *Times Higher Education Supplement*, September 2015. Available online at https://www.timeshighereducation.com/news/ernst-and-young-drops-degree-classification-threshold-graduate-recruitment, checked on 2/16/2016.

Trentacosta,C.J., & Shaw, D.S. (2009): Emotional self-regulation, peer rejection, and anti-social behaviour: Developmetal associations from early childhood to early adolescence. In *Journal of Applied Developmental Psychology* 30 (3), pp. 356–365.

Vohs, Kathleen D.; Baumeister, Roy F.; Schmeichel, Brandon J.; Twenge, Jean M.; Nelson, Noelle M.; Tice, Dianne M. (2008): Making choices impairs subsequent self-control: a limited-resource account of decision making, self-regulation, and active initiative. In *J Pers Soc Psychol* 94 (5), pp. 883–898. DOI: 10.1037/0022-3514.94.5.883.

Walker, J. (2015a): A psychological and developmental understanding of affective-social self-regulation. DProf. University of Winchester, UK.

Walker, J. (2015b): A psychological understanding of over-self-regulation. DProf. University of Winchester, UK.

Walker, J. (2015c): AS Tracking: A psychological and developmental understanding of embracing change. DProf. University of Winchester, UK.

Walker, J. (2015d): AS Tracking: A psychological and developmental understanding of self-disclosure. DProf. University of Winchester, UK.

Walker, J. (2015e): AS Tracking: A psychological and developmental understanding of trust of others. DProf. University of Winchester, UK.

Walker, J. (2015f): AS Tracking: A psychological and developmental understanding of trust of self. DProf. University of Winchester, UK.

Walker, J. (2015g): How the AS Tracking assessment measures self-regulation. DProf. University of Winchester, UK.

Walker, Simon P. (2014 h.): Educating the self-regulation of bias. University of Bristol. UK. Available online at http://simonpwalker.com/#/research-publications/4587873262.

Walker, Simon P. (2014 g.): Navigating the world via heuristic bias. Cognitive-affective heuristic biasing contributes to successful navigation of epistemically varied tasks in secondary school. Human Ecology Education, England. Available online at http://simonpwalker.com/#/research-publications/4587873262.

Walker, Simon P. (2015h): Engaging students in optimising their metacognition. Human Ecology Education. UK. Available online at http://steeringcognition.org/#section-press-2.

Walker, Simon P. (2015i): Thinking, straight or true? Human Ecology Education. UK. Available online at http://simonpwalker.com/#/research-publications/4587873262.