Educating the self-regulation of heuristic bias

The impact of school environment upon the development of heuristic bias self-regulation in children and adolescents

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Abstract

A series of studies explored the impact of school as a 'priming environment' upon the heuristic bias regulation of adolescent and pre-adolescent children. School impact at adolescence was not found to impose patterns of habitual or instinctive heuristic bias. However, contextual biases relating to specific school environments were observed. Epistemically homogeneous and heterogeneous schools had different priming effects on heuristic student bias. In addition, local environmental conditions and interventions could prime academically improved heuristic student biases. These results support a model of cognitive-affective-social state (CAS) as a regulator between internal data processing and external epistemic demand, in which liability for heuristic bias state is jointly related to the individual and to their environment. Implications for investigating the effects of school-based education are suggested.

Keywords
Dual mind theory, priming effects of school environment, emotional contagion, cognitive-affective epistemic self-regulation, protective-risk factors

Abbreviations:
CAS Cognitive Affective Social state

1.1 Introduction

Priming effects have been documented as evidence of the ‘affect heuristic’ (Eich et al. 2000(Bower, Forgas 2000; Kahneman et al. 1982; Eich, Eric Kihlstrom, John F. Bower, Gordon H. Forgas, Joseph P. Niedenthal, Paula M. 2000). Priming effects are examples of environmental influence which lead to individuals making affectively biased decisions. For example, priming candidates with an affective stimulus such as fear, disgust, attraction prior to offering the candidate a decision or choice. It might be conjectured that a school represents an exemplar of an archetypal priming environment. Schools intentionally construct priming conditions through explicit messaging of rewards and consequences in order to direct and motivate desired behavioural student outcomes. One may conjecture, for example, that threat of punishment for non-compliance would evoke anxious or fearful states, reducing willingness to take risks in learning, or to make mistakes. Equally, positive affect states might be primed by consistent positive teacher verbal and non-verbal behaviours. In such ways, school environments may function to prime a range of inter-weaving affective states designed to constrain or limit subsequent cognitive responses in individuals.

Priming has largely been studied in individual-response studies rather than in collective groups such as school populations. Collective responses have been studied far more widely within the emotional contagion literature first proposed by Hatfield and developed by Cote (Hatfield et al. 1994; Sy T., Cote S., Saavedra R. 2005). Schools share some of the features that are expected to result in emotional contagion, or affective linkage- emotional states being shared between group participants (Lindekens 2001; Barsade 1994; Elfenbein 2014, Barsade 2002, 2002). Within-adolescence studies have shown that peer impact may have an enlarged effect on teenage behaviour and cognition (Fett et al. 2014; Burnett et al. 2011). Social comparison, social consequence recognition and mimicry are means of contagion that have obvious relevance within a school. Of particular relevance is the shared vantage point of group members which is understood as members ‘sitting on the same side of the table’ (Elfenbein 2014). Schools manifest a polarity of sides between teachers and students; one explanation of the reduced heterogeneity of CAS state scores in epistemically controlling schools is that this polarity is increased, reducing the apparent diversity of student responses on their side of the table. A common enemy creates common allies.

1.2 Effect of priming on academic outcome

In this study, the effect of priming in schools on academic outcome is investigated. In a series of experiments with secondary school students, Walker (Walker 2014 g.) showed that error was not an inevitable consequence of heuristic bias in a student’s academic outcomes, but that heuristic bias regulation may improve academic outcomes. In different school populations Walker showed that high academically performing students adjust their cognitive-affective-social heuristic bias as they engage between maths, english and science lessons. He used a novel heuristic bias assessment regulation to demonstrate that heuristic bias contributed positively to cognitive ability. By measuring how students regulated seven factors of cognitive-affective-social state (CAS state) as they imagined participating in different curriculum lessons, Walker identified almost 10% of academic outcome in the student cohorts he measured which could be attributed to CAS state bias regulation but which, importantly, could not be attributed to a student’s cognitive ability as measured by a test of general intelligence (Walker 2014 g.). From this he developed an Optimal heuristic CAS state bias model for maths, english and science learning.

Other authors have provided evidence that heuristic perception may contribute to cognitive effectiveness (Gigerenzer 2008; Gigerenzer et al. 2011; Gigerenzer, Todd 1999; Goldstein, Gigerenzer 2002). The kernel of Gigerenzer’s argument is that more data need not necessary lead to improved cognitive judgement. Walker’s results indicated that heuristic contribution may not be limited to speed and efficiency but to cognitive accuracy. What mattered, Walker identified, was not heuristic bias *per se*, but the ability of the student to *regulate* their heuristic bias, as measured by the bias of their cognitive-affective-social state, such that it was epistemically optimal for the curriculum subject the student was engaged in.

Cognitive-affective-social state (CAS state) may be seen as an embodied, unifying trait and state model of heuristic cognition in which social and affective functions are implicated (Hudlicka 2002; Watt 2005; Panksepp 2003). Walker conjectured that CAS state bias regulation identified a primary data processing function of the mind, serving as an interface between external and internal data. When navigating through the world, he suggested, the mind has to make constant epistemic adjustments to cope with the varied epistemic forms of knowledge that are encountered. These include epistemic differences between hard, objective scientific knowledge and soft, subjective arts knowledge. A varied epistemic landscape both in secondary school and in wider life, will result in differences in mental strategy, such as planning, sequencing, perspective-taking and learner-responsiveness, for external data to be accurately retrieved and incorporated by the mind (Walker 2014 g.).

From this Walker proposed that CAS state bias regulation functioned as a kind of epistemic data filter or conduit through which external data was filtered before higher data processing (Walker 2014 g.). If the CAS state bias regulatory filter functioned poorly then epistemically inaccurate data would be delivered to deeper cognitive sense-making functions, limiting the capacity of those functions to do things with it. For example, hard objective scientific observations may be reshaped to become concrete, subjective narratives before they reach the cognitive functions that will subject them to higher order sense-making. This re-shaping through the initial CAS filter may reduce the quality of intelligence that can be obtained from that data (Figure 1). Using a term ‘rubbish in, rubbish out’ from the world of business intelligence, Walker suggested the same limits on human intelligence may apply.

