Motivation Contagion at School: Do Friends Show Similar Motivation in Behaviour and Brain?

Thesis submitted for the degree of Doctor of Philosophy

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Declaration

‘I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.’

Miss Laura Grace Burgess

Declaration of Contributions

Chapter 1 section 1.1. is written as a paper, published in *Mind, Brain and Education*. All other chapters are written in thesis chapter style and will be written up as papers following submission.

The reference and information regarding my contributions to the paper are as follows:

Burgess, L. G., Riddell, P. M., Fancourt, A., & Murayama, K. (2018). The Influence of social contagion within education: A motivational perspective. *Mind, Brain, and Education*, *12*(4), 164-174. https://doi.org/10.1111/mbe.12178

This paper provides a review of the literature surrounding social contagion and sets out the motivational perspective to explain why social contagion occurs. I carried out the full literature search to support the paper and wrote the first draft in full. Other authors contributed during the redrafting and peer review process. The idea to add a teacher contagion section and to add the motivational perspective were contributions from other authors. Following this, the literature search, drafting and writing of the teacher contagion section was carried out by myself, and the motivational perspective was originally drafted by my supervisor (Dr Kou Murayama) and then redrafted by myself.

Abstract

It has been shown that the motivation of students' is related to academic achievement. However, while research on the socio-cognitive factors that contribute to students' motivation is increasing, limited attention has been placed on the impact of their real social networks and peer interactions. Therefore, this thesis investigated the spread of motivation between friends i.e. motivation contagion, within a real school environment.

To identify the impact of friendships on levels of academic motivation, a longitudinal research study was performed, measuring individual levels of motivation, and social network connections. Additionally, an fMRI study was carried out to establish if observed behavioural similarity could also be identified in brain activation. In Chapters 2 and 3, I examined similarity of motivation between friends using cross-sectional data. Additionally, students network position was also examined, to establish whether being better socially connected is related to levels of individual motivation. In Chapter 4, longitudinal models were constructed in order to break down similarity into its component parts; selection and influence. Chapter 5 includes the fMRI study detailed above, taking measures of brain activity in response to reward and correlating them with the same responses of those with whom they had social connections.

Across chapters, the results were varied and in all cases the hypotheses were partially supported. Similarity between friends was observed in some measures of motivation, but not in others. In terms of motivation contagion, results indicated that selection effects were more pervasive than influence effects, suggesting that friendships are more often formed on the basis of similarity, rather than becoming similar over time. Finally, friendship pairs showed similarity in striatal activation in the brain in response to the cue phase of a rewarding task, but the results varied across two samples.

The findings are considered from various perspectives including developmental and methodological considerations. Further, application to educational practice is also discussed. Overall, this thesis provides an original contribution by combining psychology, education and neuroscience to provide new insights into the dynamic nature of friendships in the context of school life.

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1. General introduction

The opening chapter of this thesis consists of a review paper, published in *Mind, Brain and Education*, followed by a summary of the aims of the thesis and contents of each chapter. To close, a description of each construct referred to throughout this thesis is provided.

The title of the review paper is *'The Influence of Social Contagion within Education: A Motivational Perspective'*. The paper provides a description of the framework for social contagion and gives an overview of the literature relevant to education, explaining how recent methods enable more complex questions about the dynamics of friendship, in relation to education, to be addressed. A motivational perspective is also provided to explain the mechanism through which social contagion occurs, in the context of the research presented. This review provides clear background for the chapters that follow, as further explained by the proceeding sections that outline the specific aims of the thesis and describe each chapter.

1.1. The influence of social contagion within education: A motivational perspective

1.1.1. Abstract

This paper provides an overview of research on social contagion in the context of education. We highlight the importance of students' social interactions in school, considering contagion between peers and contagion from teachers to students using a motivation perspective. The framework of contagion is introduced broadly, followed by a focused review on both peer and teacher related social contagion in school environments. Then we introduce methodology for mapping behaviour change to networks that are a direct representation of school cohorts. We argue that these different lines of research can be coherently interpreted from a motivation perspective, suggesting the critical role of motivation in social contagion, in the context of education. We highlight the limited amount of research on positive contagion effects and we call for further investigation into ways in which to increase the contagion of positive, academic behaviours. Finally, the neuroscience behind social contagion, both for the mechanisms and the interactions, is discussed.

1.1.2. Introduction

Yawning, laughing, and smiling… all examples of behaviours that pass from one individual to another. However, consider behaviours more specific to a classroom environment --- are these also contagious? Imagine a friendship group of students in which one individual has a high interest in science --- does their interest have the power to spark interest in the rest of their social group? Social contagion is an important psychological process that argues that it does.

In fact, since the 1800's, the term contagion has been used to describe many social actions, ranging from social and behavioural, to criminal and hysterical. Described as the involuntary 'catching' of behaviours and attitudes across connected individuals (Levy & Nail, 1993), social contagion has also become a well-accepted phenomenon in the psychology literature. However, at present, there is limited research on social contagion in the context of education. This is surprising, because in education, it cannot be denied that certain children, no matter their age, have the natural ability to influence the moods and behaviours of their fellow students, without showing an explicit intention of doing so. While this may be a universal observation of teaching professionals, contagion is also present between teachers and students. The purpose of this article is to review the relevant literature on social contagion in the context of education, and discuss its application to the field of mind, brain, and education.

Another purpose of this article is to discuss social contagion in education from a motivational perspective. One of the potential limitations of the previous studies, which documented social contagion effects, is that they are relatively mute about the psychological mechanisms. On the other hand, psychological research on motivation has long indicated the importance of social relationships in students' motivated behaviour. These lines of work suggest that many, if not all, of the social contagion phenomenon observed in education could be explained by motivational mechanisms. In this article, we will attempt to discuss a variety of social contagion phenomena in education from a motivational perspective, with the aim to provide an integrated view on these segregated studies.

In the following, we first discuss the framework for social contagion. Next, we discuss a wide range of literature that suggests the prevalence of social contagion in educational settings, while mentioning the advancing methods for examining social networks and patterns of influence. We will then introduce a motivational perspective on social contagion and discuss how the social contagion phenomena reviewed earlier can be explained by the motivational view. In the closing sections, we will discuss future directions and recent contributions to the topic of social contagion in education

from the social network and social neuroscience fields.

1.1.3. Framework for social contagion

In contagion literature, the focus lies on the influence of one individual on another, and the spread of influence in their friendship (or social) network. In more recent literature (especially in the emerging field of network science, Cohen & Barabási, 2002), a social network is often described in terms of 'nodes' and 'ties'; each person in the network existing as an individual node, and each person they name, or by whom they are named as a friend, is described as a tie. Therefore, nodes that are linked by a tie are assumed to be connected by friendship, which may or may not be reciprocated.

Specifically, a contagion effect is observed over time, and is characterized by similarity that is driven by influence and transmitted through a friendship tie (Ryan, 2001). Importantly, a mere similarity between connected individuals does not always mean that contagion has occurred. Rather, there can be two possible explanations; similarity due to contagion or similarity due to homophily. Social contagion suggests that the tie between individuals is the driving force for any convergence in behaviour, attitudes or personality. On the other hand, homophily suggests that individuals with similar interests connect and spend initial time together more often than those with dissimilar interests (McPherson, Smith-Lovin, & Cook, 2001). Therefore, the two processes seem to mirror each other: similarity in social contagion is driven by the tie, whereas for homophily, similarity drives the tie formation. When friends are similar, contagion and homophily processes may be acting together or independently, and these processes should be evaluated separately when investigating contagion effects. Furthermore, it should be noted that many different terms are used to describe this contagion versus homophily effect, and in modern literature the distinction is most often described as selection (i.e. homophily) and influence or socialisation (i.e. contagion). The terms are used interchangeably throughout this review i.e. contagion and homophily or selection and influence.

The seminal study by Kandel (1978) used longitudinal friendship pair data to study similarities between friends, addressing whether observed similarities are a product of homophily or contagion. Through a set of systematic analyses of the longitudinal data, this study identified that both homophily, followed by contagion, contribute to the similarities between friends. This work is among the first to highlight the importance of separating the mechanisms driving peer similarities. Since this seminal work, social contagion has been recognized as a universal phenomenon which can be observed in many different social populations and domains, going far beyond that of adolescent research (e.g. contagion in the workplace, Welsch, 2016;

Bakker, 2009, contagion via social media, Guadagno, Rempala, Murphy, & Okdie, 2013; Lerman & Ghosh, 2010).

1.1.4. Social contagion in education

Though social contagion is studied in a broad range of fields, we now draw special attention to contagion in friendships during adolescence, and the impact of selection and influence on child and adolescent behaviours at school. Numerous studies have investigated the role of homophily and contagion on a range of topics including; adolescent depressive symptoms (Giletta et al., 2011; Prinstein, 2007); adolescent alcohol use (Burk, van der Vorst, Kerr, & Stattin, 2012; Popp, Laursen, Kerr, Stattin, & Burk, 2008); dynamics of religion in friendship (Cheadle & Schwadel, 2012); interest similarities (Fink & Wild, 1995); and similarities in perceived self-regulated learning (Jones, Alexander, & Estell, 2010). In sum, demonstrating the importance of contagion during school and throughout adolescence, having implications for behaviour and attitudes that will follow into adulthood. At present, there are limited papers that specifically and directly focus on social contagion in the school context. However, there is a large body of work focusing on peer influence, closely linked to the concept of contagion among students. There is also emerging evidence on contagion between teacher and student, and between teachers, including from senior staff to teachers. These studies can be considered as different manifestations under the umbrella of social contagion.

1.1.4.1. Negative peer influence

The term peer influence, which is different from our description of influence in terms of contagion or socialisation, refers to the concept that people shift their opinions, attitudes and behaviours based on those of the people with whom they are closely associated (Moody, 2001). While social (or peer) contagion is a term reflecting more general peer processes, without the implication of pressure to conform to a behaviour, peer influence or pressure may imply that people are coerced into behaviours (Dishion & Dodge, 2005). In other words, peer influence can be regarded as a special aspect of social contagion. Perhaps because of this negative connotation, studies of peer influence have mainly focused on a variety of negative adolescent behaviours, including smoking, drinking and substance use as risk behaviours outside of the classroom (for a full review see Brechwald & Prinstein, 2011). These studies indicate the power of peer influence in increasing negative risk behaviours, along with increasing delinquency among school age cohorts.

These investigations rarely consider friend selection when evaluating the strength of influence, meaning the research cannot statistically distinguish homophily from contagion. Despite this, the research can inform educators on the general impact

of peer influence on academic behaviours and consequently has become a well investigated area of study.

In a unique experimental design, Cohen and Prinstein (2006) used a novel computerized 'chat room' to research adolescent male conformity to negative health risk behaviours. During the study, 11th grade (16-17 years) participants believed that they were in conversation with three best friends they had nominated prior to the experiment. In reality, the participant was viewing the responses of e-confederates, whose answers were experimentally manipulated. The researchers found that high peer status lead to greater levels of conformity to health risk behaviours, with social anxiety also moderating the level of conformity; those who were most anxious conformed regardless of peer status. These results demonstrate experimentally that peer influence can be simulated in online experimental settings, also demonstrating how personality types mediate peer contagion.

It should be noted that not all research conceptualises peer influence as coercive in nature, but some research rather examines more naturalistic situations where peer effects are subconsciously working and is therefore more in line with our conceptualization of social influence. For example, Zimmerman (2003) has examined peer effects in a controlled environment, taking advantage of the new living arrangements of students entering college. Using random room assignment, the assumption was that similarities in roommates' grades at a later point would provide a strong argument for peer influence naturally occurring between the roommates, impacting on their grade outcomes. Zimmerman found that, although the overall effects were relatively small, negative peer effects were present and were more strongly linked to verbal SAT scores than to math SAT scores. For example, their data suggest that those who had average GPA were likely to drop in performance when they shared a room with someone in the bottom 15% of the verbal SAT distribution (see also Sacerdote, 2001).

Along a similar line of thought, research on social influence also examined the effects of the quality of social relationship on academic outcomes. Wentzel and Caldwell (1997), for example, investigated the influence of friendships, peer acceptance and group affiliation on academic achievement for 6th year students. To measure friendship, students were asked to nominate three friends, and to measure peer acceptance, researchers measured each student's willingness to spend time with each other (see Asher & Dodge, 1986). The results showed that number of reciprocated friendships, peer acceptance and group membership all contributed to predicting GPA and used this finding to make a case for the critical role of peers in facilitating students' academic performance.

In sum, the aforementioned research demonstrates the role of peer influence in social adjustment, academic adjustment and achievement, across a wide age range of students and settings. These findings support the idea that students are affected by their peers during adolescence (often influenced more than by their parents, see Harris, 2011), and shows why examining peer contagion might be valuable to educators (Sacerdote, 2011). However, much of the peer influence research considers negative and/or risk behaviours (for exceptions, Berndt & Keefe, 1995; Woo, Kwak, Lim, & Kim, 2015).

1.1.4.2. Teacher contagion

The contagion effect observed between teachers and students may not be formed by the same mechanisms as peer influence, but nevertheless can be considered as another manifestation of social contagion in education. From day-to-day observation of a learning environment, it is possible to see that the behaviour of teachers has the power to influence that of the students they are teaching. Christophel (1990) noted that immediacy behaviours of teachers modify the motivation of students to learn. Furthermore, the well-known 'Dr Fox Effect' also shows how teachers' influence students, demonstrating that lectures performed with more enthusiasm result in better test results (Ware & Williams, 1975).

Literature on teacher contagion highlights the impact of increasing stress on teachers and the passing of this stress, and other emotions, onto their students. In a study examining the link between classroom teacher burnout and morning cortisol levels in elementary school children, Oberle and Schonert-Reichl (2016) measured salivary cortisol levels of students to assess the relationship between student stress and teacher burnout levels. The results revealed that students had higher morning cortisol levels if their teacher reported a high level of burnout, consistent with the idea of stress contagion proposed in social psychology (Huang, Wang, Wu, & You, 2016; Wethington, 2000). If stress contagion can pass from teacher to student, it is also reasonable to suggest that teachers may be 'catching' the stress from more senior staff. Indeed, Westman and Etzion (1999) identified a crossover effect of job-induced tension between school principals and teachers, demonstrating that stress in the workplace can jump between employees and elevate the stress of all staff.

However, research on teacher contagion has not only focused on stress. For example, Radel, Sarrazin, Legrain and Wild (2010) used an experimental manipulation to examine how the motivation orientation of teachers translates to the motivation of students. They delivered lessons to separate classes, one where students believed that the teacher was motivated by an extrinsic monetary incentive, and another where the students believed that the teacher had volunteered and was therefore intrinsically

motivated to lead the class. Despite the teaching content being identical, students taught by the paid teacher reported lower interest and less engagement compared to students taught by the volunteer teacher. Furthermore, in a follow up experiment, the same pattern of interest and engagement was shown when new, naïve students were taught by the student learners who were originally taught by the paid teacher. Findings such as these highlight the role of intrinsic motivation, the power of interpersonal cues about motives for teaching, and the power that unintentional motivational influence of teachers can have on students' learning.

Houser and Waldbuesser (2017) examined how teacher satisfaction and confirmation behaviours are related to their perceptions of students' nonverbal classroom behaviour. The research showed that more highly expressive teachers are more likely to induce students to be more expressive, and therefore increase their level of nonverbal responsiveness. This study was based on ideas from emotion contagion theory (Hatfield, Cacioppo, & Rapson, 1993), arguing that confirmation behaviours of teachers has an emotional impact on students that is then reflected in the students' nonverbal responses. Such responses are fed back to the teacher, who will adjust their perceptions accordingly and continue to mirror and reinforce the felt emotion. In line with this idea, Mottet and Beebe (2000) found that teachers' emotional response and students' emotional response co-vary. With a large-scale longitudinal survey, Frenzel, Goetz, Lüdtke, Pekrun and Sutton (2009) also found that teacher enjoyment influences their students' enjoyment over time, providing further evidence for teacher contagion in emotion and demonstrating the important role that social contagion plays in educational settings.

1.1.5. Recent work with social network methodology

While the research reviewed thus far covers a wide range of methodologies, examining different forms of contagion, we now focus on modern techniques employed in research on social networks. So far in this review, the statistical models and tests used in the majority of peer influence research are not able to statistically distinguish between the effects of homophily and contagion, as processes for group similarity. In recent years, however, more robust methods for analysing networks dynamics have emerged in the field of network science and psychometrics, allowing the field to gain better understanding of the mechanisms that support social contagion. These methods are especially useful for assessing social networks in schools and can enable us to assess the influence within classrooms and year groups.

Analysis of network dynamics originally emerged from the Framingham Heart Study, a longitudinal study with data that spans over 20 years, containing multiple waves of participants, linking many generations within a community. Using this mass

data, Christakis and Fowler examined different network effects, such as spread of obesity, happiness, smoking habits, loneliness and divorce (Cacioppo, Fowler, & Christakis, 2009; Christakis & Fowler, 2007, 2008; Fowler & Christakis, 2008; McDermott, Fowler, & Christakis, 2013; Rosenquist, Murabito, Fowler, & Christakis, 2010). Since this foundational research, there has been much more focus on the impact of contagion in social networks (e.g. Aral, Muchnik, & Sundararajan, 2009). Stochastic actor-based modelling (Snijders, van de Bunt, & Steglich, 2010) is an example of a contemporary methodology that enables the prediction of network changes between discrete time points, longitudinally, accounting for the different mechanisms driving similarity. To date only a limited body of research has used stochastic actor-based modelling in educational settings, but the method is becoming increasingly popular due to its ability to separate selection effects from influence effects, through examining changes over time.

The strength of stochastic actor-based modelling lies in its flexibility and granularity to specify social influence and selection processes. Using the concept of "micro steps", the model accounts for multiple sequential changes that occurred between the time points when behavioural measures were taken. The model also accounts for the different types of similarity, distinguishing between homophily and contagion processes that are often confounded in other methodologies. Generally speaking, the model assumes that actors make decisions about changes to these ties at multiple time points (i.e. micro step). The technique involves rigorous statistics, showing progression in the field by challenging other models, considering network and behaviour as mutually dependent (Steglich, Snijders, & Pearson, 2010).

Indeed, there are clear benefits to using social network analysis in classroom environments. As reviewed earlier, there is clear suggestion that social contagion plays a critical role at school during adolescence (Berndt & Keefe, 1995; Wentzel & Caldwell, 1997), but most of the previous research used correlational techniques, making it difficult to disentangle between selection and influence processes. Some studies used experimental approaches to test the causal effect of contagion (Cohen & Prinstein, 2006; Radel et al., 2010), but these studies disregard the potential role of homophily at school. In other words, these studies failed to take into account the full information of the network dynamics to examine contagion processes.

Shin and Ryan (2014b) conducted one of the earliest examinations of the selection and influence effects in early adolescence at school by using stochastic actor-based modelling. They examined social network effects on achievement goals and academic adjustment. The sample included students aged 11 – 12 years, with data collected over two waves in the school year. Achievement goals were measured

in three categories; mastery-approach goals (i.e. goals to develop one's competence), performance-approach goals (i.e. goals to do better than others), or performance-avoidance goals (i.e. goals not to do worse than others) and social network data was recorded by asking students to nominate their best friends. Overall, the model revealed different mechanisms for the different forms of achievement goal. Students tended to make friends with others that held similar mastery goals, increasing further in similarity between the two waves of data collection (i.e. influence/contagion). By contrast, those with performance avoidance goals did not tend to form friendship ties with similar goal-oriented individuals or tend to become more similar to friends over time. In addition, the students who held performance avoidance goals made many friendship nominations which were not reciprocated. This first study provided new insights into the selection and influence processes driving the achievement goals of early adolescents' (Shin & Ryan, 2014a).

Shin and Ryan (2014a) also analysed data based on other motivational variables (e.g., self-efficacy and intrinsic value) as a measure of academic adjustment. In this analysis, the selection results revealed a tendency for students to seek out friends with similar levels of self-efficacy and achievement, whereas influence was identified in effortful and disruptive behaviour, and in students' levels of intrinsic value. Taken together, these results indicate that both selection and influence processes are present in academic adjustment. Students select their friends based on grades and confidence level (i.e. selection), with behaviour becoming more similar as a result of those selections in either a positive or negative direction (i.e. influence).

In further investigation of academic functioning and peer contagion, Rambaran, Hopmeyer, Schwartz and Steglich (2016) designed a similar study in which they used stochastic actor-based modelling to identify selection and influence effects in academic functioning, specifically measuring GPA and truancy levels. The authors collected data on the social acceptance and popularity of students, along with GPA scores and number of unexplained absences from school. Selection effects were observed for achievement, while both selection and influence played an equal role in truancy. Furthermore, students had a tendency to become similar in both attendance and truancy over time thus demonstrating a contagion effect. These results indicate that students have the power to influence positive as well as negative behaviours in their peers. Similarly, Gremmen, Dijkstra, Steglich and Veenstra (2017) analysed selection and influence effects based on achievement levels. After analysing the longitudinal data, it was apparent that at the first wave of data collection, selection (homophily) based on similar grades was the most prominent process. In the second wave, they found evidence that influence (contagion) drives grades to become similar over time,

but only when there is evidence that the students have become better acquainted.