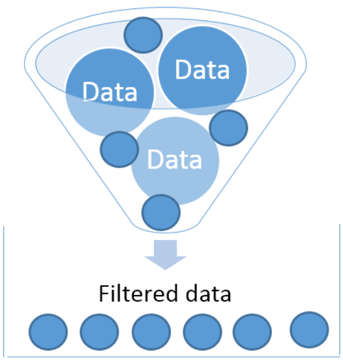


Figure 1. A model of the relationship between heuristic biasing as a primary data filter and algorithmic processing as a secondary data processing, retention and application.

Construed as a regulator between internal data processing and external epistemic demand, Walker conjectured that the priming nature of the external environment may have a bearing on the ability of a student to regulate his heuristic CAS state bias. For example, if the external environment was epistemically homogeneous and controlling, one would predict that overall student population CAS state bias regulation variance would be reduced. If the environment was epistemically heterogeneous and varied, one would predict that heuristic CAS state bias variance would increase.

2.1 Measuring CAS state bias regulation

Kahneman and Tversky’s definition of heuristics can be stated as the replacement of a complex, difficult question with an easier mental substitute (Kahneman et al. 1982). Many questions are too difficult for us to answer without considerable effort, they suggest. Kahneman posits that the question ‘how much would you contribute to save an endangered species?’ is complex involving consideration of kinds of species, spending priorities, environmental causality etc. (Kahneman 2011). He suggests that system 1/process 1 mentally substitutes a simpler heuristic question as an imperfect but adequate means of getting an answer to the too-difficult question; in this case ‘How much emotion do I feel when I think of dying dolphins?’

According to Kahneman, other heuristic substitutions might include: ‘How happy are you with your life these days?’, becomes ‘What is my mood right now?’ ‘How popular will the president be in six months from now?’ becomes ‘How popular is the president right now?’ What is common to such heuristic substitutions is that they replace a more general, abstract, remote, theoretical scenario with a concrete, immediate, personally-experienced and affect-loaded scenario. In contrast to non-heuristic thought which is detached, rational and logical, *heuristic* thought centrally sustains mental participation in the story, an act of self-identification with the issue.

Heuristic thought implicates a neural capacity to imagine ourselves as first-persons into a situation. Gaesser provides evidence that the regions of the brain that structure memory and imagination are involved in the construction of our affective, empathic responses to our environment (Gaesser 2012). Others evidence that the imagination plays a central role in organising our behaviours (Decety, Grèzes 2006; Garry, Polaschek 2000). Such centres must be implicated in heuristic biasing. Strikingly for heuristics, imagination is particularly implicated in future-orientated guidance. Schacter evidences that the brain projects forward a method of self-operation prior to then enacting that projected sequence (Schacter et al. 2007). This supports a model of cognition that requires the ability to anticipate and organise mental operations in order to fulfil a sequence of mental activities effectively (Stein, 1994). The brain’s capacity to imagine serves as a guide or route map directing action (Schacter 2012). Evidence such as this suggests that the mind does not rest in a neutral state but rather is making ‘forward investment’ provided by the continuous activity of the imagination, projecting forward future self-operation.

Such forward investment may explain the effortful work involved in the recruitment of what is known as system 2/process 2. System 2/process 2 may involve the *inhibition or braking* of the forward momentum of system 1/process 1. In effect, putting a sudden brake on an up-and-running cognitive, affective, behavioural operation, the momentum of which may continue to take thought forward in that direction unless considerable cognitive effort is expended to restain it.

2.1.1 Structure of heuristic bias assessment

A heuristic bias assessment was developed to measure the forward investment of heuristic thought. The assessment involved three parts: an initial task, an instinctive heuristic bias response task and a contextual heuristic bias response task. Cognitive, affective and social factors of heuristic thought were measured.

2.1.2 Part one: Initial task. The initial task of the heuristic bias assessment involved an online computer-based imagination activity. Through a set of audible, recorded instructions, the candidate was asked to imagine a mental image of the characteristics of an unprescribed open space. Rules developed by Grove (Grove, Panzer 1989), governing the use of instructional clean language when leading candidates in mental imagery, ensured the candidate’s imagination provided a prescription of the open space. This ensured that the effects of Stanovich’s pre-set mental parameters are minimised (Stanovich, West 2014). Explicit goals in the mental task were not specified ensuring framing effects are also minimised.

2.1.3 Part two: Instinctive heuristic bias response task. Following the initial imagination of the mental space, the candidate was asked to react to a series of 28 events, incidents or required tasks imagined to take place within their mental space. None of the events require technical skill or involve cognitive difficulty. Each task response was self-scored on a six point Likert scale. The 28 items were developed to measure seven factors proposed by Walker in a model of Personal Ecology (Walker, 2007, 2009). Personal Ecology is a multi-factor, bi-polar model in which factor bias is conceptualised as a means by which an individual negotiates interaction with the surrounding environment. As such, it was identified as a potential model of some cognitive, affective and social factors conjectured to contribute to heuristic bias. Walker (Walker, 2009) claims that three of the seven factors (factors 5,6 and 7) contribute to cognitive bias, two factors contribute to learner affective bias (factors 1,2,) and two factors to learner social bias (factors 3,4).

Factor number/		Factor biases			
1.	**Trust of own ideas, opinions**	*Questionning of own ideas etc….*	⟷	*Trust of own ideas etc..*	***Affective factors***
2.	**Trust of others' ideas etc...**	*Questionning of other's ideas etc….*	⟷	*Trust of other's ideas etc…*	
3.	**Embracing change**	*Resisting change*	⟷	*Embracing change*	***Social factors***
4.	**Self-disclosure**	*Holding back ideas, opinions etc…*	⟷	*Disclosing ideas, opinions etc…*	
5.	**Perspective**	*Detached perspective when thinking*	⟷	*Personal perspective when thinking*	***Cognitive factors***
6.	**Processing**	*Connecting ideas when thinking*	⟷	*Sequencing ideas when thinking*	
7.	**Planning**	*Focusing on the process/ experience*	⟷	*Focusing on the outcome*	

Figure 2. The biased polarities for each of the seven factors.

Each factor is a bipolar construct in which the poles represent a heuristic biased state. For example, Factor 1. is a scale between the two poles of *trusting of own ideas, qualities and opinions* and *questionning of own ideas, qualities and opinions*. A factor score toward trust indicates a heuristic bias to trust one's own ideas, opinions and qualities rather than question them; the extremity of the factor score represents the degree of heuristic bias manifest. Walker and Walker asserts that an extreme factor score indicates both an extreme heuristic bias as well as a bias that is likely to be less modulatable (Walker, J., Walker, S. 2013). Instinctive factor scores are computed from raw item scores via a transformational algorithm and standardised on a 1-15 scale.

<u>2.1.4 Part three: Contextual heuristic bias response task.</u> Having established a candidate's *instinctive* heuristic biases for the seven factors, candidates are then asked, via audible instructions, to imagine a specified *context or situation* taking place within their imagined space. The instructions follow as similar a routine, pattern and verbal format as the instinctive response task. An example of a specified context might be a maths lesson in which case, the candidate will imagine their concrete maths class taking place within their imagined space. Prescriptions as to whether the candidate should focus more on the teacher, material, maths task, or peers are not given in order to avoid the introduction of alien framing effects; the candidate's focus of attention is taken to be a representation of their own heuristic bias framing effect.

Candidates then react for a second time, to the series of 28 events, incidents or required tasks which are now described as occurring within the context of the maths lesson imagined to be taking place within their mental space. By the introduction of a specific context into the imagined space, a comparative measure of heuristic bias of cognitive, affective and social factors against is obtained. The second set of scores represent contextual heuristic bias.

After a short break, candidates return to the assessment and repeat the above instructions a third time. This time, a different subject lesson is introduced, for example science or english. Once again, the bias response task is repeated and the 28 items scored providing a third set of scores representing heuristic bias in this second subject lesson. Finally, candidates repeat the process one further time, focusing on the third remaining subject of science, maths or English, and a final measure of the 28 items scores is obtained for that third context.

By this mechanism four sets of heuristic bias scores are obtained for each of the seven factors: an instinctive heuristic bias score and three contextual heuristic bias scores, thus tracking the regulation of the candidate's heuristic bias as she moves between contextual learning activities.

Part one: Initial Task	**Part two : Instinctive heuristic bias response task sample items:**	**Part three: Contextual heuristic bias response task sample items:**
Imagine you are standing outside- choose an area of the space you want to call your own.	3. How easy would it be for someone to walk across your boundary into your space?	3. How easy would it be for your maths class to walk straight across your boundary into YOUR SPACE?
	9. Imagine you could keep part of your space private. How much of your space would you keep private?	9. Imagine that you could keep a part of your space private in your maths class. Do you feel more comfortable keeping your thoughts and feelings in your private space?
	11. Do you like things to change in your space?	11. Do you like change in YOUR SPACE when your maths class is in it
	16. Someone has given you a challenge to solve in your space. You can CHOOSE a challenge about facts and objects, or about people and stories. Which do you choose?	16. In your maths class, your teacher has given you a challenge to solve in your SPACE. |You can CHOOSE a challenge about facts and objects, or about people and stories. Which do you want to choose?
	21. If a visitor came to your space would you plan what they are going to do?	
	26. You need to make something in your space. Do you try new and different ways to do it?	
8 further cues	21 further items	23 further items

Figure 3. Sample items of parts one, two and three of the assessment

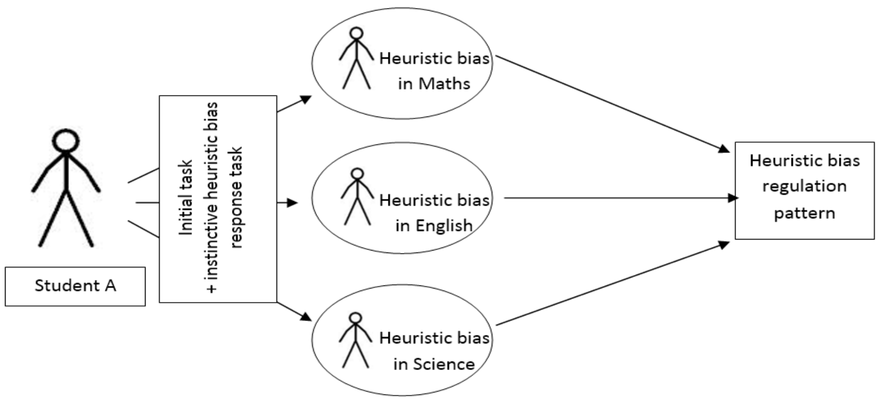


Figure 4. Schema of heuristic bias regulation assessment of maths, english and science class biases

3.1 Method

Four UK secondary schools were first ranked on level of environmental control and homogeneity, on the basis of four observable characteristics.

1. Exhibition of top-down authority (enforcement of uniform, time keeping, behavioural rules)
2. Exhibition of shared pedagogic (teaching) approaches between teachers
3. Balance of teacher-directed vs pupil-directed teaching methods
4. Control/supervisory oversight given to pupils when out of lessons

Observations were made during on-site visits through direct pupil observation and through staff interview. An overall rank of cultural control was given to each school, encompassing both the teaching and non-teaching components of the observation.

2.2 Student CAS state bias regulation assessment

Student CAS state bias regulation of Year 10 students (aged 15) was measured using the CAS heuristic bias assessment in the four secondary schools (n= 496). In addition affective- state (AS) bias regulation was measured in Year 5 students (Year 5) in four primary schools (n = 98) for study 8.

4.1 Results

Statistical analyses were performed using PSPP 0.7.5.

4.2 Instinctive biases in different populations of 15 year olds are not significantly different.

No significant relationship was found between student 'instinctive' heuristic bias for any of the seven factors, or any combination of the seven factors, and school in year 10 students F (1, 496) =4.87, significance F = 0.396.