1.1.6. A motivational perspective on social contagion

So far, we have shown that social contagion occurs at many different levels in education. Research on peer influence has suggested delinquency behaviour is transmitted between friends, while other research indicates that students' academic engagement and achievement seem to be influenced by their friends. Furthermore, social contagion is not limited to peer-to-peer relationships; often teacher's behaviour and emotion also have contagious effects on their students.

How does social contagion occur in the context of education? While social contagion has been documented in a wide range of literature, its underlying mechanisms are relatively underexplored. Some research has suggested that part of the contagion effect could be explained by mimicry. It is a human tendency to inherently mimic a range of actions from vocal accents (Adank, Stewart, Connell, & Wood, 2013) to physical mannerisms (The Chameleon Effect: Chartrand & Bargh, 1999). Other studies also indicated that emotional mimicry (e.g., Hess & Fischer, 2014), a term describing the imitation of emotion, has been tied closely to the theory of primitive emotional contagion (Hatfield, Bensman, Thornton, & Rapson, 2014; see also Hatfield et al., 1993). This mimicry and feedback process may operate at a conscious level, but research has shown that this process is more automatic and unconscious than people think (Chartrand & Lakin, 2013).

However, it is not probable that mimicry and feedback play a major role in the context of education. This mechanism is still an important source of social contagion in education, but in classrooms, where peers literally study together in the same space, social relationships tend to be extremely rich and dense. In such a situation, friends are likely to influence each other in a more explicit way. Indeed, it is difficult to explain some of the findings we have reviewed (e.g., social contagion of GPA) solely from a mimicry and feedback perspective.

Here we argue that motivation plays an important role in social contagion in the context of education. Although the role of motivation in social contagion has been overlooked in the literature, several theories of motivation provide some interesting and complementary perspectives of social contagion occurring in classrooms. For example, according to the social learning theory proposed by Albert Bandura (Bandura, 1986), a persons' motivation is grounded in the concept of self-efficacy, the personal judgement of one's own capability to achieve a task (Bandura, 1977). Importantly, Bandura (1977, 1986) argued that self-efficacy is formed through the socialisation process, and identified several sources of self-efficacy; direct experience, vicarious experience, and verbal persuasion. In terms of social contagion, if a person has a high level of self-

efficacy, this may contribute to convergence in behaviours between their friends. For example, think about the case we described at the outset of the article --- where students' interest in science enhances their friends' interest in science. Based on social learning theory, if a student has a tie to a student who is highly competent and interested in science, his/her enthusiasm may spread through the tie via his/her verbal encouragement or explanation to the other student (i.e. verbal persuasion). Alternatively, the recipient of the tie may observe the success and enthusiasm of the friend and consequently begin to enjoy science vicariously (i.e. vicarious experience). It is also possible that the recipient of the tie has more opportunities to enjoy science as the friend is actively engaged in that subject. Consequently, those students with high levels of self-efficacy may have contagious effects on their friends in the classroom.

Some other theories of motivation also indicated the importance of social relationships in motivation. For example, the self-determination theory (Deci, Vallerand, Pelletier, & Ryan, 1991) stipulates that people are naturally motivated to satisfy their need for relatedness --- people's basic psychological need to feel supported and accepted by others, as well as a need for autonomy and competence. Indeed, this type of striving for relationships has been considered as the core component of human motivation (Baumeister & Leary, 1995; Wentzel, 1999). From this perspective, social contagion phenomena can be explained as students' motivated behaviour to maintain social relationships. Even for the theories that originally did not incorporate social aspects (e.g., theories of achievement goals, Murayama & Elliot, 2009; causal attribution theory; Weiner, 1985), recent developments acknowledge the social influence in these motivational constructs (e.g. Darnon, Dompnier, & Marijn Poortvliet, 2012; Juvonen & Weiner, 1993).

Indeed, this motivational account can easily explain the social contagion phenomena that we reviewed earlier. For example, social contagion of delinquent behaviour may be a result of social learning --- seeing your friend smoke may make you feel that you can do the same thing (i.e. increased self-efficacy to smoke). Or it is also possible that adolescents smoke because they are motivated to be affiliated with a particular peer group. Although the term "peer influence" implies some coercion, from our motivational perspective, this influence is also mediated by the motivation of those who receive the influence. Moreover, although this motivation perspective is acknowledged in the literature (especially in the work of peer influence; e.g., Akers, 2017), we suggest this as a more general framework to understand educational social contagion phenomenon in a broader context.

To apply this framework further, social contagion of academic engagement and GPA can also be understood as a manifestation of social contagion of self-efficacy,

because self-efficacy has been shown to be strongly related to these variables (Dogan, 2015; Komarraju & Nadler, 2013). In a similar manner, teacher contagion effects can also be considered as a version of social learning process --- if students think that their teacher is feeling stressed and incompetent, students are likely to catch that feeling by inferring that they are learning something boring and difficult.

1.1.7. Discussion

This review has introduced social contagion as an important consideration in education research. After describing the framework for socially contagious behaviours, we focused on the impact of social contagion between peers in education and introduced another form of contagion in the classroom, that between students and teachers. We have introduced new methodologies that now enable us to closely investigate the dynamics of friendship and social networks. These new methods are proving beneficial to education research as they can enable us to gain deeper insight into classroom activity and thus inform classroom interventions such as those focused on the development of social emotional learning and social emotional and academic learning (see Greenberg et al., 2003). Additionally, results from social contagion research may build our understanding of peer group learning (Parr & Townsend, 2002). Finally, we drew the research together from a motivation perspective, describing the underlying mechanism of social contagion. To end, we discuss two potential future directions for social contagion research.

1.1.7.1. Toward "positive" social contagion effects

Despite the growing interest in analysing social networks in schools, there is scope for further investigations. Currently, the research described has mainly focused on contagion of academic functioning and adjustment in school cohorts. However, since the investigation by (Ryan, 2001), there have been few studies that consider motivation as a driving force for academic contagion. Indeed, there are a number of motivational concepts that have attracted little attention in the literature of social contagion (outlined in the previous section).

Furthermore, much of the aforementioned research in peer influence and adolescence is centred on reducing negative behaviours, as opposed to supporting the spread of positive behaviour. Van Workum, Scholte, Cillessen, Lodder and Giletta (2013) identified that the happiness of adolescents is influenced by the happiness level of their friends, so it is possible this may translate to behaviour. Moreover, research on peer mentoring (where peer leaders volunteer their time to help fellow students) demonstrates that structured peer interaction can have a positive impact on both sides of a peer program partnership (Tredinnick, Menzies, & Van Ryt, 2015). Despite this, it is well established that teachers can identify any troublesome behaviour in their class

environment, and that certain behaviours cause more disruption than others (Wheldall & Merrett, 1988). However, the research has not yet provided comprehensive evidence to determine whether well socialized students may be having a positive impact on those around them in a natural, subconscious way (e.g., a well-motivated student facilitates motivation of other students via social contagion). Investigation of the strength of contagion for motivating positive behaviours is a natural next step in fully understanding social contagion.

1.1.7.2. Contributions from neuroscience

An additional future direction to consider is the neurological basis of social contagion. Though direct research on the neural basis of social contagion is limited and relatively unexplored, there is increasing interest in the neural basis of social influence and conformity, and the value this can have in explaining real-world situations. In a review of neuroscience on social conformity (Stallen & Sanfey, 2015), the authors discuss mechanisms of conformity and their similarity to those seen in neuroscientific studies of reinforcement learning, e.g. regions associated with conflict and reward expectation. Furthermore, in a recent meta-analysis of studies examining the neural components of social conformity, Wu, Luo, and Feng (2016) identified the importance of regions commonly reported to be related to reward and normative decision-making, including ventral striatum, dorsal posterior medial frontal cortex, and anterior insula. In the context of contagion, though on a smaller scale, this research suggests an interesting possibility that reward processing and reward learning are the key mechanisms underlying social contagion (see also Suzuki, Jensen, Bossaerts, & O'Doherty, 2016).

There has also been extensive research on automatic mimicry or imitation in neuroscience (for a meta-analysis see Caspers, Zilles, Laird, & Eickhoff, 2010). This line of work has proliferated since the neuroscientific evidence that certain groups of neurons ("mirror neurons"), predominately located in motor and somatosensory cortex, fire spontaneously both when action is executed, and the same action is observed (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Iacoboni, 2009; Rizzolatti & Craighero, 2004). The findings are too diverse to summarize in a nutshell, but one of the key implications is that this line of work suggests the importance of "embodied cognition", emphasising the role of motor and perceptual system in the process of mimicry or imitation (Brass & Heyes, 2005; Gallese, 2009; Goldman & de Vignemont, 2009). So far, social contagion research in education has mostly relied upon self-reported questions. However, this line of neuroscientific evidence indicates the importance of incorporating measures related to action and perception to comprehensively understand the nature of social contagion.

Another angle from which to look at the neural basis of contagion, is to map the changes in the brain to the behaviour of a social network. Recent research has explored how we create a cognitive and neural map of our social networks. In this way, the research is shifting emphasis from the mechanism behind the behaviour convergence, to the storage and maintenance of our personal social network formation (for a summary, see Falk & Bassett, 2017).

Parkinson, Kleinbaum and Wheatley (2017), carried out an fMRI study in which a subset of individuals from a larger social network were presented videos of individuals from whom they had various degrees of separation and required to rate degree of separation. Analysis revealed that participants have accurate representation of the broad network of which they are a part, and are able to accurately perceive the positions, with spontaneous activation correlating with familiarity of individuals. Based on previous findings, the authors predicted that social distance would be signalled in the superior temporal cortex (STC), inferior parietal lobe (IPL), and medial prefrontal cortex (MPFC). This hypothesis was somewhat supported, with spontaneous activation found in lateral posterior STC through to posterior lateral temporal cortex, moving superiorly to the IPL. Previous research has identified these areas as being associated with mental navigation, suggesting that the spontaneous activity is the result of retrieval of information from the spatial-construed, mental construction of the individuals' social network.

In other recent research Parkinson, Kleinbaum and Wheatley (2018) used inter-subject correlation analysis (Hasson, Nir, Levy, Fuhrmann, & Malach, 2004) to assess similarity in the brain activation between pairs of individuals while participants naturally watch movies. Results demonstrated that the distance between pairs in the overall social network could be accurately predicted based on the similarity in activation across multiple areas of cortex, between friendship pairs. Although correlational (i.e. contagion and homophily cannot be distinguished) these results suggest high levels of similarity between friends not just on a trait level, but also at the neurological level, demonstrating the overall value of neuroscientific research in contributing to our knowledge of social contagion and the underlying processes.

1.1.8. Conclusion

For many years, educational researchers have demonstrated the importance of social processes at school. Indeed, a number of studies have shown that students' academic achievement, along with psychological and behavioural adjustments, are influenced by the classroom's social climate (Ames, 1992; Frenzel, Pekrun, & Goetz, 2007; Murayama & Elliot, 2009; Wentzel, 2000). Despite awareness of the critical role of social contagion in influencing classroom climate, these processes have attracted

surprisingly little empirical attention in the field. The purpose of this review was to demonstrate the value of social contagion theory in developing the way we approach educational research. In the past, a lack of an appropriate methodological framework has limited the empirical investigation of these phenomenon, but recent methodological advances have provided methods for researchers to make full use of the information in complex social network data. It is our hope that this review will provide inspiration for education and neuroscience researchers' alike, provoking interest in social contagion and motivation within the classroom, to provide further research evidence within this fruitful field of enquiry.

1.2. Project context

The work presented in this thesis was carried out under a PhD studentship that was awarded as a Collaborative Award in Science and Engineering by the South East Doctoral Training Centre (CASE studentship; SE DTC). The project was therefore in collaboration with the school used as the sample herein, and with one connected school within their foundation group. The aims of the work were discussed with the collaborating school prior to the confirmation of the final study design, along with discussions about the questions that should be addressed, in terms of the value that the findings would be able to contribute to the individual school, as well as to the wider educational community. This considered, a longitudinal project led by the present PhD candidate was developed to include a collection of academic motivation measures as well as additional measures that supplemented the central theme of motivation. As a result, the work presented in this thesis represents the majority of the longitudinal study conducted, with some minor additional measures collected at request of the collaborating school, that are not included in this thesis. These measures will be investigated following submission of the current work, and a list of these additional constructs and associated measures/scales can be found in the appendices (8.1.).

The following sections give detail about the specific content of this thesis, and further specify the focus on motivation and the types of motivation that were assessed across the longitudinal project.

1.3. Overall aims

The review presented at the outset of this section calls for more research in the area of social contagion across the motivation, education and neuroimaging fields. As suggested, there is much to be gained from clearer conclusions about the impact of friendship networks at school. Therefore, the broad aim of the following chapters is to investigate the social contagion of motivation in school settings. As such, the following chapters are formed from data that was collected as part of a large-scale longitudinal investigation. Briefly, students completed an online questionnaire measuring their

academic motivation, and also provided their social network information. Later, a subset of students was then invited to a magnetic resonance imaging (MRI) session, where they completed a motivational task while functional brain imaging data was collected. As a multi-dimensional investigation, several specific aims are addressed throughout this work, forming the four empirical chapters that are presented in this thesis.

The first aim is to establish whether similarity in motivation is observed between friends at school. Similarity, though a complex process comprising of both homophily (i.e. selection) and contagion (i.e. influence) dynamics (McPherson et al., 2001), should be identified in the first instance, in order to justify further investigations addressing the dynamic aspect of this construct. To identify similarity in motivation between discrete pairs of friends, cross sectional data from the separate waves of the project is used. By comparing the motivation scores of connected individuals at a single time point, it is possible to establish whether general similarity is present as an average correlation across all friendship connections that form the overall network.

The second aim is to investigate the relationship between the network position of an individual, and motivation score. Not only is it possible to consider similarity within discrete dyad connections using assortative mixing (Newman, 2002), but it is also informative to consider the network interactions all together (Newman, 2010). Centrality is a network measurement method that is reflective of the relative importance of a person within a social network (Newman, 2010). Different types of centrality can be assessed, giving different insights about each individual's network position. Eigenvector centrality is of specific interest here, as a measure of a person's overall opportunity to spread influence in their network (Bonacich, 1987, 1991; Ruhnau, 2000). This measure looks at the number of connections of each individual, but also the number of connections that the people they are connected to have as well. Based on the theory of social contagion (Levy & Nail, 1993), it is logical that the better socially connected a person is, the more opportunity they will have to influence and also to be influenced. If motivation is a factor that is susceptible to social contagion and can be increased or decreased depending on your connections, then exploring the relationship between network position and level of motivation can clarify whether number of social connections a person holds is related to high or low motivation. If you have more friends, then there are more opportunities for social contagion to occur. Therefore, by using regression models in which centrality is used to predict motivation, it is possible to determine if motivation level can be predicted by a persons' network position. Using this method, the second aim is addressed.

The third aim builds on the first and second aim, with the objective to establish whether social contagion is observed in school social networks via influence processes, in a longitudinal social network investigation of selection and influence effects. Here, two time points of longitudinal data are used to model the dynamic and interchangeable nature of social networks and behaviour (Snijders et al., 2010). Here, several types of motivation are modelled over the two time points, directly addressing the third aim by disentangling selection and influence processes. In this way, any contagion effects that are present can be isolated, addressing the third aim.

Finally, the fourth aim is to establish whether observed behavioural similarity between friends translates to neural similarity between friends. This objective provides a different perspective to address the overall aim to investigate the social contagion of motivation, by looking at neural similarity when the brain is reacting to reward. The response to reward is considered to activate areas of the brain associated with motivation (Robbins & Everitt, 1996; Shohamy, 2011). Further, we are motivated to behave in similar ways to our friends in order to maintain and sustain our relationships (Baumeister & Leary, 1995; Wentzel, 1999). Therefore, if a person aligns their behaviour to be the same as their friend, does the associated brain activity also look the same? This question is addressed by correlating the neural activation of friends when they participate in a rewarding task, using the same analysis methods as implemented to address the first aim.

The following section gives a more detailed rationale and outline of the contents of each chapter.

1.4. Outline of chapters

The opening of this thesis is constructed from a published review paper. This provides much of the background literature for the thesis in that it outlines the existing literature on social contagion in an educational context and provides links between the education, motivation and neuroscience fields. The paper acknowledges the different forms of social contagion in the school environment, and while covering peer pressure and teacher contagion, places emphasis on the underlying role of peers as providing an essential contribution to overall school experience. This literature review provides examples for how new methodologies enable more complex questions to be answered about the mechanisms and processes occurring within friendship groups, providing opportunity for classroom investigations that focus on the factors most influential to school success.

In Chapter 2, the first empirical study is introduced. This study reviews data that was collected as pilot research on sixth form students from two different schools. This sample is of interest because the increase in freedom and choice, when students move

from high school education to sixth form education, leads to increased reliance on peer networks and social support systems (Hertzog, Morgan, Diamond, & Walker, 1996). Therefore, these social circumstances provide a platform through which motivational experiences can be shared, and influence can be observed between friends (Urdan & Schoenfelder, 2006). It is on this basis that the hypotheses addressing aims one and two are constructed. In this study, it is first predicted that friendships pairs will be correlated on their motivation scores, demonstrating similarity between friends, and secondly, that high levels of centrality will significantly predict scores on the motivation measures examined, demonstrating the importance of network position. To test these hypotheses, students in both participating schools completed a motivation survey covering a number of different motivation constructs and provided social network information, detailing their social connections within their year group. From the data, it emerged that the hypotheses were partially supported. Across the school samples, almost all types of academic motivation were similar between friends in at least one sample. Further, some measures of motivation could be predicted by centrality measures, while others could not, again, varied by sample. As a result, no clear trend emerged across the two school samples, each cohort showing individual patterns of similarity between friends. These varied results are discussed in terms of their contribution to the existing literature, mixed findings being potentially unsurprising due to the fact that the motivational orientations of the individuals that make up the network will drive the overall observed similarities (Urdan & Schoenfelder, 2006).The limitations and future directions of the research follow, leading on to the study described in Chapter 3.

Chapter 3 contains the second empirical study. Here, cross-sectional data from a whole school, collected from two cohorts (namely the first and second waves of data for the longitudinal study) following the sixth form pilot study, is reviewed. Addressing the same aims as Chapter 2, the key difference in this study is the sample included. While in Chapter 2 the focus lies on sixth form students, in Chapter 3 the sample is extended to include high school year groups. While it is clear that there are mechanisms through which older students will assimilate their motivation (Hertzog et al., 1996), it is also the case that younger students rely on friendship in the early years of high school, using social support systems to manage the changes in school expectations in terms of increased autonomy and focus on achievement (Simpkins, Parke, Flyr, & Wild, 2006). Similar to the argument presented in Chapter 2; these social circumstances provide a platform through which motivational experiences can be shared, and influence can be observed between friends. As such, the hypotheses in this chapter are the same as those presented previously in Chapter 2; firstly, that

friendships pairs will be correlated on their scores on motivation measures, and secondly that high levels of centrality will significantly predict scores on the motivation measures examined. Methodology described in this chapter is the same as in the preceding chapter, where students all completed a motivation and social network survey. Findings were limited in that both hypothesis one and two were only moderately supported. Significant similarity between friends was observed in one cohort for three of the motivation measures examined but this finding was not repeated in the other cohort, who showed no significant similarity on any of the measures. Additionally, findings for hypothesis two were also limited, where levels of centrality only predicted levels of subject specific interest and boredom. Several interpretations of these results are provided, and comparisons to the findings of previous literature are drawn. The limitations of cross-sectional research of this nature are also discussed.

Chapter 4 addresses the third aim, along with the cross-sectional limitations of previous chapters, through a longitudinal investigation of selection and influence effects. In this study, the longitudinal aspect allows for changes in social networks and motivation to be modelled over time, giving an impression of selection (i.e. homophily) and influence (i.e. contagion) effects. To date, only a small collection of research has been carried out in schools to model these separate effects, with even fewer studies directly measuring motivation as a variable for change (examples; Rambaran et al., 2017; Shin & Ryan, 2014a, 2014b). Nonetheless, from this research it appears as though academic motivation and adjustment do demonstrate various selection and influence effects. Based on this previous literature, the hypothesis for Chapter 4 states that selection and influence effects will be identified for the motivation constructs measured. Specific hypotheses about the individual measures are not specified, due to the lack of clear findings across previous research. However, an additional hypothesis was included for the boarding status of the school students, where it was expected that boarding students would cluster in friendship groups due to their proximity outside of structured school hours (Martin, Papworth, Ginns, & Liem, 2014). Data collection for this chapter was identical to those in Chapters 2 and 3, where students completed a motivation and social network survey over two time points, one year apart. The effects observed from the longitudinal modelling showed strong findings for the effects of boarding status. As predicted, students with the same boarding status were more likely to be nominate each other as friends and were also more likely to be nominated as friends compared to day students. As for motivation, only one selection effect was identified for students sense of value for learning, suggesting that friends were selected based on similarity in this trait. Further, one influence effect was identified for perseverance of effort, a sub-measure of a person's level of grit. The contribution of

these results, though limited, is discussed along with suggestions for overcoming the current limitations as areas for future study.

In Chapter 5, motivation contagion is considered from a neuroscientific perspective, addressing the fourth aim outlined above. As highlighted in the review at the outset of this thesis, there is limited neuroscientific research which directly addresses social contagion. However, a multitude of literature exists that examines motivation in the brain (examples; Robbins & Everitt, 1996; Shohamy, 2011) and also social behaviours and conformity to risk taking behaviours (examples; Casey, Jones, & Somerville, 2011; Steinberg, 2008). When taking a motivational perspective for why social contagion occurs, the theories can be further applied to the brain, especially in the case of the reward network in the brain. Via social learning theory (Bandura, 1977, 1986) vicarious experiences can lead to the experience of reward being shared between friends – by extension this may be reflected in the brain activity of these two friends. In this final chapter, the hypothesis is that the brains of socially connected individuals will show correlated levels of activation in areas of the brain associated with reward processing. A subset of the students from the larger longitudinal project were invited to take part in an MRI session where they completed a rewarding task during a functional scan, following this they provided their social network information via an online survey. The data from each student was then used in a correlation analysis to compare the activation between connected individuals. The main finding was that activation to cue incentives during the task was significantly similar between friends in the youngest year group tested, an effect that was sustained when meta-analysing the finding with the older year group. This finding is discussed in terms of the general developmental differences in the reward network at this sample's age range, and additionally the individual differences that can contribute to varying experiences of reward. To close, limitations and further directions are discussed.

In the general discussion the results of all chapters are summarised and appraised together. When considering the results collectively, interesting implications arise and are discussed together with overall limitations and directions for future study.

1.5. Overview of project sample

1.5.1. Samples by chapter

As outlined, the following empirical chapters include data from the collaborating school, and from one other school that is part of the foundation group, led by the main collaborator. Data from the additional school only include one sixth form cohort (age 16-19 years), included in Chapter 2. All other chapters include data from the collaborating school only. To clarify, data in Chapter 2 are sampled from both schools,

and data in Chapter 3, 4 and 5 only included data sampled from the main collaborating school. In Chapter 2, only sixth form students are included. These are students who are in post 16 education, so have finished their compulsory education of set subjects and are moving onto further education or qualifications in subject areas of their choice. Three sixth form samples are included in Chapter 2, one from the additional school and two from the main collaborating school (taken 1 year apart). In Chapter 3, cross-sectional data from a wider range of school years is used, taken from the first time point of data that was collected in the longitudinal project, with the collaborating school. Chapter 4 uses the same time point 1 data and tracks the same students in the following year. Finally, Chapter 5 includes a subset of the students from the first time point, those in years 8 and 9, aged 12-14 years. This information is displayed graphically in Figure 1 below.

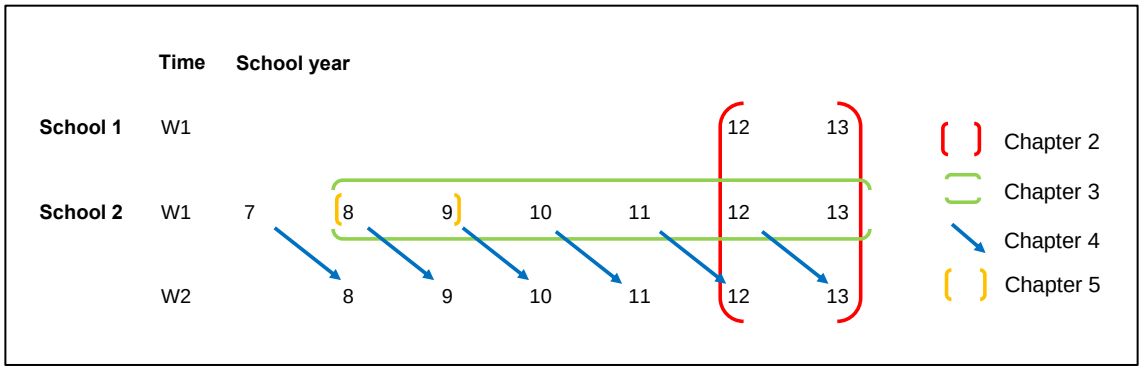

Figure 1. Overview of sample included for each empirical chapter. W1/W2 refer to the time point in the longitudinal investigation. School year ranges from 7-13, this covers an age range from 11-19 years old.

1.5.2. Sample characteristics

The collaborating school is a suburban independent day and boarding school for girls, providing a unique and interesting sample for investigating the aforementioned aims. A boarding school is a unique environment, where students that board are exposed to ongoing activities and interactions with teachers and peers outside of the structured school day, providing them with a very different ecological environment in comparison to their non-boarding peers (Martin et al., 2014). Research by Pfeiffer, Pinquart and Krick (2016) shows subtle differences in the social development of day and boarding students, and suggests that while boarding students may have a higher sense of autonomy from their parents compared to day students, the prosocial behaviour demonstrated by all students in an independent school shows no difference between the boarding statuses. These differences provide an additional

dynamic when considering friendship development and potential for influence of motivation within friendships.

However, based on the current work of Collie, Martin, Papworth and Ginns (2016), differences between the motivation of boarding and day students, in terms of their personal best goal orientations, do not seem to be apparent. In their research on the impact of interpersonal relationships with peers, teachers and parents on personal best goals, it was identified that peers and teachers were most strongly associated to the goal development, with very little difference between the boarding statuses of the students. This is informative in that it shows how goal orientation, or motivation, is related to peer relationships in the school context. Moreover, it also demonstrates little difference between the boarding level of students, an indication that while social development leads to some differences between day and boarding students (Pfeiffer et al., 2016), individual motivation is seemingly stable.

As detailed in the overview of chapters, boarding status is modelled in the longitudinal study in Chapter 4. To date, research on boarding school populations is scarce, therefore research questions related to this characteristic are novel and exploratory. This considered, due to the proximity of boarding peers, it is expected that we will identify a large proportion of friendships between those of the same boarding status. The findings relating to boarding status are discussed in later chapters.

1.6. Overview of constructs

The following section outlines in detail the motivation constructs that were assessed within Chapters 2, 3 and 4 and that make up the motivation survey administered to participants at each wave of the data collection. The theories and background supporting each construct are described, along with justification as to the relevance of each construct in supporting the overall research question. As all research aims are related to similarity or contagion of motivation via social networks, a comprehensive view of motivation is provided. Broadly, the overall goal of the survey created for the following chapters was to give an extensive view of academic motivation, forming this by including multiple concepts of motivation from different theories and models. By including a range of different views, the different theories are combined in order that they all contribute to the same overall research question.

1.6.1. Academic self-concept

Self-concept is a term that refers to a person's perception of themselves, as formed through environmental experience and interaction with others (Shavelson, Hubner, & Stanton, 1976). Moreover, self-concept is something that develops as we age, growing to become multifaceted as our experiences accumulate and the more complex structure of self-concept is formulated. As we gain more experiences, each

experience influences our self-concept and we evaluate this either against a personally constructed absolute ideal, or more relative standards such as those set by peers. Through early adolescence (12-15 years), the structure of self-concept is led by inner thoughts, feelings and attitudes (Damon & Hart, 1982; Rosenberg, 1979), and the resulting developmental and social changes can often lead to unstable self-concept. However, as older adolescence is reached, maturation and adjustment to new social roles and physical attributes leads to stabilisation of self-concept (Demo, 1992). This is a consideration in the current research, as it is possible that we may identify inconsistencies in individuals' reports of self-concept over time as a product of changing peer dynamics. These dynamics could provide further insight into these changes.

Finally, Shavelson et al. (1976) argue that self-concept is differentiable from other related concepts, despite having clear overlap with other constructs. For instance, there is a relationship between self-description (self-concept) and self-evaluation (self-esteem). While self-concept refers to the cognitive descriptive aspect of sense of self, self-esteem reflects the emotional evaluation of one's feelings (Beane & Lipka, 1980). As such, Beane & Lipka (1980) suggest that these constructs should be examined separately, but under the general topic of self-perception. While it is clear that self-concept is correlated with other forms of self-perception, this construct can be broken down into further factors (Shavelson et al., 1976), one of which is focussed upon in the following chapters.

Self-concept is considered here with a focus on academic self-concept. Defined as self-concept relating to academic areas, academic self-concept is one of the major forms of self-concept in the context of education (Shavelson et al., 1976). The overall structure of self-concept is then broken down further into specific subject areas (e.g. mathematics). One of the common measures of academic self-concept was developed by Marsh (1990) in order to assess the self-concept of different school subjects. Marsh (1990) developed a series of Self-Description Questionnaires, later developed into academic self-concept measures, namely the Academic Self-Description Questionnaire I and Academic Self-Description Questionnaire II (ASDQ-I, ASDQ-II). Both ASDQ measures are based upon the Marsh/Shavelson model (Marsh & Shavelson, 1985) which builds upon the original structure of the Shavelson et al. (1976) model, with the inclusion of two academic factors (math and verbal) alongside a single non-academic factor (including social, emotional, physical self-concepts). This updated version of the original model was created due to the increase in research that proposed that self-concept was much more multi-dimensional than suggested in the first model proposed (Marsh, 1990). In addition, no measure yet existed for the

measurement of academic self-concept in younger and older adolescence. The development of measures for a wider age range helped to overcome previous concern about developmental differences in academic self-concept. Therefore, the ASQD-I was developed for younger students (aged 10 years to 12 years) and the ASDQ-II for older students (aged 12-16).

Self-concept has been demonstrated to be closely linked with motivation (Shavelson et al., 1976). There are several examples of research that examines self-concept and academic motivation to understand their influence on academic achievement (Akomolafe, Ogunmakin, & Fasooto, 2013; Green et al., 2012; Guay, Ratelle, Roy, & Litalien, 2010). From this research, it emerges that academic motivation and self-concept share a substantial amount of variance in explaining academic achievement, being closely correlated. However, Green et al. (2012) also demonstrated that the two concepts contribute unique variance in predicting different outcomes related to academic achievement such as behavioural engagement, homework completion, classroom participation and absenteeism. Therefore, demonstrating the complementary relationship between the two concepts. This research also has application in terms of developing our understanding surrounding how to support and enhance self-concept in students in order to improve academic outcomes.

1.6.2. Interest and value

The concepts of interest and value are included in the following chapters, defined as components of Wigfield and Eccles (2000) expectancy-value theory of achievement motivation. From their perspective, it is argued that motivation should be conceptualised as the expectations that we have about our performance on a task and therefore the value we attribute to the activity (Eccles et al., 1983; Wigfield & Eccles, 1992). Further interest value, or, intrinsic value, is defined as a concept that encapsulates the feeling of doing an activity or task out of enjoyment for it. This relates closely to the idea of intrinsic motivation (as defined by Ryan & Deci, 2000, as a component of Self-Determination Theory). Additionally, Hidi and Renninger (2006) describe the development of interest as consisting of four phases, describing interest as a psychological state that changes through our phases of development. To develop interest, one must first have situational interest, which next develops into maintained situational interest. Following this, the third phase is the emergence of an individual interest, which can lead to the fourth phase, a well-developed individual interest (Hidi & Renninger, 2006; Hidi, Renninger, & Krapp, 2004).

As such, in the description by Wigfield and Eccles (2000), our beliefs about our ability to complete a certain task, along with the value that we attribute to such task,

come from the construction of self-schemas that continuously develop from our early years onwards. As we accrue different life experiences, the schemas that we construct change, leading to different overall expectancies, values and interests (Eccles et al., 1983). In terms of achievement motivation, interest and intrinsic value towards school and individual school subjects can impact on the overall academic adjustment of students (Pintrich & De Groot, 1990). In fact, Wigfield and Eccles (2000) tested their expectancy-value model of achievement motivation through the lens of mathematics achievement in school children. The validation showed a clear conceptual distinction between ability perceptions, task difficulty perceptions and task value perceptions, demonstrating how expectancy and value work together within the model and change over time as young adolescents develop. Further, the structure of adolescent expectancy beliefs and values has been thoroughly investigated, and the positive relationship between task value and ability perception has long been established (Eccles & Wigfield, 1995). Overall, this model considers how the different perceptions that we hold and develop as individuals can impact upon motivation and ability belief, especially in academic populations.

Frequently, the measure for assessing children's ability beliefs and subjective task values developed by Wigfield and Eccles (2000) is used to measure level of expectancy-value in students, including items that refer to intrinsic value, or interest. The scale is constructed of three sets of items, reflecting the structure of the model as outlined above; ability belief items, expectancy items and usefulness, importance and interest items.

1.6.3. Boredom

Boredom, arguably the opposite of the definition of enjoyment and interest as explained previously (section 1.6.2.) is the absence of interest towards a subject due to low demands of students who perceived themselves as having high ability (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010). Boredom is one of the many emotions associated with education and attending school. Pekrun, Goetz, Titz and Perry (2002) highlight the mix of both positive and negative emotions that impact upon learning capabilities at school, showing that academic emotions are related to multiple areas of academic life including motivation, learning styles, cognitive resources, self-regulation (description see section 1.6.5.), and academic achievement. Based on the control-value theory of achievement emotions, that integrates assumptions from expectancy-value (Eccles et al., 1983) and attributional approaches (Weiner, 1985), Pekrun et al. (2002) developed a quantitative measure of academic emotions – the Academic Emotions Questionnaire (AEQ). This work supported the previous qualitative work that

had been carried out to explore the range of emotions experienced at school in a cohesive quantitative measure.

The AEQ is frequently used to explore a number of emotions in a selection of different school subjects. One of the focus subjects has been mathematics. Frenzel et al. (2007) researched boys' and girls' appraisal of their own performance in mathematics, applying the concepts of control-value theory to explore gender differences in achievement emotions for mathematics. The authors identified a pattern of emotions in girls where they report less enjoyment and pride in mathematics than boys, along with higher anxiety, hopelessness and shame, despite the two genders having similar levels of academic performance. Further, Ahmed, Minnaert, van der Werf and Kuyper (2009) have used this scale as part of an investigation into the influence of social relationships on academic achievement, via both emotion and motivation pathways. Their investigation identified that motivational beliefs and emotions (including AEQ measures) partially mediate the effect of perceived social support on academic achievement, giving insight into the effect of supportive relationships on achievement levels at school. This research is in line with the overall aim of the current thesis, combining motivation and social context to investigate how social environments impact on academic adjustment.

As it is important to acknowledge the range of emotions that students experience at all stages of education both the positive and the negative emotions should be measured. Therefore, boredom is isolated and assessed directly throughout this thesis to provide insight into the negative emotions that may be experienced in specific school subjects.

1.6.4. Autonomous motivation

The concept of autonomous motivation and self-regulation of motivation arises from Self Determination Theory (SDT; Ryan & Deci, 2000). Central to the theory is the distinction between autonomous and controlled motivation. Autonomous motivation is inclusive of behaviour that is intrinsically motivated and internalised, along with all forms of extrinsic motivation where people identify with the value associated to an activity and include it in their sense of self (Deci & Ryan, 2008). On the other hand, controlled motivation is inclusive of extrinsic motivation, where behaviours are determined by an external reward or punishment, and introjection, where behaviours are the product of partial internalisation of the value of the task, but from the angle of avoidance of shame, or approval seeking motives (Deci & Ryan, 2008). Therefore, SDT explains types of behavioural regulation in terms of the extent to which they are either autonomous or controlled, also determining within this distinction how internalised a behaviour is. The more internal a behaviour is, the more associated with

being autonomous it is. Finally, the theory describes four different types of behavioural regulation that each fit with either autonomous or controlled motivation; external regulation, introjected regulation, identified regulation, and integrated regulation (see Ryan & Deci, 2000, for more detail).

In educational research investigations, level of self-determination is typically assessed using the self-regulation questionnaire for learning (SRQ-L). Rather than using all four types of behavioural regulation, in this scale adapted by Williams and Deci (1996), behavioural regulation is split into two broader subscales; controlled regulation (including external or introjected regulation) or autonomous regulation (including identified regulation or intrinsic motivation). Via this method, a relative autonomy index (RAI) can be calculated, in which higher scores indicate more autonomous regulation.

To date, many educational research studies that are interested in motivation carry out their studies through the lens of SDT. In an attempt to better understand the needs of students and to improve their sense of autonomy and therefore motivation at school, a number of studies have employed the SRQ-L. For example, Garriott, Hultgren and Frazier (2017) used the SRQ-L to measure intrinsic motivation toward mathematics and science in an investigation into the negative stereotypes surrounding science, technology engineering and mathematics (STEM) subjects. In their investigation, the authors successfully identified that negative stereotyping toward STEM subjects was negatively correlated with levels of intrinsic motivation, as assessed by the SRQ-L. Further, Simpson, Jones and Taylor (2018) modified the scale for use in measuring student's motivation for viewing and utilising an online feedback system, demonstrating the adaptability of the scale to predict motivation towards specific subjects or tools within teaching. This research identified that students who received online feedback had a higher RAI score than the students that received feedback using the traditional method, indicating that they had higher intrinsic motivation when using the feedback, and that this was more supportive of autonomy. Taken together, these examples show the adaptability of the scale and how it can be applied across educational research.

1.6.5. Grit

Grit is a concept that provides an answer to the question: Why do some individuals accomplish more than others, despite having seemingly equal intelligence? Defined as "perseverance and passion for long-term goals" (Duckworth, Peterson, Matthews, & Kelly, 2007, p. 1087), grit is the idea that a person works towards a goal with strength and determination despite challenges they may face. A person who is 'grittier' has increased stamina for overcoming failures, not letting disappointment or

boredom divert them to a different task or lead them to cut their losses, a positive trait to possess. However, the 'dark side' of being 'gritty' can also be considered, when a person is stubborn in their approach to achieve goals, or glorifies their accomplishments (Miller, 2017). Further, in the measurement of grit, the overall concept is broken into two factors, perseverance of effort, and consistency of interest; making a distinction between consistent interest in a topic versus sustaining effort to achieve a goal.

Though conceptually similar to other motivation and achievement models, grit has been identified as a standalone concept in the context of high school study. Muenks, Yang and Wigfield (2018) investigated the overlap with motivation concepts and theories including self-efficacy, task values, and goal orientations. Using exploratory factor analysis, the authors demonstrated that while associations with each additional variable were identified, the overall findings suggested that grit is distinct from other future oriented motivation concepts (i.e. self-efficacy, task values, and goal orientations). Further, perseverance of effort appeared as a significant predictor of end of year grades. This considered, measurement of grit is often used in conjunction with other measures of motivation, with various research examining the associations between grit and other variables and their ability to predict forms of academic engagement and achievement (Hochanadel & Finamore, 2015; Tang, Wang, Guo, & Salmela-Aro, 2019).

To measure grit in school students, the shortened version of the grit scale (GRIT-S; Duckworth & Quinn, 2009) is often implemented. The shortened version of the scale is preferred due to having reduced items that do not compromise the overall validation of the scale but that still comprise the two factors of grit; consistency of interest and perseverance of effort (Duckworth & Quinn, 2009). These two factors of grit are investigated in the research presented throughout this thesis, where shorter scales are preferred due to the overall size of the survey and the age of the sample taking part; asking students to complete shorter scales gives less opportunity for boredom effects and random responding in the questionnaire.

1.6.6. Growth mindset

Dweck (1986) first suggested the idea of growth and fixed mindset as an explanation for the differences in people's views about their intelligence. The theory is broken into two categories, those with a growth mindset, who have the belief that their capabilities can develop through hard work and perseverance, versus those who have a fixed mindset, believing that their talents are pre-determined and innate, with little scope for change. In general, it has been identified that those with a growth mindset attitude tend to achieve more than those with a fixed mindset, a finding that holds

across many domains (Leadership & Coaching; Chase, 2010; Consumer Psychology; Wheeler & Omair, 2016; Employee work engagement; Caniëls, Semeijn, & Renders, 2018; Education; Claro, Paunesku, & Dweck, 2016).

There is clear application of implicit theories of intelligence in education; if teachers can encourage and foster growth mindset attitudes in their students then achievement should improve in students with a previously fixed outlook. Research such as that by Paunesku et al. (2015) has demonstrated the effectiveness of mindset interventions in a large-scale investigation, showing the value of giving interventions to all students, especially those most at risk of underachieving and dropping out of school. Further, mindset does not stand alone in its contribution to motivation research; Hochanadel and Finamore (2015) discuss the importance of fostering both growth mindset and grit in schools, demonstrating how theory of mindset overlaps with the concept of grit (as defined in section 1.6.5.). Grit being somewhat the basis for having a growth mindset in that an attitude toward developing skills is essential for both perseverance of effort and maintaining consistency in interest towards a task (see also; Polirstok, 2017).

Various measures for assessing growth mindset are available depending on the sample of interest. Frequently used is the Implicit Theories of Intelligence Scale for Children (Dweck, 2000). This scale can be used with children over the age of 10 to calculate where students lie on the spectrum between growth and fixed mindsets. Further, this scale is especially appropriate for the age range of the participating school presented in the following chapters.