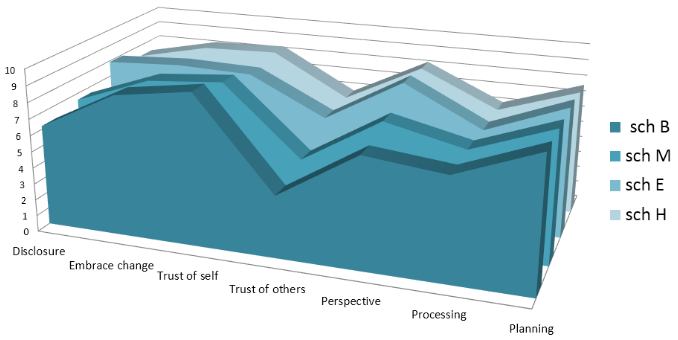


Figure 5. Illustrating that mean year 10 cohort instinctive heuristic bias scores were not related to 'school' when four schools (B, M, E and H) were considered.

Instinctive heuristic bias is not related to differences in school. This result, measuring four different UK populations of fifteen year old students, confirms that geography and schooling do not significantly alter age-related instinctive heuristic bias.

4.3 Collective CAS state regulatory bias variance correlates with observed environmental control

Schools E, B, H and M ranked 1,2,3 and 4 respectively on the measure of environmental control and homogeneity, with school E being the most environmentally homogeneous and controlling and school M being the least.

A regression analysis was performed to test for the relationship between environmental control school rank and individual student CAS factor variances between subjects. F (1,2286) =5.114, significance F = 0.024. The relationship was significant indicating that environmental control probably constrains individual's CAS state bias regulation.

Mean in-school variance in schools B and E, when treated as a pair, showed remarkable consistency between the five factors (mean = 0.0292) whilst mean in-school variance of paired schools M and H was different (mean = 0.3144) (Figure 6). A two-sample T test assuming unequal variances was then performed to test the assumption that there is no significant difference between the variances of CAS factors in group M,H and group B,E. The assumption proved false (t -2.480> t critical two-tail 2.200), indicating that there is significant difference between the variances of groups M, H, B and E. A comparison of means of the variances of the five factors in schools B, E compared schools M, H shows that B, E (mean = 2.255) is significantly lower than M, H (mean = 2.715).

School	**Environmental control rank**	**Affective Factors**		**Cognitive Factors**		
		1. Trust of own	**2. Trust of others**	**5. Perspective**	**6. Processing**	**7. Planning**
E	**1**	2.269	2.269	2.118	2.269	2.269
B	**2**	2.381	2.381	1.831	2.381	2.381
H	**3**	2.687	3.820	2.082	2.664	2.461
M	**4**	2.434	3.364	2.924	1.945	2.767

Figure 6. The variances in schools B, E, M and H for CAS factors: Perspective, Processing, Planning, Trust of own ideas, Trust of others' ideas.

4.3.1 Discussion

'In school' CAS state bias is a function of the regulatory control a school environment may place over a population of students to regulate their CAS state individually and independently. Different schools exert a different collective heuristic bias suggesting that factors such as ethos, student expectations, pedagogic uniformity or diversity, curriculum format, exertion of discipline and authority may be factors which exert a top-down influence over individual student's regulation of their CAS state. Schools exhibit collective CAS state biases which reflect environmental factors (Figures 7.1, 7.2, 7.3).

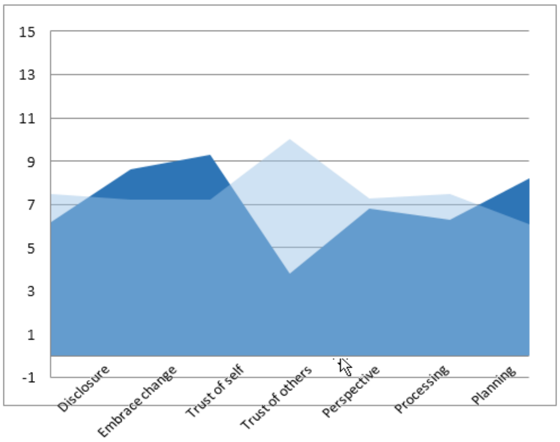


Figure 7.1. School B: Mean instinctive student score for CAS factors (X axis) (dark shading) overlaid by in-school student scores (light shading).

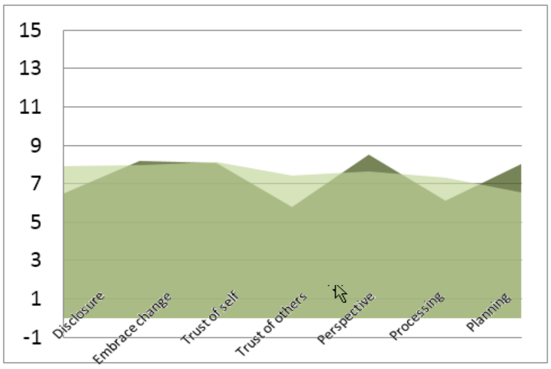


Figure 7.2. School E: Mean instinctive student score for CAS factors (X axis) (dark shading) overlaid by in-school student scores (light shading).

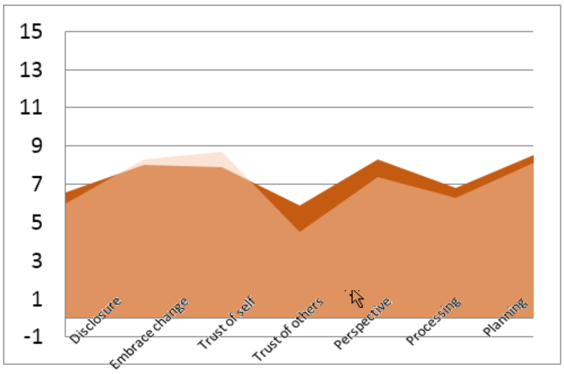


Figure 7.3 School M: Mean instinctive student score for CAS factors (X axis) (dark shading) overlaid by in-school student scores (light shading).

These results suggest evidence that cognitive as well as affective states in schools can be 'contagiously linked'. Schools share some of the features that are expected to result in emotional contagion, or affective linkage-emotional states being shared between group participants (Elfenbein 2014; Barsade 2002; Lindekens 2001). Within-adolescence studies have shown that peer impact may have an enlarged effect on teenage behaviour and cognition (Fett et al. 2014; Burnett et al. 2011). Mimicry within a classroom may play a large part; a limited range of cognitive strategies exhibited within a class group may reduce the perceived permission to experiment with other strategies, for example.