1.6.7. Construct summary

As can be noted throughout this overview, the constructs presented here all tie closely to the overarching theme of motivation. Throughout this thesis (In Chapters 2, 3 & 4), all of the above are included as independent constructs, each being measured via a large motivation survey, providing a comprehensive view of academic motivation both in specific school subjects (e.g. competency and interest items) and general academic life (e.g. overall value, grit, mindset). By covering these constructs within one survey, the overall aim to investigate the social contagion of motivation in school social networks is addressed. In combining ideas from multiple theories of motivation, it will be possible to provide further reaching conclusions about the similarity and contagion of academic motivation between friends.

- Chapter 2 -

2. Cross-sectional study of similarity in academic motivation between sixth form students at two UK schools

2.1. Introduction

It has been noted consistently in the literature on adolescent development, that the behaviours and attitudes of an individual adolescent are often similar to the behaviours and attitudes of their friends (Brechwald & Prinstein, 2011). In fact, our social relationships are often formed on the basis of similarity. We have a preferential attraction to those who are similar and make our friendship selections on this basis. Observations such as these have led to increases in research designed to understand peer influence processes, as the initial selection of a like friend is unlikely to be the only mechanism behind the influence that is observed between individuals (Veenstra & Dijkstra, 2011). Understanding how the social environment of adolescents impacts on their development is an even more popular area of research in education, where there is increasing attention on the social factors that influence students at school, especially when considering students' motivation.

Over the last few decades, motivation has been identified as a leading factor in students' learning and achievement at school, impacting on all forms of academic outcomes (for a meta-analysis see Robbins et al., 2004). This finding is further evidenced by more recent research such as that by Murayama, Pekrun, Lichtenfeld and vom Hofe (2013), who identified that when measured over time, motivation is a better predictor of improvement in academic achievement than intelligence scores – a more traditional measure of attainment. With findings such as these becoming well established, it is important to examine what determines the motivational state of students in schools. Furthermore, a growing body of evidence has been investigating the socio-cognitive factors that can contribute to the school experience, highlighting learning environment, teacher style and parental beliefs as contributors to student motivation (for a review see Anderman & Wolters, 2006). However, within this field of motivation, little work has so far been carried out on school peer groups and networks, and the impact that school friends have on academic motivation.

At school, students have many opportunities to build social networks and spend time with one another, meaning that peer group activity is an additional social factor that may impact on motivation at school. Throughout the school day, students experience many situations where they can make friends, be it during lunch or break times, or during group work in a classroom. This is even more the case as students' progress through the school years and are given more freedom and choice. As a result, their reliance on peer relationships is increased; the students being encouraged

to seek wider support systems (Hertzog et al., 1996). Through these social circumstances, students share their motivational experiences, and have the power to influence the motivations of the students they are connected to, and vice versa (Urdan & Schoenfelder, 2006).

2.1.1. Motivation and friendship

As indicated, there has so far been little focus on how similarities in motivational orientation may guide the friendship process and the outcomes of such friendships. To date, much of the literature on similarity between adolescents focusses outside of the school context and examines the influence from peers on adolescents' engagement with negative risk behaviours (for a full review see Brechwald & Prinstein, 2011). However, there are a few examples of research where levels of motivation have been considered. For example, research such as that by Kindermann (1993, 2007) has shown that friends are selected, and friendship networks and clusters formed, when similarities are found in the motivational orientation of the group members. This finding was supported across time, and it was demonstrated that, despite structural changes to the network (i.e. changes in the members of the friendship groups), the motivational orientation of the group remained relatively stable over time. This echoes the idea that friendships are often formed, and selections made on the basis of similarity, as when there is similarity in personal characteristics, the likelihood of a friendship forming increases (Kupersmidt, DeRosier, & Patterson, 1995).

Further research, looking at a more individual level, has investigated the association between peers and achievement motivation (Nelson & Debacker, 2008). The cross-sectional study used self-reported data from middle and high school age students, investigating measures of classroom climate, achievement-related beliefs, values of a best friend, achievement goals, social goals and self-efficacy. Results demonstrated that if a student felt valued and respected by their peers, they were more likely to be oriented towards adaptive achievement motivation. Furthermore, an adaptive achievement motivation style was also related to good quality friendships and being close friends with those who valued their education. The converse was also true, in that poor-quality friendships and a disregard for school values was indicative of a maladaptive achievement motivation orientation. Findings such as these highlight the importance of the attitudes within peer groups and the impact that they can have on their fellow peers at school.

2.1.2. Social network approach

Until now, has research focussed on the perceptions and stability of friendships, rather than examining the peer networks directly. Much of the research is based on individuals self-reported view of their connections, or of their reliance on

friends for academic support. By using social network data, it is possible to investigate peer networks and motivation from a different perspective. The concept of assortative mixing i.e. the preference to connect to others with similar characteristics to oneself (Newman, 2002), enables questions to be asked about the levels of similarity between connected peers; an analysis technique not yet utilised in education research. Moreover, assessing a persons' position within and the centrality of social networks i.e. assessing the influence of individuals in a network (Newman, 2010), opens new opportunities for understanding adolescent friendship and motivation. To date, few educational research studies have considered centrality as a technique to assess social networks. Of those studies that have used this measure, a broad range of topics have been addressed, from assessing differences between the school peer networks of children with and without autism spectrum disorder (Kasari, Locke, Gulsrud, & Rotheram-Fuller, 2011) to using centrality in a measure of school interventions for aggressive young people (Farmer, Farmer, & Gut, 1999). New perspectives can be gained by applying these different social network techniques to the question of motivation and peer interaction.

2.1.3. Current research

In order to further quantify the impact that peers have in the context of motivation at school, the current research draws attention to older adolescents (sixth form students between the ages of 16-19 years), investigating similarity between friendship dyads and across friendship networks. In summary, the research examines whether measures of motivation (i.e. levels of motivation) are similar between connected individuals. While there is little research on peer effects in sixth form students, it has been shown that across the years prior to further education, friendship groups increase in their stability (Değirmencioğlu, Urberg, Tolson, & Richard, 1998) and that certain adolescents become increasingly susceptible to peer influence (Stautz & Cooper, 2014). As such, if friendships become more stable further into education, and the reliance on their peers increases in association with the structural changes to higher education (Brooks, 2007; Hertzog et al., 1996), then we might expect to observe similarity between the motivational levels of friends in sixth form, as a product of friendships.

More specifically, in the following investigation, several types of academic motivation are assessed, including interest for, and boredom of school subjects, academic self-concept, autonomous motivation, value for learning, grit and views on intelligence (all constructs outlined at the outset of this thesis, section 1.4.). These variables, described in the following section, are all selected on the basis that they have been shown to predict important academic outcomes in relation to academic

motivation (Bashant, 2014; Blackwell, Trzesniewski, & Dweck, 2007; Guay et al., 2010; Mega, Ronconi, & De Beni, 2014; Pekrun, Hall, Goetz, & Perry, 2014; Zimmerman & Schunk, 2012). To gather social network data, we asked participants to nominate students in their year group, with whom they have the closest friendships. The investigation utilises two different forms of analysis, both from network science, leading to two sets of predictions. We predict firstly that scores on motivation measures will be correlated between friendships pairs demonstrating similarity between friends, and secondly that high levels of centrality will significantly predict scores on the motivation measures examined. In order to answer these questions data is analysed using friendship pairs extracted from the network (assortativity analysis), and then on individual nodes as components of the network as a whole (centrality analysis).

2.2. Methods

2.2.1. Sample

Data presented here were collected from two different schools, defined here as cohort 1 and cohort 2. School 1 (cohort 1) is characterised as a relatively small central city school in London, whereas School 2 (cohort 2) is characterised as a small independent day and boarding school for girls.

The data from School 1 were collected from 104 sixth form students in year 12 and year 13 in the UK schooling system (mean age = 17.22 years; 23 female, 2 prefer not to say). While the lower school admits male students only, the sixth form (upper school) is mixed gender. The ethnic composition of the sample was as follows: White = 25%, Asian = 35%, Black = 12%, Mixed = 11%, other = 17%.

Subsequently, two sets of data were retrieved from School 2, forming cohorts 2a and 2b, data from cohort 2a were collected from 84 sixth form students in year 12 and 13 (mean age = 17.15 years; 82 female, 2 prefer not to say), and in cohort 2b (collected one year later) from 111 sixth form students, also in year 12 and 13 (mean age = 16.93 years; 111 female). The ethnic composition of each sample was as follows: White = 81% Asian = 7% Black = 7%, Mixed = 4%, other = 1% (cohort 2a), White = 70%, Asian = 23%, Black = 2%, Mixed = 5% (cohort 2b). Thus, the two samples collected from School 2 form a longitudinal sample. However, in the present chapter only the cross-sectional aspects are examined (see Chapter 4 for longitudinal investigation). Participation rates of the year groups can be found in Table 1.

Table 1. Percentage participation rates broken down by school cohort and year groups within each cohort.

	n	% attendance
Cohort 1		
Year 12	58	81.7
Year 13	42	75.0
Total	100	78.3
Cohort 2a		
Year 12	40	62.5
Year 13	44	80.0
Total	84	71.3
Cohort 2b		
Year 12	62	80.5
Year 13	49	76.6
Total	111	78.5

The study was approved by the University of Reading School of Psychology and Clinical Language Sciences Ethics Committee. For both schools, informed consent was obtained from students prior to their participation (information sheets and consent forms can be seen in Appendix 8.2. and 8.3.). Prior to the testing session the students all attended an assembly at which the investigator introduced the study and provided details about the project and their participation. Following this, each student was given an information sheet and the opportunity to ask questions ahead of completing a consent form and proceeding with the study. Data from four students in cohort 1 was removed prior to the data analysis (leaving an overall sample of 100 participants), as they had started some of their sixth form studies a year early, so were more integrated in their lower school social network than in the sixth form social networks.

2.2.2. Procedure

In all cases, data were collected in one visit, mid-way through the school year (in the spring term). Students completed an online motivation survey and then a social network survey in a single session using SurveyMonkey (SurveyMonkey Inc., San Mateo, California, USA). The motivation survey comprised several scales, collected to obtain an overall view of the students' academic motivation, whereas the social network survey was purely for collection of the network information.

All participants were provided with standardised instructions before beginning the surveys. In order to begin the surveys, the students were required to submit their signed consent form to the researcher, at which point the researcher provided them with their anonymous ID number, to be used for the duration of the research.

Students completed surveys across two school computer rooms in a group

setting. The researcher ensured that students remained silent while in the testing room, and responses were made anonymous by using screen dividers between each computer in the room.

2.2.3. Measures

2.2.3.1. Behavioural measures

The following measures were collected from all samples and are provided in 8.4., with cohort 2b as an exception. In the survey completed by cohort 2b, items referring to English classes were omitted due to time constraints that led to the overall survey being restricted in length. Cronbach's alpha is reported in Table 2, presented for each measure, separately for each cohort.

***Mathematics and English interest*.** An established measure of subject interest adopted from Wigfield and Eccles (2000) was used to assess intrinsic value in English and mathematics classes separately. The items were scored on a 7-point Likert scale (e.g. "Mathematics/English is interesting" 1 = strongly disagree to 7 = strongly agree). Another sample item is "I like Math/English" (1 = strongly disagree, 7 = strongly agree). The three-item scale was identified as reliable across all samples for both mathematics and English classes and an average of the items was calculated to give an overall mean interest score.

***Mathematics and English boredom*.** Items adopted from the Achievement Emotions Questionnaire (AEQ, Pekrun et al., 2002) were used in order to assess levels of boredom for mathematics and English classes. The three items were scored on a 7-point Likert scale, including those such as "Mathematics/English bores me" (1 = strongly disagree, 7 = strongly agree), and "I find Math/English fairly dull" (1 = strongly disagree, 7 = strongly agree). The scale was found to be reliable across all samples for both mathematics and English scales and as above, an average of all items was calculated to give an overall mean interest score.

Mathematics and English competence. An established measure of academic self-concept developed by Marsh (Academic Self-Description Questionnaire (ASDQ), 1990) was used to measure beliefs about competence in mathematics and English classes. Academic self-concept is represented by the Marsh/Shavelson model developed by Marsh (1990), conceptualised into two higher order factors of math academic and verbal academic self-concept. The scale contained items such as, "Compared to others my age I am good at Mathematics/English" and "I learn things quickly in Mathematics/English" (Marsh, 1990). The six competence items were scored on a 6-point Likert scale (1 = strongly disagree, 6 = strongly agree) and were shown to have high reliability across all samples. The items were appropriately reverse coded and averaged to give one score for each participant.

Autonomous motivation in mathematics. The learning self-regulation questionnaire (SRQ-L, Ryan & Deci, 2000) was used for mathematics only, with the 14 items all relating to reasons behind autonomous participation in mathematics classes (scored on a 7-point Likert scale; 1= Not true at all, 7 = Very true). Sample items include “I will participate actively in mathematics classes: Because I feel like it's a good way to improve my skills and my understanding of mathematics”, “I am likely to follow my instructor's suggestions for mathematics classes: Because it's important to me to do well at this.”, “The reason that I will continue to broaden my skills in mathematics is: Because it's a challenge to really understand mathematics.” This scale is comprised of two component subscales, measuring controlled regulation and autonomous regulation. Autonomous regulation is synonymous with the idea of self-determination, in that an individual governs their own behaviour and regulates their own experience. On the other hand, controlled regulation refers to an external drive for behaviour. Here, in order to quantify the scale, a relative autonomy index (RAI) is calculated by subtracting the controlled score from the autonomous score. The seven items measuring autonomous regulation and seven items for controlled regulation were each shown to be reliable in all samples.

***Value for learning*.** To further assess value at a non-subject specific level, general value for the content learnt at school was measured using adapted items from Wigfield and Eccles (2000). Here four items were scored on a 5-point Likert scale, sample items being “Compared to most of your other activities, how useful is what you learn in school?” (1 = not useful at all, 5 = Very useful), and “For me, being good in school is...” (1 = Not at all important, 5 = Very important). The scale showed good reliability across all samples. When averaging all items, a high score indicates high value for learning.

***Grit*.** Grit is a construct established by Duckworth et al. (2007) relating to perseverance and drive to achieve long-term goals. The Short Grit Scale (GRIT-S, Duckworth & Quinn, 2009) is used here to measure both consistency of interest and perseverance of effort at school. A sample consistency of interest item would be “I often set a goal but later choose to pursue a different one.” (5-point Likert scale, 1 = Not like me at all, 5 = Very much like me), where a perseverance of effort item would be “Setbacks don’t discourage me.” (1 = Not like me at all, 5 = Very much like me). In these examples, consistency of interest is expressed as an ability to maintain attention and interest on the task in hand, whereas perseverance of effort refers to the effort applied when facing challenges in achieving one’s goals. In the current study, both subscales had acceptable reliability across all samples and an average of each subscale was computed for each participant for use in further analyses.

***Mindset*.** Finally, the last measure of motivation used was a scale of Implicit Theories of Intelligence. The scale was developed by Dweck (2000) and measures adolescents' mindset. An individual's mindset lies on a spectrum between fixed and growth, with fixed mindset reflecting a case in which a person believes that their intelligence cannot change, and growth reflecting the opposite case where a person believes that they can alter their intelligence level at any point. The scale consists of eight items, measured on a 5-point Likert scale. Sample items include "No matter who you are, you can change your intelligence a lot." (1 = strongly disagree, 5 = strongly agree) and "To be honest, you can't really change how intelligent you are." (1 = strongly disagree, 5 = strongly agree). The scale showed high internal consistency across all samples and when items are averaged for each participant, a high score is indicative of a growth mindset, with scores on the lower end of the scale indicating a fixed mindset.

Table 2. Cronbach's alpha and number of respondents to each motivation survey. Participant *n* is reduced for measures of autonomous and controlled regulation due to items being addressed at those students currently studying mathematics only, students who did not take mathematics did not complete the scale.

		Cohort 1		Cohort 2a		Cohort 2b	
	No of items	Sample size (n)	alpha (α)	Sample size (n)	alpha (α)	Sample size (n)	alpha (α)
Math Interest	3	100	0.95	82	0.95	110	0.96
Math Boredom	3	99	0.95	82	0.92	108	0.94
Math Competence	6	100	0.89	84	0.90	111	0.94
English Interest	3	99	0.95	84	0.95	-	-
English Boredom	3	99	0.96	84	0.95	-	-
English Competence	6	100	0.89	84	0.93	-	-
Autonomous Motivation	7	70	0.86	19	0.76	40	0.71
Controlled Motivation	7	70	0.79	19	0.62	40	0.68
Value	4	100	0.81	84	0.72	111	0.77
Grit - Consistency of Interest	4	100	0.74	84	0.80	111	0.82
Grit - Perseverance of Effort	4	100	0.66	84	0.63	111	0.67
Mindset	8	100	0.85	84	0.92	111	0.93

2.2.3.2. Network measures

To measure the students' friendship connections, participants were asked to nominate up to five people from their year group that they considered themselves to be closest to (Coie, Dodge, & Coppotelli, 1982). We avoided using the word 'friend' directly, as a means of sensitivity toward the participants. Students in cohort 1 nominated an average of 4.42 friends each, with 75% of students choosing to nominate the maximum five allowed. In cohort 2a, students nominated an average of 4.54 friends each, with 80% of students choosing to nominate five friends (the maximum allowed). In cohort 2b, an average of 4.60 friends were nominated, with 85%

of students choosing to nominate the maximum five. An example of one of the networks can be seen in Figure 2.

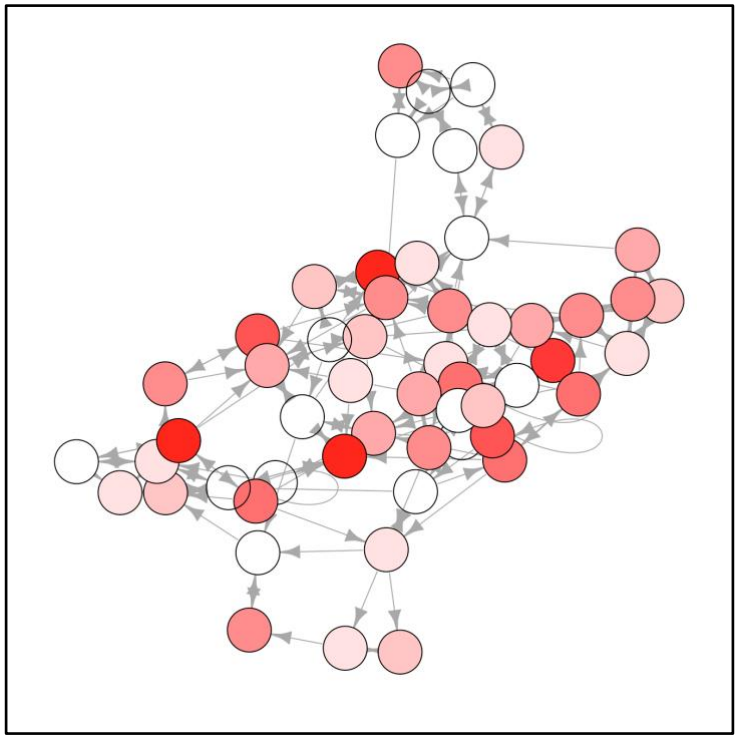

Figure 2. Example social network graph representing Year 12 (16-17 years) from cohort 1. Red students are those with high eigenvector centrality in the network (further explained in section 2.2.4.2.).

2.2.4. Analytic strategy

All analyses were conducted using two methods, both originating from network science.

2.2.4.1. Assortativity

In the first instance, analysis focussed on friendship dyads (i.e. pairs of friends), using a technique called assortative mixing to calculate an assortativity index for each of the measures tested. An assortativity index gives a correlation between the scores of individuals connected to each other via a friendship tie (Newman, 2002). Firstly, a directed adjacency matrix of equal dimensions is generated from the nomination friendship network data, in which the presence of a tie is represented by a '1' and no tie represented by a '0'. All participants are represented in the binary matrix, which is then broken down in the analysis into its component friendship dyads using the package *assortnet* in R (*v0.12*, Farine, 2014), from which point the scores of the individuals who have a tie are correlated. An overall index of assortativity is calculated for each behavioural measure tested by synthesising the correlations between all friendship dyads within the network. Because this is essentially a correlation coefficient, the value ranges from -1 to 1 and positive values indicates that there are

similarities between friends (in comparison with between non-friends). Standard errors were calculated using jackknife simulations (Efron & Tibshirani, 1993).

Within the separate samples, each year groups' social network was collected independently of the other year groups. Therefore, in order to see if the trends were similar across year groups, giving an impression of the sixth forms as a whole, we firstly computed assortativity for each year group in each school separately and then synthesised the results using fixed-effects meta-analyses (Borenstein, Hedges, Higgins, & Rothstein, 2009).