4.4 When environmental control is low bright students regulate bias more optimally than less academically successful / less cognitively able students

Using Walker's model of optimal heuristic bias for different curriculum lessons (Walker 2014 g.) a one-way ANOVA was performed to test the relationship between Optimal heuristic bias and Grade rank in schools M and H. The relationship between F (1,96) =6.689, significance p = 0.01412. The slope is significantly non-zero, indicating that there is probably a relationship between Optimal heuristic bias and Grade rank in schools M & H.

A one-way ANOVA was used to test for the relationship between Optimal heuristic bias and Set in schools B and E. The relationship between Optimal heuristic bias and Set differed significantly F (1, 153) = 1.958, p = 0.1655 The relationship between Optimal heuristic bias and Set did not differ significantly indicating there is probably not a relationship between Optimal heuristic bias and Set at schools B and E.

<u>4. 4.1 Discussion</u>

Walker conjectures that science may be described as a discipline in which the mental task of the science student is to put aside their own personal feelings or experiences and submit to the evidenced outcomes of a body of practice and knowledge (Walker 2014 g.). A similar epistemic property would apply to maths, whilst the opposite epistemic property would apply to English in which the recruitment of one's personal, subjective perspective as an 'author' of the dialogue with the subject. Walker claims that other CAS factors have optimal biases for different curriculum subjects; for example Trust of self, Trust of others and Planning (Walker 2014 g.).

This result evidences that the ability of the student to regulate their heuristic bias, as measured by their CAS state bias, such that it is epistemically optimal for the curriculum subject is contingent upon a low level of environmental control. A high controlling, epistemically homogeneous school environment can reduce the ability of students to regulate their CAS state. CAS state regulatory capacity is best described from this result as an ecological mental function, the modulatable capacity of which can be suppressed by a controlling external environment.

4.5 Under environmentally controlling conditions high and low performing students respond differently.

A one–way ANOVA identified that the relationship between the mean standard deviation of the three cognitive CAS factors (Perspective, Processing and Planning) and Set in schools B and E differed significantly F (1, 68) = 8.89, p = 0.0039. A regression analysis was performed to confirm the relationship of SD of cognitive factors and Set in schools B and E resulting in F (1,68) =8.88, significance F = 0.00398. The slope is significantly non-zero, indicating that there is probably a relationship between the SD of cognitive factors and Set in schools B and E.

<u>3.5.1 Discussion</u>

Schools B and M are high- controlling homogeneous school environments. This result evidences that under environmentally controlling conditions, high and low academically performing students respond differently. More academically successful students try, but fail, to regulate the three cognitive factors optimally. This result suggests that environment may play an active role in diverting students from adjusting their CAS state optimally for the task in hand. A highly controlling environment may function like a well signed motorway, in which high performing students travel well but fail to develop their varied metacognitive navigation. Such students show signs of seeking their own metacognitive navigation but not success.

By contrast, less academically successful students respond differently to a controlling environment. Unlike high performing students, they do not seek to find their own epistemic routes. Instead, they exhibit a passivity, showing a low level of bias variance for cognitive factors across their range of subjects. Environmental control cedes control from low performing students imposing cognitive boundaries which are not challenged.

4.6 Under heterogeneous and low-controlling environmental conditions, low performing students exhibit epistemic lostness.

A one–way ANOVA identified that the relationship between the SD of cognitive factors and Set in schools M and H did not differ significantly F (1, 25) = 1.05, p = 0.31 and F (1, 250) = 0.87, p = 0.36. A regression analysis was performed to confirm the relationship. The slope is not significantly non-zero, indicating that there is probably not a relationship between variance and set in schools M and H.

4.6.1 Discussion

Schools M and H are heterogeneous, low-controlling environments. Both high and low performing students both exhibited similar variances in the cognitive factors between curriculum subjects. High performing students modulated their heuristic bias optimally, whilst low performing students modulated their heuristic biases sub-optimally. Whilst high performers have developed an instinctive ability to navigate the varied epistemic landscape successfully, low performers show signs of being epistemically lost, changing CAS state biases in an unguided and errorful manner from learning context to learning context.

4.7 Micro environments can cause local improvements in CAS state bias regulation

238 predicted student predicted GCSE grades across maths, science and English were obtained from school H. A one-way ANOVA was used to test for the relationship of the ‘responsiveness factors’ (factor 1, trust of self and factor 2, trust of others) against predicted grade in school H.

The relationship between ‘trust of others’ and ‘trust of self’ differed significantly between students predicted D and E/F/G grades, F (1, 238) = 13.51, p = 0.000294 indicating that D grade students exhibited a more effective ‘responsiveness’ state than E/F/G grade predicted students. This result was not surprising as it fits the prior result that effective responsive affective state correlates with higher academic performance.

The relationship between ‘trust of others’ and ‘trust of self’ differed significantly between students predicted D and C grades when data was transformed to equalise sample sizes, F (1, 368) = 10.18, p = 0.001538 indicating that D grade students exhibited a more effective responsive state than C grade predicted students. This result was counter-expectation, in which higher performing students (C grade) exhibited a disorganised responsive bias, associated with lower performing students and vice-versa. Finally, the relationship of ‘trust of others’ and ‘trust of self’ between C and E/F/G grade students was tested. There was no significant difference in affective responsiveness bias between C and E/F/G grade predicted students F (1, 233) = 2.71, p = 0.1004 when data was transformed to equalise sample sizes (Figure 7).

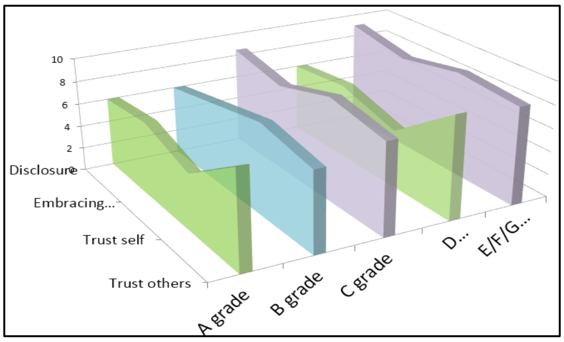


Figure 8. Students predicted E/F/G on grade scale exhibited the anticipated disorganised responsiveness heuristic bias (high Trust of self bias, high Trust of others bias) whilst students predicted D grades exhibited effective responsiveness heuristic bias (low Trust of self bias, high Trust of others bias), also seen in A grade students.

4.7.1 Discussion

D predicted grade students exhibit unexpectedly effective heuristic responsiveness bias, a bias level only evidenced by A grade predicted students. By contrast both C and E/F/G students show a consistently high incidence of students exhibiting a heuristic bias toward low responsiveness. The result suggests that D grade prediction has a heuristic state ‘activator effect’. The C/D borderline is significant in UK secondary schools, representing a pass/fail threshold at GCSE. Schools invest additional resources into D grade students to boost the proportion of passes. D grade students may therefore experience a different micro environment than C or E/F/G predicted grade students.

Abundant evidence exists showing that summative assessments, such as predicted grades, create ceilings and floors for learners (Hattie 2009a). This result provides a heuristic bias explanation for this phenomenon, indicating that low/high affective responsiveness heuristic bias state is not fixed but may be subject to extrinsic and intrinsic temporal regulation, such as predicted grade. This result sits within the literature on the role self-regulation plays in the development of wide ranging of self, social and cognitive competences (Buckner et al. 2009; Vohs, Baumeister 2011). The evidence that self-regulatory strength is depleted after affective epistemic challenges are faced (Baumeister et al. 1998; Muraven, Baumeister 2000) provides a perspective on why the C grade slump may occur after the D grade hump.

Evidence has shown that the brain will deploy the minimum resources toward cognitive perception (Kahneman 2011; Kahneman et al. 1982; Kahneman, Tversky 1973). Built into this model is the expectation that the precious but limited resources of the rational mind (referred to variously as system 2/ process 2) are only sometimes deployed to intervene, reign in and cross check the low-cost intuitive but errorful cognitive operations of system 1/process 1. In relation to cognitive miser theory, this result suggests that the effortful control required to adopt a more optimal affective bias slumps to a lower cost bias state after an expenditure of labour (Fiske, Taylor 1985).

4.8 Coaching to improve optimal CAS state bias regulation may improve predicted grades

In a small pilot study (n= 13) of mixed-ability year 10 students in school H, 1:1 coaching was provided to support student development of CAS state bias regulation. Pre-intervention student CAS state biases in English, maths and science was measured using the CAS heuristic bias assessment. Over a 10 week period involving a 10 minute coaching conversation each week, advice was provided to individual students suggesting specific in-lesson behaviours that could improve their individual bias regulation, on the basis of their CAS state bias scores. After 10 weeks, post-intervention change in an individual’s subject-specific CAS score was re-measured. Changes in each student’s predicted GCSE grades in English, maths and science over that period were also measured.

Positive or negative changes in student CAS bias score compared to subject-specific optimal CAS were calculated and ranked. A Pearson’s r correlation was performed on the data to test for the effect size of changes in CAS to predicted GCSE grade. The value of R is 0.291 showing there is a moderate effect size (correlation) between changes in a student's subject-specific CAS score and changes in predicted GCSE grade in that subject. This effect can be expressed this way: an improvement or deterioration in CAS resulted in 21% of students improving/deteriorating in their predicted GCSE grade (Figure 8). A larger sample would be required to confirm the outcome of this small experiment. It is also noted that in some cases, CAS state bias regulation deteriorated despite coaching, suggesting that the coaching process was not as effective as it could have been.

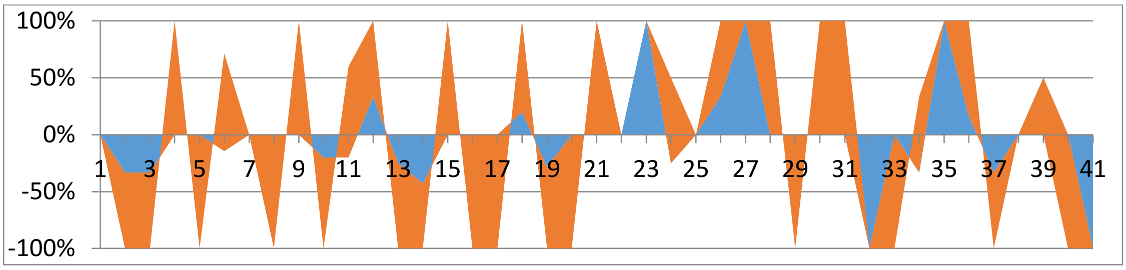


Figure 9. Change in CAS bias optimal score (BLUE) plotted against predicted GCSE grade changes in english, maths and science subjects (ORANGE), as a % of observed range of change for each.

4.9 Local school environment can provide protective or risk factors for dis-regulation

Dis-regulation can be defined as a lack of self-regulation in the affective-social factors of CAS, measured by the standard deviation of a student's factor scores from a neutral, non-biased factor score (7.5). A comparison between a student's instinctive dis-regulation and in-school dis-regulation score in school M, a boarding school was made. A paired t-test was performed to determine if boarding house as an environment reduced dis-regulation of affective-social state. The population was male.

The mean reduction in dis-regulation (M=0.18, SD =1.64, N= 51) was significantly greater than zero, t critical = 2.03, two-tail p = 0.021, providing evidence that the boarding house as an environment was significant in reducing dis-regulation and increasing self-regulation (Figure 8)

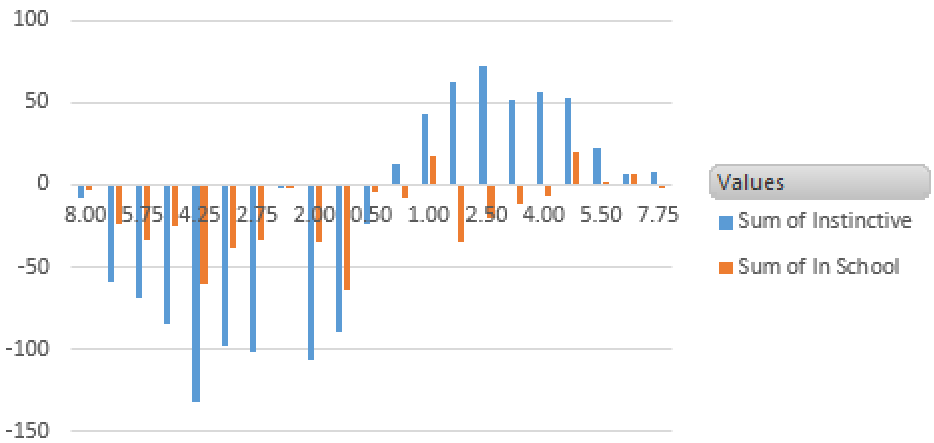


Figure 10. Showing the sums dis-regulation (divergence from the mean) of affective-social factor scores in a population when measured instinctively (blue) compared to in house (orange).