2.2.4.2. Centrality

To investigate the relationship between the friendship network and motivation beyond the dyad level, centrality analyses were conducted. Centrality uses concepts from graph theory and can be measured in several different ways. In this analysis, we focused on the degree and eigenvector centrality of each student. Degree centrality measures the number of links held by each node in the network, assessing how many connections a person has and therefore how much influence they can have on those connected to them. Eigenvector centrality goes a step further from degree centrality, considering the number of connections that each node has and how well each node is then connected to other nodes, assessing how much a single node can spread influence over the network as a whole (Bonacich, 1987, 1991; Ruhnau, 2000).

Once centrality measures had been calculated for each individual using R package *igraph* (*v1.2.4.1*, Csardi & Nepusz, 2006; R Core Development Team, 2012), we examined how these centrality indices predict levels of the behavioural measures using multiple regression analysis, controlling for year group effects with a dummy variable in each school sample.

2.3. Results

2.3.1. Descriptive statistics

Table 3 provides a summary of the mean responses to each measure, split by school sample. When exploring the distribution of the scales, in cohort 1, students were skewed, with a higher proportion showing high interest levels and low boredom levels in mathematics classes, compared to a more even distribution of interest and boredom levels for English classes. The opposite is seen in the cohort 2a sample, where an even distribution of scores is identified across mathematics scales, and a skew towards high interest and low boredom scores is seen for scales based on English classes. The remaining samples showed near-normal score distributions across the majority of scales, with a skew towards higher scores in the value for

learning scale in all samples (histograms showing score distributions can be found in 8.5.).

Table 3. Descriptive statistics for the behavioural measures, separated by school sample and year groups within each sample. N = maximum N.

	Cohort 1				Cohort 2a				Cohort 2b			
	Year 12 (n= 58)		Year 13 (n= 42)		Year 12 (n= 44)		Year 13 (n= 40)		Year 12 (n= 62)		Year 13 (n= 49)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Math Interest	5.29	1.44	5.26	1.26	3.65	1.78	4.14	1.97	4.20	1.97	4.25	1.96
Math Boredom	2.95	1.48	3.08	1.56	4.49	1.64	3.97	1.78	3.99	1.82	3.78	1.74
Math Competence	4.53	1.00	4.48	1.01	3.52	1.26	3.64	1.10	3.99	1.30	3.74	1.37
English Interest	4.05	1.95	3.57	1.82	5.36	1.77	4.84	1.69	-	-	-	-
English Boredom	3.76	1.78	4.46	1.87	2.91	1.70	3.73	1.66	-	-	-	-
English Competence	4.11	1.11	3.98	1.20	4.40	1.20	4.50	1.17	-	-	-	-
Autonomous Motivation (RAI)	1.50	1.07	1.90	1.08	1.81	1.40	1.36	1.28	1.69	1.09	1.62	0.99
Value	3.63	0.79	3.79	0.98	4.01	0.68	3.71	0.72	3.76	0.76	3.90	0.67
Grit - Consistency of Interest	2.92	0.79	2.82	0.80	3.19	0.98	3.30	0.86	3.19	0.78	3.08	1.04
Grit - Perseverance of Effort	3.62	0.64	3.65	0.80	3.70	0.65	3.56	0.81	3.50	0.66	3.76	0.68
Mindset	3.88	0.60	3.74	0.64	3.52	0.84	3.76	0.73	3.48	0.78	3.67	0.92

Note. *n* represents the maximum *n* participating in the research, *n* for each individual scales provided in Table 1.

2.3.2. Inferential statistics

2.3.2.1. Mathematics and English interest.

In the following fixed effects meta-analyses, assortative mixing is considered at the whole sixth form level by synthesising results from both year groups in each school sample. Again, a significant positive finding indicates that when combining the year groups in one analysis, connected individuals are significantly similar in their scores on the given measure. In the case of a negative r value, the correlation indicates that connected individuals are dissimilar in their scores. When integrating year groups, significant assortativity indices were found for mathematics interest in cohort 1 (r = .181, 95% CI = [0.08, 0.28], p<.001), in cohort 2b (r = .204, 95% CI = [0.12, 0.29], p<.001) and in English Interest in cohort 2a (r = .211, 95% CI = [0.10, 0.32], p<.001). This suggests that for cohorts 1 and 2b, there is a drive for students to make friends with those who are like them in their levels of mathematics interest, with less effect of similarities in English interest. On the other hand, the opposite is apparent in cohort 2a, who are more driven to be friends with similar others in terms of their English interest.

In analysing the centrality of the network as a whole, degree and eigenvector centrality measures were the variables used to predict levels of each behavioural variable in a linear regression model (an example of one of the networks can be seen in Figure 1).

The model showed that in cohort 1, both degree (β = -.037, p < .05) and eigenvector centrality (β = 0.51, p < .01) are significant predictors of mathematics interest. Interestingly, high degree centrality predicted low interest levels in mathematics, whereas high eigenvector centrality predicted high interest. In cohort 2b a different trend emerged, while degree centrality was not a significant predictor in the

model, high eigenvector centrality significantly predicted low levels of mathematics interest (β = -0.28, p < .05). No other significant findings emerged from analysis of either mathematics or English interest scales. Summaries of all findings for interest measures can be found in Table 4.

Table 4. Assortativity meta-analyses and centrality regression results presented for the mathematics and English interest scales. Centrality regression analyses are standardised and controlled for year group effects.

	Assortativity meta-analyses					Centrality regression					
						Degree Centrality			Eigenvector Centrality		
	r	*se*	*p*	*CI (Lower)*	*CI (Upper)*	Beta	*t*	*p*	Beta	*t*	*p*
Mathematics Interest											
Cohort 1	0.181	0.05	0.000***	0.084	0.278	-0.370	-2.44	0.017*	0.515	3.37	0.001**
Cohort 2a	-0.066	0.06	0.259	-0.180	0.049	-0.127	-0.82	0.414	-0.065	-0.43	0.670
Cohort 2b	0.204	0.45	0.000***	0.117	0.291	0.10	0.78	0.439	-0.28	-2.14	0.035*
English Interest											
Cohort 1	-0.081	0.06	0.208	-0.208	0.045	-0.044	-0.29	0.771	-0.046	-0.31	0.759
Cohort 2a	0.211	0.06	0.000***	0.097	0.324	-0.093	-0.61	0.542	0.248	1.65	0.103
Cohort 2b	-	-	-	-	-	-	-	-	-	-	-

** p < .05 ** p < .01 *** p < .001*

2.3.2.2. Mathematics and English boredom.

Significant findings were limited for the mathematics boredom scales. In the assortativity analysis, when integrating year groups, significant effects were found for mathematics boredom in cohort 2b (*r* = .19, 95% CI = [0.10, 0.27], *p* <.001) and English boredom in cohort 2a (*r* = .18, 95% CI = [0.07, 0.29], *p* <.01), indicating again that different subjects seem to drive different behaviours for similarity between friendship pairs across the different school samples.

In the centrality analysis, the regression model indicated that high levels of eigenvector centrality significantly predicted levels of mathematics boredom in both cohort 1 and cohort 2b (β = -0.44, p < .01, β = 0.28, p < .05, respectively). However, here it should be noted that the relationships are inverted. In cohort 1, high eigenvector centrality predicts low levels of mathematics boredom, whereas in cohort 2b, high levels of eigenvector centrality are predictive of high self-reported boredom in mathematics classes. No other significant effects were identified, and summaries of all findings for boredom measures can be found in Table 5.

Table 5. Assortativity meta-analyses and centrality regression results presented for the mathematics and English boredom scales. Centrality regression analyses are standardised and controlled for year group effects.

	Assortativity meta-analyses					Centrality regression					
						Degree Centrality			Eigenvector Centrality		
	r	*se*	*p*	*CI (Lower)*	*CI (Upper)*	Beta	*t*	*p*	Beta	*t*	*p*
Mathematics Boredom											
Cohort 1	0.033	0.06	0.565	-0.079	0.145	0.218	1.48	0.142	-0.442	-2.98	0.004**
Cohort 2a	-0.019	0.06	0.741	-0.134	0.095	0.295	1.98	0.052	-0.007	-0.05	0.965
Cohort 2b	0.187	0.04	0.000***	0.101	0.273	-0.100	-0.79	0.434	0.28	2.13	0.036*
English Boredom											
Cohort 1	-0.074	0.06	0.230	-0.194	0.047	0.006	0.04	0.969	0.108	0.70	0.486
Cohort 2a	0.179	0.06	0.002**	0.065	0.292	0.046	0.30	0.762	-0.175	-1.18	0.243
Cohort 2b	-	-	-	-	-	-	-	-	-	-	-

** p < .05 ** p < .01*

2.3.2.3. Mathematics and English competence.

Scales measuring academic self-concept in mathematics and English classes showed few significant results across school samples. In synthesising results across year groups for cohort 2b, meta-analyses of the assortativity indices revealed that mathematics competence scores appeared to be significantly similar between friends (r = .10, 95% CI = [0.01, 0.18], p = 0.026). Further, in cohort 2a, similarity appeared between dyads of friends in their levels of academic self-concept in English classes (r = .18, 95% CI = [0.06, 0.30], p = 0.004).

In the regression model for the centrality measures, only one significant finding emerged across all scales and school samples. In cohort 1, high eigenvector centrality was a significant predictor of high self-concept in mathematics (β = 0.45, p < .01), indicating that those who considered themselves as doing well and capable in mathematics were those who were in the higher positions of influence in their social networks. Results from significant and non-significant findings are summarised in Table 6.

Table 6. Assortativity meta-analyses and centrality regression results presented for the mathematics and English competence scales. Centrality regression analyses are standardised and controlled for year group effects.

	Assortativity meta-analyses					Centrality regression					
						Degree Centrality			Eigenvector Centrality		
	r	*se*	*p*	*CI (Lower)*	*CI(Upper)*	Beta	*t*	*p*	Beta	*t*	*p*
Mathematics Competence											
Cohort 1	0.091	0.05	0.093	-0.015	0.196	-0.202	-1.35	0.181	0.452	3.00	0.004**
Cohort 2a	0.016	0.06	0.779	-0.094	0.013	-0.169	-1.09	0.278	0.012	0.08	0.939
Cohort 2b	0.097	0.04	0.026*	0.012	0.182	-0.041	-0.32	0.752	-0.064	-0.50	0.620
English Competence											
Cohort 1	0.004	0.06	0.946	-0.107	0.115	-0.096	-0.64	0.525	0.272	1.79	0.077
Cohort 2a	0.177	0.06	0.004**	0.056	0.298	0.107	0.73	0.466	0.269	1.85	0.068
Cohort 2b	-	-	-	-	-	-	-	-	-	-	-

** p < .05 ** p < .01*

2.3.2.4. Autonomous motivation for mathematics.

Sample sizes were restricted for measurement of autonomous motivation for mathematics. This is due to the fact that items were aimed at those currently studying mathematics (an optional subject at this level of study), meaning that consequently data collected was from a smaller proportion of students in each school sample. In cohort 2b the sample size was too small to run the assortativity analysis – with only 6 students in year 12 taking maths at the time of data collection. Despite this, it was still possible to conduct the assortativity analysis on the cohort 1 data, revealing that across the sixth form, there is similarity between friends in their level of autonomy in mathematics (r = .16, 95% CI = [0.00, 0.34], p = 0.049).

Additionally, regression models with the centrality measures were run for each of the school samples. The model showed that in cohort 2b, high levels of eigenvector centrality significantly predict high relative autonomy index of students (β = 0.72, p < .05). In other words, those with higher opportunity for influence were the ones who actively participated in their mathematics classes. Results, including non-significant findings from these analyses are summarised in Table 7.

Table 7. Assortativity meta-analyses and centrality regression results presented for the autonomous motivation. Assortativity meta-analyses results absent from cohort 2a due to limited sample size in Year 12. Centrality regression analyses are standardised and controlled for year group effects.

	Assortativity meta-analyses					Centrality regression					
						Degree Centrality			Eigenvector Centrality		
	r	*se*	*p*	*CI (Lower)*	*CI (Upper)*	Beta	*t*	*p*	Beta	*t*	*p*
Autonomous Motivation											
Cohort 1	0.162	0.08	0.049*	0.001	0.342	0.172	0.79	0.436	0.119	0.57	0.570
Cohort 2a	-	-	-	-	-	-0.474	-1.71	0.107	-0.365	-1.10	0.290
Cohort 2b	0.178	0.09	0.056	-0.004	0.360	0.061	0.33	0.742	0.723	2.59	0.014*

** p < .05*

2.3.2.5. Value for learning.

The value for learning scale was the first of the general (non subject-specific) scales to be investigated. Here, meta-analyses of the assortativity indices for both year groups in cohorts 1 and cohorts 2a revealed significant results (r = .17, 95% CI = [0.07, 0.28], p = 0.002; r = -.14, 95% CI = [-0.23, -0.04], p = 0.006, respectively). However, it should be noted that the significant effect is positive in cohort 1 and negative in cohort 2a, meaning that there is significant similarity in scores for cohort 1 (assortative mixing has occurred), and significant dissimilarity in cohort 2a, indicating that the friendship pairs are scoring at opposite ends of the value measure. None of the centrality models showed significant predictive trends across any of the school samples. These findings

are provided alongside non-significant results from the other school samples in Table 8.

Table 8. Assortativity meta-analyses and centrality regression results presented for the value for learning measure. Centrality regression analyses are standardised and controlled for year group effects.

	Assortativity meta-analyses					Centrality regression					
						Degree Centrality			Eigenvector Centrality		
	r	*se*	*p*	*CI (Lower)*	*CI (Upper)*	Beta	*t*	*p*	Beta	*t*	*p*
Value											
Cohort 1	0.173	0.06	0.002**	0.065	0.281	-0.057	-0.38	0.702	0.291	1.94	0.056
Cohort 2a	-0.135	0.05	0.006**	-0.230	-0.039	-0.070	-0.46	0.650	0.104	0.69	0.492
Cohort 2b	0.048	0.04	0.282	-0.039	0.134	0.076	0.58	0.561	-0.117	-0.91	0.363

** p < .05 ** p < .01*

2.3.2.6. Grit.

Grit is separated into two features; therefore, analysis was broken down to assess the two component parts of the scale. Consistency of interest showed no significant similarity or dissimilarity patterns across any of the meta-analyses for each school sample. Moreover, network position and centrality showed no predictive ability for levels of consistency of interest in sixth form students.

When looking into the perseverance of effort subscale, cohort 1 showed significant findings in both assortativity meta-analyses and centrality analyses. When synthesised, assortativity indices across both year groups of cohort 1 were positive and significant (r = .16, 95% CI = [0.04, 0.27], p = 0.009), indicating that friendship dyads share the same levels perseverance of effort. Interestingly, in the centrality regression analysis, having high eigenvector centrality was predictive of high levels of perseverance in cohort 1 (β = 0.32, p < .05) meaning that those in a high position of influence are less likely to let setbacks discourage them and tend to work more diligently. Summaries of all analyses (including the non-significant effect from the other school samples) are seen in Table 9.

Table 9. Assortativity meta-analyses and centrality regression results presented for the measurements of grit, split by consistency of interest and perseverance of effort subscales. Centrality regression analyses are standardised and controlled for year group effects.

	Assortativity meta-analyses					Centrality regression					
						Degree Centrality			Eigenvector Centrality		
	r	*se*	*p*	*CI (Lower)*	*CI (Upper)*	Beta	*t*	*p*	Beta	*t*	*p*
Consistency of Interest											
Cohort 1	0.104	0.05	0.056	-0.003	0.210	-0.017	-0.11	0.911	-0.233	-1.54	0.128
Cohort 2a	0.091	0.51	0.077	-0.010	0.192	-0.172	-1.11	0.272	0.084	0.55	0.584
Cohort 2b	0.025	0.04	0.580	-0.062	0.111	-0.071	-0.55	0.585	0.125	0.98	0.332
Perseverance of Effort											
Cohort 1	0.155	0.06	0.009**	0.039	0.271	-0.030	-0.20	0.839	0.318	2.16	0.034*
Cohort 2a	0.056	0.06	0.314	-0.053	0.164	0.179	1.20	0.234	0.149	1.02	0.312
Cohort 2b	-0.004	0.05	0.930	-0.093	0.090	0.059	0.47	0.640	0.121	0.97	0.336

** p < .05 ** p < .01*

2.3.2.7. Mindset.

The final measure assessed is mindset. In this scale, a low score is indicative of having an orientation towards a growth mindset, whereas a high score would suggest the opposite, a disposition towards more of a fixed mindset. As such, the only significant finding to emerge from the assortativity meta-analyses was from cohort 2b, where a significant positive overall assortativity index suggests that friendship dyads have similar levels of fixed or growth mindset (r = .10, 95% CI = [0.01, 0.19], p = 0.029). Further, in the centrality regression from cohort 2a, having a high number of connections in the social network (high degree centrality) significantly predicted that a student would have higher growth mindset (β = 0.36, p < .05). Wider results from both types of analyses are summarised in Table 10.

Table 10. Assortativity meta-analyses and centrality regression results presented for the measure of mindset. Centrality regression analyses are standardised and controlled for year group effects.

	Assortativity meta-analyses					Centrality regression					
						Degree Centrality			Eigenvector Centrality		
	r	*se*	*p*	*CI (Lower)*	*CI (Upper)*	Beta	*t*	*p*	Beta	*t*	*p*
Mindset											
Cohort 1	-0.029	0.07	0.655	-0.157	0.099	0.006	0.04	0.969	0.124	0.84	0.402
Cohort 2a	-0.078	0.05	0.152	-0.184	0.029	0.361	2.44	0.017*	-0.106	-0.73	0.470
Cohort 2b	0.098	0.04	0.029*	0.010	0.186	-0.023	-0.18	0.859	0.088	0.68	0.496

** p < .05*

2.4. Discussion

The current research aimed to look at similarity in academic motivation between friends at sixth form. The hypothesis that friendship dyads would be similar on the measures of motivation was partially supported across the three sixth form samples that were analysed, with the highest number of similarities observed in cohort 1. Further, regression analyses enabled us to test our second prediction, that levels of centrality would be able to significantly predict scores on our motivation scales. Here, we identified that in most cases of significant findings across all three samples, eigenvector centrality (over degree centrality) appeared as the strongest predictor.

When comparing across the school samples, it is apparent that there is no clear pattern of similarity that can be characterised as a general trend between the schools. While this finding was not expected, it is perhaps not so surprising that school social networks are quite individual. Urdan and Schoenfelder (2006) suggest that when considering the effect of peers on motivation, we need to account for the motivational orientations of the individuals that make up the network, for these will have different impacts on the type of homophily that we may observe.

In the current research, for example in cohort 1, motivation associated with mathematics seems to be an important characteristic shared between friends. The meta-analysis of assortativity indices showed that there is a significant correlation between friends in their scores of self-reported mathematics interest. In the follow-up centrality analysis, it also emerged that for those who are well connected in their social network (i.e. those with the highest opportunity to spread influence), mathematics interest is high, and mathematics boredom is low. Whilst cohort 2b also showed the same pattern in their assortativity indices, in that connected individuals are significantly similar in their levels of mathematics interest, the centrality regression revealed that high levels of eigenvector centrality are predictive of low levels of mathematics interest. This may be an example of individual interests and motivation of the most central students spreading to those less central with whom they are connected to.

Despite the different directions of these findings, views on mathematics seem to be considered as important to a friendship in both cohort 1 and cohort 2b. However, in cohort 2a, this does not seem to be the case, as none of the findings for mathematics interest or boredom produced significant results. Instead, in this school sample, similarity between friends was significant for interest in English classes. However, no effects of centrality were observed across this sample, making further interpretation of this result more challenging.

In relation to the findings from previous literature, such as those by Kindermann (1993, 2007) our research suggests firstly that pairs of friends share similar levels of specific forms of academic motivation, and further demonstrate that, in some cases, the position of a student in the network (i.e. those with high eigenvector centrality) can predict the levels of certain motivational variables. Furthermore, the work of Nelson and Debacker (2008) is supported in that we show evidence of similarity between connected individuals in a similar manner to their findings that those with good quality friendships and high value for education were similar in having adaptive motivation styles (with the negative relationship also being true). The assortativity analysis gives the same output, in that interest, value and perseverance are all similar among friends in at least one or more of the school samples. From our centrality results, we support

the conclusion that attitudes within a peer group are important for connected peers. If eigenvector centrality is the best predictor of high levels of motivation, then this indicates that the central member of the group has the higher levels of motivation and therefore more connections with whom to spread their motivation.

One limitation of this research is the sizes and age ranges of the samples used. As these sixth form groups are from different schools and different time points, it is difficult to compile them into one analysis in which to statistically compare the networks and motivation. Further, although this research has been useful in providing insight into the patterns of behaviour in older adolescents, it is not yet clear how the findings of this research may be applied to younger students. Not only is the transition from UK high school to sixth form one where students may become more reliant on their peers, but also the formation of friendship on the entry to high school from primary school is an important social step where the development of a peer group is important for thriving in education. Research by Cantin and Boivin (2004) showed that in the transition from elementary school to junior high school (the UK equivalent being from primary school to high school), the supportive nature of friendships intensifies, along with an increase in the size of the social network that students hold. Though the change in school and change in opportunities for friendship is very different in this transition, Cantin and Boivin (2004) identified little adverse effects on the self-esteem and self-perception of the students, showing that the building of new social networks seems to be a natural step in this transition. Further research, in line with the present study, could explore similarity in these networks looking at a wider school population, investigating the nature of similarity in academic motivation across high school.