In another experiment, 98 Year 5 (aged 10) students attending four schools undertook a variation of the CAS heuristic bias assessment to test for the effects of publishing the results of a competitive race they took part in at their schools. An initial assessment of the child's INSTINCTIVE Affective-Social state, using the CAS bias assessment, was made to compare the impacts of three scenarios on affective-social state. The assessment then used a variation of the subject-specific CAS assessment in which three hypothetical scenarios were imagined by the child into their imagined space to assess impact of a child's Affective-Social state on each. The hypothetical scenarios were:

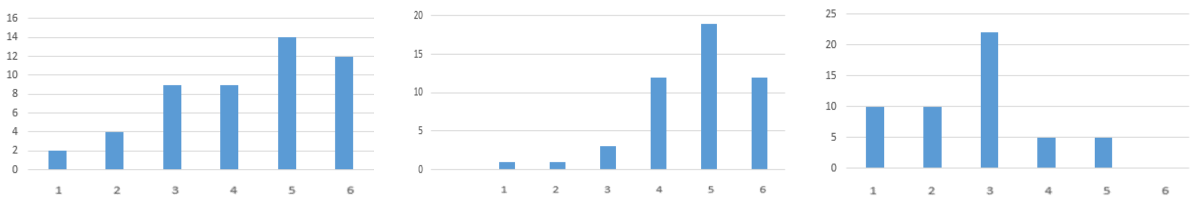
1. Imagining coming first in a cross country race at school and the results being displayed (i.e. a visible successful outcome)
2. Imagining coming last in the race and the results being displayed (i.e. a visible disappointing outcome)
3. Imagining participating in the race and the results not being displayed (i.e. an unknown outcome)

A comparison between the means of the variances of the FIRST/UNKNOWN result (mean = 0.994) is significantly lower than LAST results (mean = 1.452). Displaying the results of coming LAST had a polarising effect on children's scores for all four factors. Bias scores were pushed from a medial level to become either HIGH or LOW for each factor. This result (Figure 11), represented graphically, shows that LAST score distribution exhibited two peaks- one for low factor bias score and the other for high factor bias score. By contrast, the graph of FIRST OR UNKNOWN scores shows a typical bell-shaped distribution, with the bulk of the children's scores being in the medial range.

Being seen to come last *Being seen to come first/results unknown*

Figure 11. Number of students (Y axis) exhibiting bias scores (X axis) after three sets of results were displayed: *first, last/result unknown.*

In this experiment, the affect-priming corresponded with an increase in Factor 3 score (Embracing change) in the children (Figure 12). When children saw their result of coming first displayed, this had the effect of increasing their desire to embrace novelty, change and pace. Surprisingly, however, displaying their result of coming last also had the same effect. By contrast, not showing the result did not bias drive toward either stability or change. A high bias for pace, novelty and change is associated in general with risk taking, whilst the opposite with risk aversion (Walker, J., Walker, S. 2013).



Being seen to come first *Being seen to come last* *Result not displayed*

Figure 12. Number of students (Y axis) exhibiting Embracing change bias scores (X axis) after three sets of results were displayed: *first, last and unknown.*

<u>4.9.1 Discussion</u>

This experiment suggests that public visibility of success or failure appears to play a role in a child learning to regulate their affective-social bias. Being seen to come last caused children to dis-regulate their affective-social bias state: in other words, to move toward an affective-social state that is more extreme and less well-regulated. Some children moved toward one pole (highly trusting of themselves or others, highly disclosing etc…), whilst others moved toward the other pole (highly questionning of themselves or others, not disclosing any need….). Both reactions reflect a child dis-regulating, becoming either more defiant, self-contained, less open to feedback, or becoming more needy, more swayed by other people's opinions.

Public display of success/failure is an example of an affect-priming cue (a visible announcement of one's competitive rank against one's peers). The affect-heuristic has been conjectured to describe the impact on cognitive biasing of a primed affective state (Kahneman 2011; Keller et al. 2006; Sherman, Kim 2002; Winkielman, Zajonc & Norbert Schwarz, Robert B. 1997). In this experiment, both a positive or negatively valenced affect cue increases risk-taking; being seen to come first may provide a boost of confidence, whilst being seen to come last, a desire to move on from a painful experience as fast as possible.

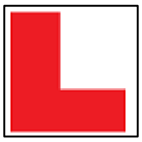
5.1 Overall discussion

To what extent is heuristic bias self-regulation educated through schooling? This study provides some initial evidence in response to this question.

5.2 Plasticity in bias state during adolescence. Evidence suggests that whatever cognitive affective social bias may be attributed to the effect of school environment has not, by the age of 15, become hard-wired. Whilst it can be observed in contextual school assessment of CAS state biases it cannot be detected in a 15 year old's instinctive, and therefore, habituated, CAS bias. CAS bias is still, in mid-adolescence, plastic.

5.3 Environmental suppression of cognitive bias regulation. Environment can suppress CAS state bias regulation. The ability to regulate CAS state bias optimally across different learning contexts, which has been attributed to academically successful students, was shown to be suppressed if the epistemic environment was homogenous and controlling. However, the effect of such suppression is not even across all adolescents. Academically brighter students, when suppressed, continue to adjust their CAS state bias between learning contexts, as if straining to exercise their cognitive biasing capacity at a more optimal level for the task in hand. However, under suppressing conditions, their efforts are unsuccessful; they do not develop optimal bias regulation patterns. This suggests that schooling which seeks to impose a singular pedagogic orthodoxy across its curriculum (perhaps for the sake of applying universal teaching appraisal criteria, for example) may have a detrimental impact on the development of cognitive bias self-regulation in higher-performing students. A highly controlling environment may function like a well signed motorway, in which high performing students travel well but fail to develop their varied metacognitive navigation. Such students show signs of seeking their own metacognitive navigation but do not succeed.