2.4.1. Conclusions

This study aimed to investigate similarity in motivation between friends in sixth form education, using techniques from network science to identify similarity effects in a cross-sectional sample of data. The findings were varied in that across the school samples tested, different measures of motivation were found to be similar between friends, leading to different interpretations that reflect the individual characteristics of the samples examined. Additionally, when looking at the centrality of individuals in the social networks, network centrality levels predicted scores on the motivation measures more successfully in some cases (e.g. across measures for mathematics motivation) over others. These findings show initial support for the hypothesis that motivation will be similar between friends, forming a basis for further cross-sectional work to explore wider age ranges, considering the development of friendship throughout education and the associated relationship with friendship similarity.

- Chapter 3 -

3. Cross-sectional study of similarity in academic motivation between students in a private suburban school

3.1. Introduction

To build on the work presented in Chapter 2, the following chapter also investigated the similarities that are observed between adolescents, in the context of a wider age range of students at high school. It is noted that as children enter early adolescence, around the same time that they transition into high school, they rely heavily on friendships and the social support that they provide (Hartup & Stevens, 1997). Such social support enables adolescents to successfully manage the developmental changes that they encounter, in terms of the increase in autonomy, the growth of personal identity and the increased focus on achievement (Simpkins et al., 2006); this especially applies in the context of education. This considered, it is reasonable to suggest that peer similarity may exist across all years of high school, given that the reliance on peer relationships also increases with the increased freedom given to students as they progress through the education system (Hertzog et al., 1996).

Early cross-sectional work on the effects of achievement on school children's friendships (Tuma & Hallinan, 1979) suggests that when a gap in achievement is wide between two children, the likelihood of a friendship tie evolving is lower than when the two individuals are closer in achievement level, suggesting that it is not only surface level characteristics such as gender and race that impact on friendship selection throughout adolescence. As motivation is identified as a leading factor in academic achievement, along with other academic outcomes (for a meta-analysis see Robbins et al., 2004), it is plausible that when achievement is similar between friends, the underlying motivation contributing to the level of achievement may also be similar.

3.1.1. Motivation in the peer context

As previously indicated, there has so far been relatively little focus in the field of motivation on how similarities in motivational orientation may guide the friendship process and/or the outcomes of such friendships. Work such as that by Kindermann (1993, 2007), previously outlined in section 2.1.1. indicates how friendships are formed based on similarities in personal characteristics and supports the idea that motivational orientation can be similar between connected individuals and clustered groups. Further, Nelson and Debacker (2008) also contribute to the literature considering motivation in the peer context, demonstrating that perceptions of friendship quality can have a direct influence on the motivation style of students in the classroom. While perceptions of friendship quality can influence motivation, Goldstein, Boxer and

Rudolph (2015) demonstrated that stability of friendship is also a predictor of students' perceptions of academic value. This finding is encouraging in that peers may have a role in influencing each other's positive attitudes towards school.

Moreover, Raufelder, Jagenow, Drury and Hoferichter (2013) took a slightly different perspective and carried out a study considering the impact of both peer-peer and peer-teacher social relationships on students' motivation, integrated into one model. Several types of academic motivation were measured in a sample of 1088 12-15 year old students, along with self-reported measures of how motivating friends and teachers are. Following this, confirmatory latent class analysis was used to estimate a four-way model of peer-peer or peer-teacher dependency or independency. Interestingly, while the authors demonstrated that it is important to consider the other social relationships that students experience at school (such as those with teachers), peer-peer dependency was the largest motivational category resulting from the model. This finding therefore reinforces the often-overlooked role of peers during adolescence in the development of academic motivation.

3.1.2. Current research

In order to further assess how similar peers are in their levels of motivation at school, the current research considers motivational similarity at a whole school level (including high school and sixth form students), investigating whether there are similarities between the levels of motivation of connected individuals in friendship dyads, and also whether the motivation level of individuals can be predicted by the position that they hold in the network overall. Research summarised by Berndt (1982) indicates that the stability of friendships does not vary considerably throughout the high school years (year 7 – year 13); one explanation being the consistency in social environment that many students experience in their school context, contributing to friendship maintenance. Taken together, if friendships are likely to form based on similarities in underlying factors such as achievement, and these friendships remain relatively consistent within the context of the school environment, then it is sensible to question how other factors like motivation are similar across school environments on the whole.

In the following investigation, several types of academic motivation are assessed, including interest and boredom for school subjects, academic self-concept, autonomous motivation, value for learning, grit and mindset (all outlined in previous sections; Chapter 1 section 1.4.; Chapter 2 section 2.2.3.). To gather social network data, we asked participants to nominate the students they have the closest friendship with, within their year group. Like the previous chapter, the investigation utilised two different forms of analysis, both from network science, which lead to two separate

hypotheses. The hypothesis is firstly, that friendships pairs will be correlated on their scores on motivation measures demonstrating similarity between friends, and secondly that high levels of centrality will significantly predict higher levels on the motivation measures examined. In order to answer these questions data is analysed using friendship pairs extracted from the network (assortativity analysis), and then on individual nodes as components of the network as a whole (centrality analysis).

3.2. Methods

3.2.1. Sample

One time point of data was collected during the spring term of the school year from a rural private all girl's school providing both day and boarding facilities. The school enrols students from year 7 to year 13 (UK school system), comprising a lower school (Key Stage 3 and GCSE's; year 7 to year 11) and sixth form (A-levels; year 12 to year 13). Informed consent was obtained from students prior to their participation. For those students aged 16 and above, consent was obtained by the same means as detailed previously (Chapter 2, section 2.2.1.). For those students aged 11-15 the consent procedure was as follows. Parents of students were required to give opt-in consent following the distribution of an information sheet and consent form via the school's online bulletin system (information sheet and consent form can be found in 8.6. and 8.7.). All students whose parents had opted in received an information sheet and assent form (seen in 8.8. and 8.9.) to complete prior to starting the session on the day so they too could agree to take part.

For the present study, data were included from years 8-13. Therefore, the sample consists of data from 289 students (mean age = 14.83 years; 287 female, 2 prefer not to say) with an ethnic composition as follows: White = 78%, Asian = 7%, Black = 6%, Mixed = 8%, other = 1%. The study was approved by the University of Reading Research Ethics Committee, UK (UREC 16/60; 8.10.). Participation rates from each year group are included in Table 11.

Table 11. Percentage participation rates broken down by year group. Reduced *n* for Year 11 is due to low opt-in consent rates from parents/guardians.

	n	% attendance
Year 8	53	93.0
Year 9	57	91.9
Year 10	70	92.1
Year 11	25	32.5
Year 12	40	62.5
Year 13	44	80.0
Total	289	75.3

3.2.2. Procedure

Data were collected at one time-point, mid-way through the school year (in the spring term) across four testing rooms (computer rooms at the school). All data collection procedures were identical to those explained previously (Chapter 2, section 2.2.2.).

3.2.3. Measures

3.2.3.1. Behavioural measures

Measures tested were identical to those reported in Chapter 2 (section 2.2.3.) where full descriptions of the included scales and sample items are provided. Details of the sample *n* for each measure and the corresponding Cronbach's alpha values can be identified in Table 12.

Table 12. Cronbach's alpha and number of respondents to each motivation survey. Participant *n* is reduced for measures of autonomous and controlled regulation due to items being addressed at those students currently studying mathematics only, students who did not take mathematics did not complete the scale.

		Cohort 1	
	No of items	Sample size (n)	alpha (α)
Math Interest	3	287	0.94
Math Boredom	3	286	0.90
Math Competence	6	289	0.92
English Interest	3	2	0.95
English Boredom	3	286	0.95
English Competence	6	289	0.93
Autonomous Motivation	7	224	0.76
Controlled Motivation	7	224	0.70
Value	4	288	0.76
Grit - Consistency of Interest	4	288	0.74
Grit - Perseverance of Effort	4	288	0.63
Mindset	8	289	0.91

3.2.3.2. Friendship networks

Method of data collection was identical to the procedure outlined in Chapter 2 section 2.2.2.. Students nominated an average of 4.8 friends each, with 90% of students choosing to nominate the maximum five allowed.

3.2.4. Analytic strategy

For cross sectional analysis of this cohort, the same analytic strategy as Chapter 2 section 2.2.4. was employed. Data were first analysed by breaking down the network into friendship dyads and calculating an assortativity index separately for each year group within each cohort (assortative mixing). After calculating these indices, results were synthesised using a random-effects meta-analysis to identify any trends across the cohort as a whole. To address hypothesis two, the separate networks within

the cohort were then considered as a whole, rather than broken up into their component dyads. Here, degree and eigenvector centrality were assessed as predictors of scores on the motivation scales referred to above (network centrality).

3.3. Results

3.3.1. Descriptive statistics

Table 13 provides a summary of the mean responses to each measure from the data collection, split by school year group. When exploring the distribution of the scale scores, students generally show normal distributions across the scales, with a slight skew towards lower boredom in English classes. Further, the students were skewed towards the higher scores in their value for learning and skewed towards lower scores in mindset – indicating a tendency towards holding a growth mindset as opposed to fixed mindset (histograms showing score distributions can be found in Appendix 8.10.).

Table 13. Descriptive statistics for the behavioural measures, separated by year group.

	Year 8 (n=53)		Year 9 (n=57)		Year 10 (n=70)		Year 11 (n=25)		Year 12 (n=44)		Year 13 (n=40)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Math Interest	4.69	1.43	4.84	1.43	4.33	1.52	4.97	1.73	3.65	1.78	4.14	1.97
Math Boredom	3.65	1.35	3.48	1.61	3.71	1.47	3.61	1.44	4.49	1.64	3.97	1.78
Math Competence	4.24	1.22	4.39	1.15	4.13	1.15	4.18	1.23	3.52	1.26	3.64	1.10
English Interest	4.62	1.51	4.97	1.45	4.39	1.59	4.45	1.85	5.36	1.77	4.84	1.69
English Boredom	3.60	1.54	3.16	1.35	3.72	1.54	3.69	1.79	2.91	1.70	3.73	1.66
English Competence	3.69	1.14	4.25	1.21	3.65	1.14	3.47	1.23	4.40	1.20	4.50	1.17
Autonomous Motivation (RAI)	1.09	1.00	1.36	0.98	0.77	1.02	1.03	0.99	1.81	1.40	1.36	1.28
Value	4.04	0.67	3.98	0.79	3.69	0.84	3.89	0.65	4.01	0.68	3.71	0.72
Grit - Consistency of Interest	2.93	0.87	3.00	0.79	3.09	0.68	3.15	0.67	3.19	0.98	3.30	0.86
Grit - Perseverance of Effort	3.56	0.68	3.68	0.66	3.48	0.65	3.40	0.67	3.70	0.65	3.56	0.81
Mindset	3.88	0.71	3.92	0.67	3.54	0.66	3.54	0.81	3.52	0.84	3.76	0.73

Note. *n* represents the maximum *n* participating in the research, *n* for each individual scales provided in Table 1.

3.3.2. Inferential statistics

3.3.2.1. Assortativity findings

In the following random-effects meta-analyses, assortativity indices are considered at the whole school level by synthesising results from all year groups within each school sample. Similar to Chapter 2, a significant positive assortativity index indicates that when combining the year groups in one analysis, connected individuals are significantly similar in their scores on the given measure. In the case of a negative r value, the correlation indicates that connected individuals are dissimilar in their scores.

When integrating year groups, a significant positive assortativity index was found for interest in English classes (r = .081, 95% CI = [-0.02, 0.18], p = .011), suggesting that students are friends with those who are similar to them in their levels of English interest. Across all other variables measured, assortative mixing did not occur, either as positive assortativity or negative, disassortativity. This means that friendship

pairs, compared to non-friendship pairs, do not show correlated levels of motivation on any of the other measures examined. These findings are shown in entirety in Table 14.

Table 14. Assortativity meta-analyses presented for the full range of motivation variables measured. Year 12 is missing from the Autonomous motivation meta-analysis due to a limited sample size, caused by scale items only being addressed to those currently studying mathematics (optional subject at A-level).

	Assortativity meta-analyses				
	r	*se*	*p*	*CI (Lower)*	*CI (Upper)*
Mathematics Interest	0.014	0.03	0.648	-0.047	0.076
English Interest	0.081	0.05	0.011*	-0.019	0.181
Mathematics Boredom	0.010	0.03	0.735	-0.048	0.068
English Boredom	0.038	0.05	0.420	-0.029	0.085
Mathematics Competence	0.048	0.03	0.109	-0.011	0.106
English Competence	0.066	0.07	0.352	-0.073	0.205
Autonomous Motivation[a]	-0.012	0.036	0.744	-0.083	0.059
Value	-0.048	0.03	0.132	-0.111	0.015
Conistency of Interest (Grit)	-0.051	0.07	0.491	-0.196	0.094
Perseverance of effort (Grit)	-0.014	0.05	0.793	-0.120	0.092
Mindset	-0.002	0.04	0.961	-0.075	0.072

** p < .05 ** p < .01*

[a] *Meta-analysis missing year 12 due to sample size issues in this year group.*

3.3.2.2. Centrality findings

The multiple linear regression used for this analysis used individual level centrality to predict level of motivation. When looking at the centrality of the network, regression analyses revealed that English class interest is predicted by the level of eigenvector centrality of an individual in the network ($\beta = 0.21$, $p < .01$). Here, where a student has high eigenvector centrality, they are predicted to report high interest in their English classes. Further, degree of centrality significantly predicted level of mathematics boredom ($\beta = 0.23$, $p < .01$), meaning that those with a high number of social connections reported higher levels of boredom in mathematics than their less connected peers. Also, high levels of eigenvector centrality (meaning that there is higher opportunity for influence in the network) predicted low levels of English boredom ($\beta = -0.16$, $p < .05$), relating to the previous finding where the model showed that high eigenvector centrality predicts high English interest. No other relationships between centrality and motivation were identified across the other motivation constructs measured. All results are summarised in Table 15.

Table 15. Centrality regression results presented for the full range of motivation variables measured. Centrality regression analyses controlled for year group effects.

	Centrality regression					
	Degree Centrality			Eigenvector Centrality		
	Beta	*t*	*p*	Beta	*t*	*p*
Mathematics Interest	-0.087	-1.02	0.309	0.062	0.84	0.401
English Interest	-0.118	-1.39	0.167	0.209	2.83	0.005**
Mathematics Boredom	0.233	2.74	0.007**	-0.094	-1.27	0.204
English Boredom	0.103	1.20	0.230	-0.156	-2.07	0.039*
Mathematics Competence	-0.145	-1.72	0.086	0.083	1.13	0.260
English Competence	0.054	0.66	0.510	0.128	1.78	0.076
Autonomous Motivation	-0.088	-0.93	0.352	0.076	0.89	0.376
Value	-0.162	-1.89	0.060	0.107	1.44	0.152
Conistency of Interest (Grit)	0.046	0.52	0.601	-0.031	-0.40	0.686
Perseverance of effort (Grit)	0.088	1.01	0.312	-0.006	-0.08	0.936
Mindset	0.104	1.23	0.220	0.015	0.20	0.842

** p < .05 ** p < .01*

3.4. Discussion

This study aimed to examine similarity between connected individuals, and centrality across social networks, within whole school samples. The first hypothesis, that friendship pairs will be correlated on their scores on motivation measures, was supported for only one of the motivation measures tested. Further, the second prediction, that high levels of centrality will significantly predict higher levels on the motivation measures examined, was only partially supported. Here, the trend found in the sample reported in Chapter 2 was repeated but to a lesser extent, with a small range of measures being significantly predicted by the centrality scores of individuals.

To expand on the finding supporting the first hypothesis; interest in English classes was the only measure of motivation identified as being more similar between friend pairs compared to non-friends. This significant finding indicates a correlation between the English interest scores of connected individuals within each year group, but also across the whole school when synthesised.

While no consistencies are observed in the assortativity analyses, some comparison can be made in regard to predictions about English interest and boredom when taking into account the findings from the centrality analysis. Here, modelling centrality with the scores of students on the English scales revealed that eigenvector centrality predicts both high interest and low boredom for English classes across all years of this cohort. Additionally, level of degree centrality was able to predict higher levels of boredom in mathematics classes. However, the type of centrality here is important for implications about the opportunity for influence to spread in the network. When degree centrality significantly predicts motivation, it implies that a higher number

of friendship connections are related to predicting high or low motivation. On the other hand, findings related to eigenvector centrality are indicative of wider opportunity for influence, as high eigenvector centrality reflects a wider reach of connections through which the motivation could spread across the network. This considered, as this data is only collected at one time point, actual influence cannot be measured. The relationship between social connectedness and motivation is simply evidenced at one standalone moment.

Therefore, these findings although limited, do indicate that there are some types of motivation that are related to friend similarity and related to friendship network position, across a whole high school sample. The current findings support previous research (Kindermann, 1993), also showing that similarities do exist between connected friends, who in this case share the same motivation levels in terms of interest for their English classes. Further, in line with research by Raufelder et al. (2013) who drew attention to the fact that peer-peer dependency is a strong motivation style, this current finding draws attention to the important role of peers in the context of motivation by demonstrating the relationship between social connectedness in the form of network centrality, indicating how by predicting the motivation levels of the most well-connected students we can gain an informed impression of how positive (or negative) influence might have the opportunity to spread.

Therefore, the hypothesis that peer similarity exists across whole school samples is not fully strongly supported considering the small number of motivation measures that yielded significant results. Drawing on the developmental argument proposed at the outset of this chapter, it may be the case that while similarity is present within year groups, the similarity changes form across the developmental trajectory. To give an example, the reason for the lack of significant findings across the year group range may be because similarity in mathematics interest may be important when students are new to a school, but then similarity becomes less important when moving further into the school, perhaps becoming more important again at a different stage. Trends such as these are seen in a selection of forest plots (Appendix 8.11.) where the older sixth form students seem to show different trends in similarity compared to lower school students in certain measures of motivation. Further research should explore this developmental explanation and model the changes between year groups over time.

As indicated, one limitation of cross-sectional research such as the present study is its inability to disentangle the friendship processes that are occurring within the network. From one time-point of data it is difficult to know whether the friends have always been similar on a particular measure or if over time they have converged and been influenced to become similar. This is an important distinction when considering

the socialisation of adolescents at school, effects of influence over time or initial friendship selection could have implications for educators by giving further insight into the dynamics of friendship in schools. Moreover, in order to provide more concrete conclusions about the direction of similarity (i.e. whether friends are significantly similar due to having high levels of motivation, or low levels of motivation), additional analysis should be undertaken. This also stands as a reason for the inconclusive findings in the current study, the different dynamics that underly the friendships are conflated, therefore lend to unstable results.

Therefore, the natural next step following the conclusions from this study is to carry out longitudinal research to tease apart the effects that are currently observed. Shin and Ryan (2014b) examined social network effects on achievement goals and academic adjustment and revealed different friendship dynamics for the different forms of achievement goal. Results such as these (for other examples see; Shin and Ryan, 2014a; Rambaran et al., 2016) provide a more in-depth view of the effect of social groups on school experience, therefore motivate the longitudinal work that follows in the proceeding chapter.

3.4.1. Conclusions

The current research aimed to investigate whether there is similarity in motivation between friends and if trends in these similarities could be seen across a whole school sample. Few common trends across the whole school were identified, and further investigation into the relationship between network position (in terms of centrality) and motivation revealed again that some types of motivation could be predicted by having high centrality levels. The results are informative in that they show the potential for influence to spread in a network and highlight the limited types of motivation that are more likely to be similar between friends at a whole school level. Further research in the following chapter will investigate the relationship between friendship and motivation variables from a longitudinal perspective.

- Chapter 4 -

4. Longitudinal study of selection and influence in academic motivation between students in a private suburban school

4.1. Introduction

The role of motivation in educational settings is well researched and the importance of enhancing motivation among students is becoming well established (for a meta-analysis see Robbins et al., 2004). With research suggesting the importance of the socio-cognitive factors that contribute to the overall school experience (for a review see Anderman & Wolters, 2006), along with the increasing social pressure to achieve at school (Feld & Shusterman, 2015), it is becoming increasingly important to measure ways that motivation can be positively encouraged in school students.

4.1.1. School as a social environment

As highlighted throughout the previous chapters, schools are social environments that play a major role in the socialisation of the students that attend them (e.g. Hartup, 1996; Bukowski, Castellanos, Vitaro & Brendgen, 2015). It is most often the case that time spent with peers outweighs time spent in other social climates, therefore peers have a large impact on development of academic beliefs and behaviours throughout the stages of adolescence (Rodkin & Ryan, 2012). This is even more so in the case of boarding schools, where the residential element provides a unique context in which different opportunities arise in terms of growth and development alongside peers (Martin et al., 2014). Regardless of the way that the school day is structured, students have various opportunities to interact and form friendships with others. Often, students have a tendency to be drawn to similar others, not only in terms of demographic characteristics, but also by levels of academic achievement and engagement (Kupersmidt et al., 1995).

With peer interaction being a focal part of the school day, and friendships naturally forming based on similarity, there is a clear opportunity for the beliefs and/ or behaviours of one peer to transfer to others in their peer network. This concept can be easily imagined in the context of motivation levels, where the motivation of one student could impact on those around them, opening the opportunity for influence and social contagion.

4.1.2. Motivation as a mechanism for friendship

Not only is it possible that levels of motivation can be shared between friends, but it might also be the underlying mechanism driving the convergence in attitudes that often result from adolescent friendships. As outlined in the opening review of this thesis (section 1.1.), social contagion can be explained by theories such as social learning

theory (SLT; Bandura, 1977, 1986) and self-determination theory (SDT; Ryan & Deci, 2000). Whether the influence comes via vicarious learning (SLT) and the observation of others' enthusiasm for a subject, or, from satisfying the basic need for relatedness with others (SDT), by adjustment of attitudes and behaviours to be in line with the peer that you are trying to maintain a relationship with, motivation might play a role in the construction of the peer social network.

4.1.3. Motivation in the peer context

In the existing literature around peers and motivation, various methodologies have been employed to address questions around the effects that peers may have on adolescent adjustment. Using latent class analysis, Shim and Finch (2014) explored the social and achievement goals of middle school students in relation to academic adjustment (including measures of peer emotional and academic support) and identified six latent classes that combine social and academic goals, related to different social and academic outcomes. By demonstrating the relationship between social and academic achievement goals, this finding reinforces the idea that social and academic goal profiles go hand in hand, with the support of both forms of goals being important for thriving in the academic climate. Further, Molloy, Gest and Rulison (2011) explored adolescents' most 'influential' peer relationships by looking at three different forms of peer relationships and their impact on academic self-concept and engagement over time. The study separated influence into distinct yet overlapping processes (socialisation and social comparison; socialisation being an overlapping term for contagion or influence as defined in the opening of this thesis (section 1.1.3.) and identified evidence of socialisation across all types of peer interaction using a series of regression analyses.

Taken together, these studies demonstrate the effects that peers have on different forms of academic adjustment and give examples of how motivation levels at an individual level can impact on connected peers.

4.1.4. Selection versus influence

While the motivation theories outlined in section 4.1.2. above provide a theoretical mechanism for the similarity that exists between friends, and the literature outlined in section 4.1.3. provides rationale for the importance of considering peer effects on academic motivation, it is also important to consider more deeply the complexity of social relationships that constitute dynamically changing social networks. As highlighted in the work of Molloy et al. (2011) peer relationships are formed through a combination of different processes. In recent social network literature, the dynamics are defined in terms of selection and influence mechanisms. Selection is defined as a

friendship being formed based on prior similarity, whereas influence is defined as a change or convergence in behaviour as a product of a friendship tie (Veenstra, Dijkstra, Steglich, & Van Zalk, 2013) – these selection and influence processes are equivalent to the terms socialisation and contagion, respectively. It is important that research into peer effects considers the separate contributions and overlap of these dynamic processes as separate components of similarity (see Figure 3). Recent developments in methodologies are now enabling these distinctions to be measured using stochastic actor-based modelling (Snijders et al., 2010).

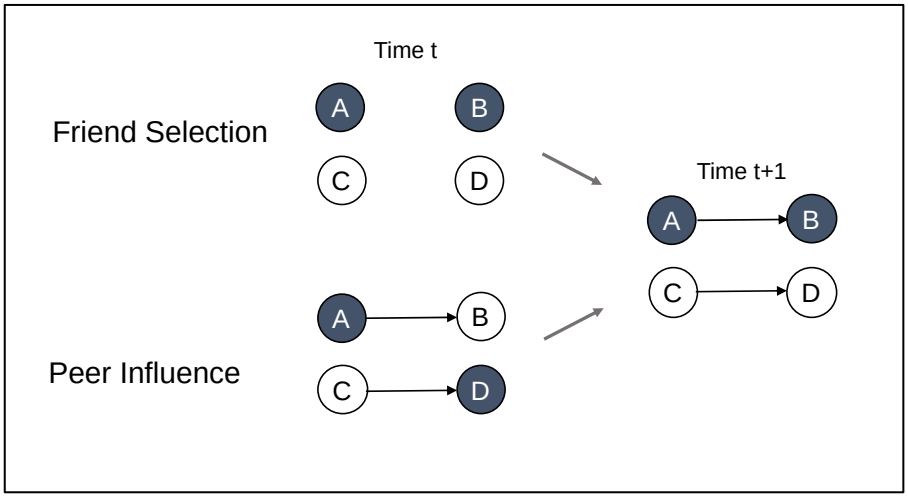

Figure 3. Depiction of selection and influence effects over time, displaying how both processes evolve differently to produce the same outcome. Selection effects see the formation of a tie based on existing similarities between friends. Influence effects see behaviour or attitudes becoming similar due to the friendship tie.

4.1.5. Research using stochastic actor-based models in education

Unlike the research described previously, the current research utilises stochastic actor-based modelling in order to disentangle the dynamic processes that are at play in adolescent friendship networks (for full description of this technique see section 1.1.5.). To summarise, stochastic actor-based modelling (Snijders, 1996, 2001, 2012; Steglich et al., 2010) can separate selection (the act of choosing to form an initial tie with a peer i.e. socialisation or homophily) and influence processes (the convergence in attitudes or behaviours because of a friendship tie, i.e. contagion). As outlined, this modelling allows the research field to take new perspectives on the development and progression of friendships, giving an insight into which behaviours are spread between connected friends over time, and the separate processes at work.

So far, research such as that reviewed in the opening chapter (section 1.1.) has provided insights into academic adjustment and achievement goals (Shin & Ryan, 2014b), motivation as a measure of academic adjustment (Shin & Ryan, 2014a) and

academic functioning in terms of grade point average (GPA) and truancy levels (Rambaran et al., 2017). Additionally, further research has used stochastic actor-based modelling to investigate other aspects of school environments. For example, Wang, Kiuru, Degol and Salmela-Aro (2018) investigated the selection and influence processes in academic achievement and school engagement in a sample of upper secondary school students. In their study, students were asked to nominate up to three peers with whom they frequently spend time, and also completed several measures of student engagement, including flow in schoolwork, school burnout, school value, school effort and levels of truancy. Following collection of this data across two timepoints, stochastic actor-based modelling was applied to examine the friendship and network dynamics. The authors identified differences in the selection and influence effects that vary depending on the dimension of school engagement. Over time, all dimensions of engagement (behavioural, emotional and cognitive) were influenced by the peer network, however in terms of friend selection, only similarity in behavioural engagement encouraged the formation of new friendship ties. As such, friends were likely to form based on similarity in truant behaviour, and across time were likely to align these behaviours to match their friends. Through their multidimensional approach to school engagement, Wang et al. (2018) demonstrate the complexity of the process behind peer similarity in that each of these types of engagement have their own internal processes that may all align in order for peers to become alike.

Moreover, Laninga-Wijnen et al. (2019) used stochastic actor-based modelling to examine the relationship between academic achievement and popularity level. Students were asked to nominate their best friends from a list of students in their year group and then completed status norm measures in a similar way, being asked who in their year group was popular, unpopular, liked and not liked. Levels of academic achievement were also included in the analysis. Laninga-Wijnen et al. (2019) demonstrated that the average achievement levels of popular and unpopular students affect the way that students select friends, whereas the acceptance or rejection norms did not play a role in the friendship dynamics. Findings such as these have direct implication for the academic adjustment of students, as friendship selection based on academic popularity or unpopularity may hinder the academic development of low-achieving students who select similarly low-achieving friends. Additionally, work by Ojanen, Sijtsema, Hawley and Little (2010) used longitudinal modelling to demonstrate selection and influence processes related to the extrinsic and intrinsic motivations for building a friendship and the associated friendship quality. Results showed that extrinsic motivation predicts that students will select a high number of peers, but indicates low friendship quality over time, whereas intrinsic motivation predicted lower

numbers of friend selections, popularity and higher quality friendships over time. Influence effects were also identified for both extrinsic and intrinsic motivation, though more so for intrinsic motivation. This insight further contributes to our understanding of the adolescent social environment, showing that motivational orientation plays a part in the formation and maintenance of adolescent friendship ties.

Taken together, the increasing use of longitudinal modelling in educational settings produces results that reinforce how understanding the difference in selection and influence friendship processes can provide useful information for educators. The findings bring awareness to differences in learning climate and the complex peer dynamics that may be at play under the surface of the classroom environments, dynamics that appear to have direct impact on the academic adjustment and achievement of students.

4.1.6. Current research

To further extend the body of work that contributes to our understanding of the relationship between academic constructs and friendship in the classroom, the following research uses longitudinal social network analysis, in the form of stochastic actor-based modelling, to disentangle the selection and influence processes that occur in friendship networks at school. Academic motivation is captured by the inclusion of a range of motivation constructs and associated scales (outlined in section 1.4. and 2.2.3.), including subject specific mathematics scales that address interest, boredom, academic self-concept and autonomous motivation, alongside more subject general measures of grit, value for learning and levels of growth mindset (for detailed overview see previous chapters). In order to account for the differences in boarding status of the students in the sample, boarding status is included as an additional time-invariant variable across the two data time points. Specific hypotheses about the individual measures are kept broad due to a lack of previous research indicating potential directions of results. However, it is expected that selection and influence effects will be identified for all motivation constructs, and that boarding status will have an effect on the network dynamics in that students of the same boarding status will cluster together, based on their proximity when outside of structured school hours (Martin et al., 2014).

4.2. Method

4.2.1. Sample

Data used here were the cohort 2a and cohort 2b data as described in Chapter 3 section 3.2.1.. For the present study, the year groups from timepoint 1 (cohort 2a) were followed up one year later at time point 2, giving two waves of data overall. Therefore, as this sample was followed up after one year rather than within an

academic year, years 7 – 12 in Wave 1 match years 8 – 13 at Wave 2. Further, in order to model the longitudinal changes in the social networks across the year, only participants who completed both waves of the research were included. This resulted in a total sample of 239 students who participated in both Wave 1 and Wave 2. In terms of participation rates, this equated to 61.9% representation of the W1 year groups and 58.7% representation of the W2 year groups.

The overall data set composition was as follows; mean age = 13.9 years (at Wave 1); 239 female participants, ethnic composition; White = 79%, Asian = 9%, Black = 5%, Mixed = 7%, other = <1%. Boarding status was collected as part of demographic information, boarding students coded as 1 and day students coded as 0; the sample was comprised of 36% boarding students. The study was approved by the University of Reading Research Ethics Committee, UK (UREC 16/60; Appendix 8.12.). Consent procedures for Wave 1 were identical to those described previously (Chapter 2, section 2.2.1.; Chapter 3, section 3.2.1.). In Wave 2, the consent procedure was amended to allow for opt-out consent, whereby parents could submit a form to withdraw their child from the data collection in the two weeks prior to the data collection session, or at any point following data collection (withdrawal form in Appendix 8.13.). The same information sheet used for cohort 1 was distributed to all parents via the same bulletin system as used in the cohort 1 data collection, no less than two weeks before the data collection. This allowed parents time to read all documentation provided and make an informed choice about their child's participation.

All students whose parents had opted them in during cohort 1 recruitment, or not opted them out during cohort 2 recruitment, received an information sheet and assent form (seen in Appendix 8.8. and 8.9.) to complete prior to starting the session on the day so they too could agree to take part.

4.2.2. Procedure

All data collection procedures for the separate cohorts and ages were identical to those explained in previous chapters (Chapter 2, section 2.2.; Chapter 3, section 3.2.) with only small variations in the measures examined at each time point. Notably, the items referring to English classes were removed after Wave 1 of data collection, and therefore will not be modelled in the following analysis.

Measures relevant to the current chapter are outlined briefly in the following section for completeness, including revised alpha coefficients in Table 16; readers familiar with detail provided in previous chapters may wish to skip this section.

Table 16. Cronbach's alpha values for each of the measures. Autonomous motivation and controlled motivation are combined in further analyses to give a relative autonomy index (RAI).

	No of items	Sample size (n)	Wave 1 alpha (α)	Wave 2 alpha (α)
Math Interest	3	239	0.93	0.96
Math Boredom	3	238	0.90	0.91
Math Competence	6	239	0.92	0.92
Autonomous Motivation	7	210	0.75	0.78
Controlled Motivation	7	210	0.73	0.68
Value	4	235	0.75	0.73
Grit - Consistency of Interest	4	236	0.70	0.76
Grit - Perseverance of Effort	4	236	0.64	0.64
Mindset	8	238	0.86	0.88

4.2.3. Measures

4.2.3.1. Behavioural measures

Mathematics interest. An established measure of subject interest was used to assess intrinsic value in Mathematics classes, adopted from Wigfield and Eccles (2000). Example items can be seen in Chapter 2 (section 2.2.3.). The three-item scale was identified as reliable across both samples (see Table 16.).

Mathematics boredom. Items adopted from the Achievement Emotions Questionnaire (AEQ, Pekrun et al., 2002) were used in order to assess levels of boredom for mathematics classes. Refer to Chapter 2 (section 2.2.3.) for example items. The scale was found to be reliable across both samples (see Table 16.).

Mathematics competence. An established measure of academic self-concept developed by Marsh (Academic Self-Description Questionnaire (ASDQ), 1990) was used to measure beliefs about competence in Mathematics classes. For further details and example items see Chapter 2 (section 2.2.3.). The six competence items were shown to have high reliability across both samples (see Table 16.).

Autonomous motivation in mathematics. The learning self-regulation questionnaire (SRQ-L, Ryan & Deci, 2000) was used as a measure of autonomous motivation, with 14 items all relating to reasons for participating in mathematics classes. For further details and example items see Chapter 2 (section 2.2.3.). A relative autonomy index (RAI) is calculated in order to quantify the scale, where the controlled motivation score is subtracted from the autonomous motivation score. The seven items measuring autonomous regulation and seven items for controlled regulation were both shown to be reliable across both samples (see Table 16.).

Value for learning. General value for the content learnt at school was measured using adapted items from Wigfield and Eccles (2000). Example items can be seen in Chapter 2 (section 2.2.3.). The scale showed good reliability across both samples (see Table 16.).

Grit. The Short Grit Scale (GRIT-S, Duckworth & Quinn, 2009) (for full scale description, see Chapter 2, section 2.2.3.) is used here to measure both consistency of interest and perseverance of effort at school. Both subscales had acceptable reliability (see Table 16.).

Mindset. Finally, the last measure of motivation used was a scale of implicit theories of intelligence, used to examine mindset of the students (Dweck, 2000). For further details and example items see Chapter 2 (section 2.2.3.). The scale showed high internal consistency across the both samples (see Table 16.).

4.2.3.2. Friendship networks

Method of data collection was identical to the procedure outlined in Chapter 2 (section 2.2.3.). Students across Wave 1 nominated an average of 4.87 friends each, with 94% of students choosing to nominate the maximum five permitted. Students across Wave 2 nominated an average of 4.52 friends each, with 85% of students choosing to nominate the maximum five permitted.

4.2.4. Analytic strategy

Stochastic actor-based modelling (Snijders et al., 2010) is used here to model the selection and influence dynamics of the social networks of each year group. This technique is an example of a contemporary methodology that enables the prediction of network changes between discrete time points, longitudinally, accounting for the different mechanisms that can drive similarity effects. The model is flexible and is able to specify social influence and selection processes as separate variables. Using the concept of "micro steps", the model accounts for multiple sequential changes that occurred between the time points when behavioural measures were taken (i.e. Wave 1 and Wave 2 in the current data).

The models are constructed under the general assumption that our relationships are directed. Each tie (i.e. $i \rightarrow j$) has a sender (i), who is titled ego, and a receiver (j) who is titled alter. From this foundation further assumptions are formed. Firstly, between time points, the underlying time parameter t must be continuous, allowing for network changes to be considered in the model as step-by-step with varying lengths of time between the changes that occur. There should be at least two timepoints of data recorded in order to model the step-by-step changes. Secondly, the changes that are observed are the outcome of a Markov process, a random process where the probabilities of the changes are determined by the most recent values in the

chain (Papoulis, 1984). Following this, it is assumed that actors (i.e. egos) are in control of their outgoing ties, linking to the actor-based nature of the model. Finally, regarding changing ties, the model stipulates that no more than one tie can change at any given moment. At any given moment, one actor (selected probabilistically) can make, break or maintain a tie, therefore breaking down the network change process into the smallest possible components.

The selection and influence processes occurring within friendships were estimated using stochastic actor-based models (*RSiena* 1.2-12, R version 3.5.0, Snijders et al., 2010). As we are aiming to identify motivation contagion across the school years, data from each year group were compiled and analysed simultaneously using the RSiena multi-group option (Ripley, Snijders, Boda, Voros, & Preciado, 2018). This approach yields more statistical power compared to separate analyses of the year groups (Ripley et al., 2018), and although it assumes that all parameters between groups are identical, the changes observed between waves of data collection in the current study were consistent across year groups, giving no cause for concern. One year group was affected by the high school to sixth form transition where many students left and several joined, resulting in a reduced sample size. However, this year group was still included in the analysis to maintain consistency through the age-ranges. Additionally, through implementing this multi-group analysis increased statistical power is gained with which to identify any influence effects.

The model is flexible, and it is possible to include many different effects. The effects specified below are selected based on their relevance to the research question and sample. The effects can be categorised into three groups, categories and specific effects described below. Graphical representations of effects are provided in Appendix 8.14..

4.2.4.1. Friendship network structure effects

The following effects examine how the friendship networks are changing over time and are called structural effects. For these structural effects, the behavioural variables (motivation scales) are not considered. Here, four network structure effects are selected for inclusion in the model.

***Density effect*.** This effect represents the tendency for students to nominate other students in the network, with a positive value indicating that the tendency to make or send out ties increases over time.

***Reciprocity effect*.** This effect is defined as the tendency to return a tie that was received, i.e. if student 1 says that they are friends with student 2, student 2 would say the same about student 1.

***Transitive triplets effect*.** This effect refers to how many direct and indirect ties a person holds, i.e. ties with friends of friends.

***Balance effect*.** This effect refers to the similarity of ties, in terms of having the same number of outgoing-ties and non-ties. Therefore, balance demonstrates preferences for similarity between the outgoing ties of actor *i* and the outgoing ties of those whom *i* is connected with, i.e. if student 1 has ties to two friend's student 2 and 3, then students 2 and 3 may also have outgoing ties to two friends.

4.2.4.2. Effects predicting friend selection based on academic motivation

In the selection portion of the models, social network ties are used as the dependant variable, with academic motivation and boarding status used as individual level covariates that act as predictor variables.

Alter effects. This effect measures how motivation level and boarding status effect the number of friend nominations that were received over time. A positive estimate here would suggest that those with high motivation scores will have an increased number of incoming nominations.

***Ego effects*.** This effect measures how motivation level and boarding status effect the ego's rate of sending out friendship nominations over time. A positive estimate here would suggest that those with high motivation scores will make an increased number of outgoing nominations.

Similarity x Reciprocity effects. This effect estimates the extent to which friends are selected and reciprocated based on the similarity of motivation level or boarding status over time (i.e. mutual friendship ties being formed based on similarity in level of motivation or similarity in boarding status).

4.2.4.3. Effects predicting influence on academic motivation

For the influence portion of the models, the behavioural variable is used as the dependant variable to assess how the behaviour influences the changes in the network dynamics over the two time periods.

***Behavioural tendency effects*.** Behavioural tendency is measured as standard by two terms; linear tendency and quadratic tendency. These model the shape of the long-term distribution of the behavioural variable across the two time points. The *linear* term describes the inclination to tend towards higher (positive sign) or lower (negative sign) scores in a given motivation variable over time. Whereas, the *quadratic* term describes the parabolic shape of the data distribution, a positive quadratic term indicates that high scores increase over time and low scores decrease over time, with number of scores centred around the mean decreasing (U-shape. A negative value indicates that scores regress towards the overall mean value (inverted

U-shape). As these are behavioural tendencies, they are not true measures of influence.

Influence similarity and reciprocity effect. The measure of influence, or contagion over time in this case is defined by the average similarity x reciprocity effect. This term reflects how individual scores on the motivation scales are increased or decreased to become more similar to the average score of those with whom students hold reciprocal friendship ties (where mutual friendship nominations have been made).

To summarise, RSiena can estimate these effects and standard errors so that it is possible to see how the network is formed and how the change in motivation interacts with the change in network.