On the other hand, lower academically performing students, when suppressed, develop fixed and rigid biases as a consequence. This may be because the energy and motivation for bias self-regulation is depleted by environmental control. One piece of evidence supporting this as an explanation was that lower academically performing students within non-suppressive schools did not develop such fixed and rigid biases; lower academic ability *per se* does not equate to bias fixity. Bias fixity may be an expression of cognitive miserliness; when suppressed, there is no apparent gain to be made in straining for an alternative biased response. Over time, one would predict that such environmentally-induced cognitive passivity is likely to reduce the self-regulatory strength available to an individual. One implication may be that schooling which seeks to impose a singular pedagogic orthodoxy across its curriculum may also have a detrimental impact on the development of cognitive bias self-regulation in lower-performing students, by breeding cognitive passivity.



5.4 Cognitive bias self-regulation can be improved by explicit training and accurate environmental priming. Two studies evidenced the impacts of explicit and accurate environmental priming on heuristic bias self-regulation. The C/D grade activator effect implied that local conditions could prime a more optimal affective bias state in students. The lack of maintenance of an optimal bias state, when those activator conditions were then removed, indicated that it was an effortful state.

Evidence of priming which impacted cognitive bias state self-regulation was found in the small pilot coaching study. In this study, priming took the form of explicit identification of bias states, as well as the priming of alternative behavioural strategies to be adopted within class. The effects of this priming showed some evidence of being carried over into actual classroom learning behaviours, with changes in CAS state bias regulation correlating moderately with changes in predicted GCSE grade. The study indicated a promising avenue for further investigation into the effects on academic outcomes of improving heuristic bias self-regulation.

5.5 Local environment can provide protective and risk factors for dis/regulation. Two studies evidenced the role that local environment can have in biasing affective-social state to either a more regulated or dis-regulated state. In the first, the context of a boarding house acted to regulate intrinsic student affective-social biases. One explanation may be that the close proximity of fellow students provided a framework of accountability and acceptability of social behaviours, limiting dis-regulation. It would be instructive to test if such a containing context, resulted in a wilder dis-regulation when that container was removed (i.e., when such students were freed from the social constraints).

The second experiment, in which three different scenarios of public exposure of results was set up, indicated that 10 year old children are dis-regulated by affectively negative visibility (being seen to come last). Both positive and negative affective visibility (being seen to come first or last) had the effect of biasing affective-social state toward risk taking.

A growing body of work from the fields of psychology and neuroscience on self-regulation and effortful control is highlighting the significance of self-regulation in healthy adolescence and educational outcomes (Liew 2012). Jessor et al found protective environmental during adolescence as well as self-regulatory psychosocial factors can be a significant predictor of future behavioural problems (Jessor et al. 1995). Schunk and Zimmerman have written extensively about the impacts of self-regulation on academic outcomes (Zimmerman 1996, 1996, Schunk 1990; Zimmerman, Schunk 2001), whilst Blair has highlighted it's early significance in school success in young children (Blair, Diamond 2008). A well regulated child will develop the ability to adjust their pace, being able to persevere with difficult, boring tasks rather than seeking novelty or distraction. This experiment suggested that displaying the results of the race appeared to cause bias toward novelty and change rather than better self-regulation of attention.

5.6 Further questions

The identification of a measurable school impact on CAS state bias regulation raises the possibility of further investigation into how heuristic biases develop within the context of education. Regimes of ongoing, robust, standardised testing and assessment measure the impact of education on children's academic outcomes down to the smallest degree (Deary et al. 2007; Hansen et al. 2004; Marks 2006; Heck 2000; Bridge et al. 1979; Hattie 2009b; Pascarella, Terenzini 2005). However, if Walker's claim that 10% of academic outcome is attributable to CAS heuristic bias regulation (Walker 2014 g.) is valid, then understanding the development of such bias regulation within schooling may have important educational implications. Children spend six hours a day, five days a week, for thirteen years, in school; it would seem sensible to try to understand what cognitive, affective and social bias patterns may be attributed to those hours.

The challenges in developing reliable *in situ* subjective-state pupil-assessments contribute to a relative dearth of information about what impacts a school environment is actually having upon its population day-to-day (Brener et al. 2003; Heck 2000; Verhulst, Ende 1992). The heuristic bias assessment of CAS state may offer a route to 'see inside the mind' of an individual student *in situ* within the school day. Studies which explore correlations between *in situ* CAS state bias regulation data and other convergent school metrics, such as absences, discipline records, incidents as well as positive indices such as responsibilities, awards and grades, are required to understand the significance of CAS state bias regulation data to educational outcomes more fully.

6.1 Conclusions

A series of studies explored the impact of school as a 'priming environment' upon the heuristic bias regulation of adolescent and pre-adolescent children. School impact at adolescence was not found to have imposed patterns of habitual or instinctive heuristic bias. However, contextual biases relating to specific school environments were observed. Epistemically homogeneous schools exhibited lower CAS bias state student regulatory variance than epistemically heterogeneous schools. Optimal heuristic CAS bias state regulation for the specific demands of english, science and maths lessons was observed in high performing students in heterogeneous schools but not observed in equivalent students in environmentally homogeneous schools. Low performing students in homogeneous schools displayed heuristic cognitive passivity, whilst in heterogeneous schools they displayed heuristic disorientation. In addition, local environmental conditions or interventions could prime academically improved CAS heuristic student biases. Finally, local environments were evidenced to have the potential to cause better regulation, as well as dis-regulation, of CAS heuristic bias. These results support a model of CAS state as a regulator between internal data processing and external epistemic demand, in which liability for heuristic bias state is jointly related to the individual and to their environment. The sheer volume of social investment made by society into the younger generation through schooling suggests that better understanding of the priming effects of school upon children's cognitive-affective-social heuristic biases is a worthwhile ongoing project.

Disclosure

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