4.3. Results

4.3.1. Descriptive statistics

Table 17 provides descriptive information summarising the changes in friendship networks between Wave 1 and Wave 2. The Jaccard Index of 0.38 included in the table indicates the level of stability of the networks. The index should be more than 0.3 in order to have adequate statistical power with which to run the SIENA dynamic modelling (Veenstra & Steglich, 2012). Hamming distance represents the number of observed changes in the network and is used as an indication of the number of micro-steps needed to reach the second network from the first (sum of the dissolved and emerged ties). The number of friendship nominations at each wave demonstrates a small decrease in the number of ties across waves, also showing a small reduction in the average number of friends nominated, as indicated by the average outdegree (maximum possible outdegree being 5). Across both waves, the networks show a high degree of reciprocity, with around 50% of friendships being reciprocated in each wave.

Table 17 also includes the means and standard deviations from each of the motivation variables measured. The trends across waves that are demonstrated here are accounted for in the behavioural dynamics of the SIENA modelling through the linear and quadratic effects that consider the direction of the behavioural tendencies.

Table 17. Descriptive statistics of network structure and behavioural responses from individuals. Hamming distance is the sum of the dissolved and emerged ties, while the Jaccard index indicates the degree of stability between the two time points. Within each wave, average outdegree indicates the average number of ties that were sent out, the density index indicates the potential connections in a network that are actual connections and the reciprocity index represents the proportion of reciprocated ties. *N* is reduced for RAI due to fewer students opting to study mathematics in the upper years (A Level students).

Variable	*n*	Wave 1 - Wave 2	Wave 1	Wave 2
Changes from W1 to W2				
Friendship tie changes				
Average no. of ties dissolved		64		
Average no. of ties emerged		52		
Average no. of ties maintained		77		
Hamming distance (change)		116		
Jaccard index (stability)		0.38		
Within each wave				
Friendship networks				
Average ties			141	129
Average outdegree			3.20	3.05
Density Index			0.08	0.09
Reciprocity Index			0.44	0.53
Math Interest	239			
Mean			4.57	4.46
SD			1.56	1.69
Math Boredom	238			
Mean			3.71	3.77
SD			1.50	1.59
Math Competence	239			
Mean			4.13	4.14
SD			1.21	1.21
Autonomous Motivation (RAI)	210			
Mean			1.12	1.02
SD			1.03	1.09
Value	235			
Mean			3.95	3.79
SD			0.75	0.73
Grit - Consistency of Interest	236			
Mean			3.05	3.13
SD			0.80	0.86
Grit - Perseverance of effort	236			
Mean			3.59	3.59
SD			0.68	0.70
Mindset	238			
Mean			3.76	3.53
SD			0.73	0.78

Table 18 includes a correlation matrix representing the correlations between the scores on the motivation variables at each wave and within waves. In general, all motivation variables measured at Wave 1 were positively correlated when measured against the same variables at Wave 2. Moreover, boredom in mathematics was negatively correlated with all other (positive) measures, with positive correlations demonstrating consistency of interest due to the scoring of the scale. In the consistency of interest grit subscale, a low score is indicative of high consistency of

interest, meaning that the positive correlation is between high levels of boredom and high scores on the consistency of interest subscale (high scores here meaning a lack of consistency in interest).

Table 18. Correlations between motivation variables across the two waves of data. Across waves, measures are highly correlated e.g. Wave 1 mathematics competence scares are highly correlated with Wave 2 mathematics competence scores (r = 0.82, p < .01).

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. W1 Math competence	-															
2. W1 Math interest	0.66**	-														
3. W1 Math boredom	-0.53**	-0.80**	-													
4. W1 Autonomous motivation (RAI)	0.26**	0.40**	-0.40**	-												
5. W1 Mindset	0.06	0.19**	-0.13*	0.26**	-											
6. W1 Grit - Consistency of interest	-0.10	-0.14*	0.19**	-0.20**	0.19**	-										
7. W1 Grit - Perseverance of effort	0.24**	0.18*	-0.18**	0.28**	-0.24**	-0.31**	-									
8. W1 Value	0.10	0.19**	-0.14*	0.11	-0.30**	-0.14*	0.35**	-								
9. W2 Math competence	0.82**	0.57**	-0.48**	0.21**	-0.09	-0.12	0.19**	0.11	-							
10. W2 Math interest	0.57**	0.69**	-0.63**	0.28**	-0.20**	-0.21**	0.08	0.11	0.68**	-						
11. W2 Math boredom	-0.38**	-0.47**	0.54**	-0.26**	0.19**	0.18**	-0.05	-0.12	-0.46**	-0.74**	-					
12. W2 Autonomous motivation (RAI)	0.29**	0.28**	-0.29**	0.42**	-0.22**	-0.27**	0.22**	0.17*	0.33**	0.44**	-0.42**	-				
13. W2 Mindset	0.06	0.12	-0.09	0.10	0.63**	0.19**	0.21**	0.24**	0.10	0.18**	-0.18**	0.24**	-			
14. W2 Grit - Consistency of interest	-0.17**	-0.14*	0.13*	-0.11	0.15*	0.54**	-0.31**	-0.13*	-0.16*	-0.15*	0.20**	-0.30**	0.14*	-		
15. W2 Grit - Perseverance of effort	0.14*	0.09	-0.11	0.14*	-0.20**	-0.37**	0.51**	0.24**	0.16*	0.18**	-0.25**	0.28**	-0.25**	-0.46**	-	
16. W2 Value	0.07	0.12	-0.11	0.01	-0.20**	-0.20**	0.22**	0.63**	0.13*	0.19**	-0.22**	0.15*	-0.23**	-0.17**	0.34**	-

Note. W1 = Wave 1; W2 = Wave 2; RAI = Relative Autonomy Index (in mathematics)
** p < .05 ** p < .01*

4.3.2. Friendship network structure effects

The results examining the network structural effects are seen in the upper portion of Tables 19 and 20, under the heading, network effects. The internal network dynamics were represented by four parameters; density, reciprocity, transitivity and balance. As these effects are modelled independently of the behavioural motivation variable, it is expected that the models will show similar estimates across all models on these four parameters.

***Density effect*.** The significant negative density effect (e.g. Mathematics Interest; β = -1.30, SE = 0.43, p < .01), indicates that students tend to nominate fewer friends over time. This is consistent with the descriptive statistics reported earlier (Table 17), number of nominations decreased between Wave 1 and Wave 2 of data collection.

***Reciprocity effect*.** Students have a significant and positive preference for reciprocal friendships, as demonstrated by the positive reciprocity effect (e.g. Mathematics Interest; β = 1.35, SE = 0.12, p < .001).

***Transitive triplets' effect*.** There was no effect observed for transitivity (e.g. Mathematics Interest; β = 0.003, SE = 0.05, p > .05).

***Balance effect*.** Finally, students had a tendency to nominate friends in similar patterns to others (noted by the positive significant balance estimates, e.g. Mathematics Interest; $\beta = 0.26$, SE = 0.03, $p < .001$), suggesting that students do not tend to be friends with their friend's nominated friends (no transitivity), rather they send out similar numbers/patterns of ties.

Taken together, there is a strong tendency for reciprocal friendships, with no trend towards the formation of closed networks or closed larger peer networks. Instead, peers make structurally similar nominations and prefer to leave their sub networks open.

4.3.3. Boarding status

Regarding the parameter estimates of network tendencies involving boarding status, similarity effects were significant for both alter effects and similarity and reciprocity effects; results located in the upper middle section of Tables 19 and 20, under the heading, selection effects. As a time-invariant, or constant co-variate, boarding status is not changed over time. Additionally, the same constant variable is used in each model, whereas the motivation variable is changed. Therefore, similar to network structure effects, it is expected that similar estimates will emerge from all models. Across the models of the behavioural measures, positive significant alter effects of boarding status were present and consistently observed for similarity and reciprocity (e.g. Mathematics Interest; $\beta = 0.81$, SE = 0.23, $p < .001$), with very minor discrepancies across other models (e.g. Mathematics Interest, $\beta = 0.15$, SE = 0.08, $p < .06$; Mathematics Boredom, $\beta = 0.16$, SE = 0.07, $p < .05$). The positive alter effect indicates that boarding students tend to be nominated as friends more often than day students. The positive boarding similarity and reciprocity index indicates that students have a preference to select friends of the same boarding status as themselves, and that those friendships are likely to be reciprocated.

4.3.4. Effects predicting friend selection based on academic motivation

Results associated with friendship selection and motivation are located in the lower middle section of Tables 19 and 20, under the heading, selection effects. Few significant effects were noted in the selection effects based on similar motivation levels, as detailed in the following section.

Alter effects. No alter effects were observed for any of the motivation measures, meaning that the level of motivation of a peer did not increase or decrease the likelihood of them being nominated as a friend.

***Ego effects*.** As above, no ego effects were observed for any of the motivation measures. This finding indicates that motivation level of the student is unrelated to the

number of nominations that they make. This is logical, as the majority of students filled the maximum nominations, choosing five friends to nominate.

Similarity x Reciprocity effects. For motivation level, one significant positive effect was identified for the value for learning measure (β = 2.42, SE = 1.01, $p < .05$), suggesting that friends tend to select and reciprocate friendships when levels of value for learning are similar between them. No other motivation measures showed significant effects, indicating that friends do not select each other based on similarity in their mean scores on these motivation scales.

4.3.5. Effects predicting influence on academic motivation

The results associated with the influence of behaviour over time are located in the bottom section of tables 19 and 20, under the heading, influence effects.

Behavioural tendency effects. Behavioural tendency effects were identified in six of the eight variables measured. Of these six, value for learning and level of mindset were shown to have a negative significant linear trend, suggesting that over the year sense of value for learning decreased (β = -0.23, SE = 0.11, $p < .05$) and also level of growth mindset decreased (β = -0.23, SE = 0.09, $p < .01$). Further, the quadratic effects for mathematics competence (β = -0.27, SE = 0.10, $p < .01$), autonomous motivation (as measured by RAI) (β = -0.16, SE = 0.05, $p < .01$), value for learning (β = -0.48, SE = 0.11, $p < .01$), both subscales of grit (consistency of interest; β = -0.33, SE = 0.11, $p < .01$, perseverance of effort; β = -0.39, SE = 0.12, $p < .01$) and mindset (β = -0.32, SE = 0.14, $p < .01$), were all negatively significant. This negative effect indicates that students' scores migrate to the middle of the scale over time, becoming centred around the mean for each given motivation measure. Students with higher scores at Wave 1 show a decline in their score by Wave 2, where students in the lower end of the distribution at Wave 1 improve their scores by Wave 2.

Influence Similarity x Reciprocity effect. The effect of friendship influence was defined by the average similarity and reciprocity effect. A positive significant effect was identified for level of perseverance of effort (second sub-measure of grit) (β = 2.95, SE = 1.35, $p < .05$) and an effect estimate trending towards significance was identified for mindset (β = 2.42, SE = 1.32, $p < .07$). The significant finding indicates that students tend to adopt the perseverance of effort level of their friends over time, perseverance of effort being the only measure of motivation that was influenced by friendship network at a significant level, as the mindset measure was close to reaching the significance threshold, the interpretation here is less clear. All other findings for the average similarity and reciprocity effect were not significant.

Table 19. Siena estimates of math interest, math boredom, math competence and autonomous motivation (RAI) for selection and influence effects (Wave 1 and Wave 2). These measures are all subject specific to mathematics.

	Math Interest		Math Boredom		Math Competence		Autonomous Motivation (RAI)[a]	
Variable	Estimate (*b*)	*SE*	Estimate (*b*)	*SE*	Estimate (*b*)	*SE*	Estimate (*b*)	*SE*
Network effects								
Outdegree (density)	-1.296**	0.43	-1.246**	0.42	-1.287***	0.38	-1.987***	0.26
Reciprocity	1.345***	0.12	1.318***	0.12	1.336***	0.12	1.300***	0.13
Transitive triplets	0.003	0.05	-0.003	0.06	0.007	0.05	0.006	0.06
Balance	0.264***	0.03	0.270***	0.03	0.263***	0.03	0.278***	0.03
Selection effects								
Boarding alter	0.147†	0.08	0.158*	0.07	0.149†	0.08	0.057	0.09
Boarding ego	0.004	0.11	0.001	0.11	0.004	0.10	0.152	0.13
Boarding similarity x reciprocity	0.808***	0.23	0.805***	0.24	0.802***	0.24	0.548**	0.19
Motivation alter	0.005	0.03	0.048	0.04	-0.003	0.04	0.126	0.07
Motivation ego	-0.065	0.04	0.071	0.06	-0.061	0.06	-0.037	0.12
Similarity x reciprocity (selection)	0.095	0.57	-0.503	0.75	-0.333	0.51	1.320	1.49
Influence effects								
Linear Shape	0.011	0.05	-0.019	0.05	0.009	0.09	-0.049	0.05
Quadratic Shape	-0.034	0.04	-0.053	0.03	-0.272**	0.10	-0.163**	0.06
Average similarity x reciprocity (influence)	-0.310	1.02	-0.300	0.91	-2.423	1.67	0.711	1.23

[a] Autonomous motivation model ran with only 4 year groups, the upper two year groups were removed due to the transition to sixth form resulting in a substantial reduction in the number of students studying mathematics - in other models these year groups are included as items were adapted so that participants recalled their last experience of studying mathematics.
† *p* < .06 * *p* < .05 ** *p* < .01 *** *p* < .001

Table 20. SIENA estimates of value for learning, both measures of grit (consistency of interest and perseverance of effort) and finally growth mindset, for selection and influence effects (Wave 1 and Wave 2). These measures are all subject general.

	Value		Grit - Consistency of Interest		Grit - Perseverance of effort		Mindset	
Variable	Estimate (*b*)	*SE*	Estimate (*b*)	*SE*	Estimate (*b*)	*SE*	Estimate (*b*)	*SE*
Network effects								
Outdegree (density)	-1.352***	0.41	-1.318***	0.39	-1.342***	0.40	-1.301**	0.41
Reciprocity	1.231***	0.14	1.340***	0.12	1.289***	0.14	1.351***	0.13
Transitive triplets	0.005	0.05	0.009	0.05	0.01	0.05	-0.015	0.06
Balance	0.271***	0.03	0.263***	0.03	0.261***	0.03	0.274***	0.04
Selection effects								
Boarding alter	0.143‡	0.08	0.151*	0.08	0.141	0.08	0.151*	0.08
Boarding ego	0.016	0.11	0.013	0.10	0.009	0.10	0.024	0.11
Boarding similarity x reciprocity	0.847***	0.25	0.821***	0.24	0.872***	0.24	0.752**	0.25
Motivation alter	-0.001	0.07	-0.083	0.07	-0.044	0.09	0.042	0.10
Motivation ego	0.023	0.10	-0.072	0.11	0.048	0.13	0.282	0.17
Motivation similarity x reciprocity (selection)	2.421*	1.01	0.211	0.84	1.174	1.18	-0.022	1.14
Influence effects								
Linear Shape	-0.225*	0.11	0.099	0.07	0.022	0.09	-0.234**	0.09
Quadratic Shape	-0.480**	0.16	-0.333**	0.11	-0.387**	0.12	-0.316**	0.14
Average similarity x reciprocity (influence)	0.691	1.44	0.092	1.24	2.953*	1.35	2.424‡	1.32

‡ *p* < .07 * *p* < .05 ** *p* < .01 *** *p* < .001

4.4. Discussion

Following an increase in research on enhancing academic motivation in school children (Robbins et al., 2004), the current study focussed on the dynamics of friendship, and how social networks may influence the levels of motivation of students due to interaction and social connections with their peers. The present research aimed to explore the selection and influence effects across a range of measures of student motivation by utilising sophisticated longitudinal analyses that enable the modelling of these separate social processes (Veenstra et al., 2013).

4.4.1. Selection processes in understanding student motivation

Selection effects were limited in this sample, the only significant finding for similarity in motivation emerging from the value for learning measure. Therefore, while friendship selections do not seem to be formed on the basis of similarity in other measures of academic motivation, students are befriending those who have similar views to themselves regarding sense of value surrounding what they learn in school. This finding fits well with literature suggesting that we make friends with others when their attitudes and broader values match with our own (Brechwald & Prinstein, 2011). Students' sense of value for learning seems to be a relevant value through which adolescents form their friendships, insight that may be valuable when considering school engagement and classroom environments (Ryan & Patrick, 2001).

However, while level of value for learning is involved in friendship selections in the current findings, this result contradicts that of (Wang, Kiuru, Degol, & Salmela-Aro, 2018) who also used a multidimensional approach, looking at peer dynamics in relation to student engagement from a behavioural, emotional and cognitive perspective. In their findings, selection effects were only noted for behavioural engagement (truancy), as opposed to emotional (value, burnout, flow) or cognitive (effort) forms of engagement. In their research, value for learning was found to be influenced between friends over time, rather than identified as a selection effect, the opposite to the findings here. While there are considerations to explain the contradiction in findings, such as differences in the sample size and culture between this study and the current research, the conflict in findings only provides more evidence towards the growing body of research that demonstrates the complexity of adolescent relationships.

4.4.2. Influence processes in understanding student motivation

Similar to selection effects, influence effects measuring changes in motivation over time as a product of friendship were also limited in this population. The true influence effect was defined in these models as similarity and reciprocity, where a significant effect indicated that students adopt the same level of motivation as their friends over time. Of the motivation types measured, perseverance of effort (as a measure of grit) was the motivation variable that showed a significant positive effect, with mindset showing a result trending toward the significance threshold. The behavioural tendency for both perseverance of effort and mindset was such that high scorers became lower over time, and low scorers became higher. After accounting for the quadratic effects, there is a tendency for reciprocal friends to become similar over time, resulting in the students 'meeting in the middle' of the scale.

This means that one friend may be reducing their perseverance of effort to be similar to their friend, while the other increases theirs to become similar. In one sense,

peers provide support towards boosting perseverance in ways that cannot be provided by others, in that peers are often aware of special circumstances that put them in the correct position to encourage perseverance in their friend (Hamm & Faircloth, 2005). For example, if friend A (with low perseverance) confides in friend B (with high perseverance) over feeling pressure to succeed in a particular test, then friend B is in a position to encourage increased levels of perseverance in friend A. However, there is also the other side, where the perseverance of one student becomes lower. This could be the product of observational learning and exposure to the friend whose perseverance is low. Through vicarious experience of this state, the initial high level of perseverance could reduce (Bandura, 1977, 1986). It is also interesting that in the current investigation, perseverance and mindset level both seemed to follow the same pattern. Literature on grit (Duckworth et al., 2007) and growth mindset (Dweck, 2000) are often discussed in parallel, even more so in the context of how to increase these traits in educational settings (Fitzgerald & Laurian-Fitzgerald, 2016; Hochanadel & Finamore, 2015). Understanding the dynamics of these attributes in the context of friendship provides valuable insights for the development of specific interventions on the topic of grit and mindset.

The lack of significant findings in the other motivation measures contradicts the findings of Shin and Ryan (2014a) in their investigation of selection and influence effects in academic adjustment. In fact, their research suggested that intrinsic value for learning was influenced in a linear direction over time, while the current study identified no influence effects, demonstrating that selection was the more prominent effect in terms of value for learning and friendship dynamics. While similar methodology was employed, and the same number of time points used, there could be several reasons for this contradiction in findings, explained in terms of sample differences such as age and culture – expanded on in the limitations section below (section 4.4.4.). Moreover, the scale used in Ryan and Shin's paper is different to the scale used here, suggesting that the specific type of value assessed may be important for influence to be identified.

4.4.3. Effect of boarding status

Strong selection effects were identified by the inclusion of boarding status in the motivation models. Boarding students were not only more likely to be selected as friends, but also were more likely to reciprocate friendships with those who share the same boarding status as them. This result is to be expected if we consider the work of Martin et al. (2014). Martin and colleagues explained that, while differences in academic motivation and various other outcome measures (such as wellbeing and engagement) are sparse between day and boarding students, the boarding environment outside of the structured academic day is quite unique. Boarders are

exposed to ongoing activities and interactions with teachers and peers in a more structured way to day students, providing them with a very different ecological context to their non-boarding peers. This difference in day-to-day environment leads to differences in socialisation of the students (Bronfenbrenner, 1993). Therefore, selecting friendships based on the similarity of boarding status is to be expected; firstly, due to sheer exposure to one another and increased opportunity for friendships due to structured contact time, and secondly, due to the shared experience of being socialised away from family while staying at school.

4.4.4. Limitations and future directions

The current research explores academic motivation from a range of perspectives across a whole school sample, considering different theoretical approaches to motivation. Therefore, it is difficult for the current research to make comments about the developmental differences between ages as students change throughout the high school period. It is reasonable to suggest that the findings we see in the current study are for the most part unstable effects due to the fact that the data from each small year group were pooled as group (Ripley et al., 2018). The results are not lacking in value as a consequence of this, but future research may wish to focus on a smaller age range, or a larger study design to further this work and make extended comments on developmental trajectory. This future focus is supported by research such as that by Gremmen et al. (2017) who modelled selection and influence effects across a developmental trajectory, measuring academic achievement as their variable of interest. Their research showed evidence that selection effects are more prominent in younger adolescents, in terms of academic achievement (i.e. low-achievers prefer to select low-achieving friends) whereas influence effects arise in the following year once students get to know each other.

The distinctiveness of the sample used here should also be acknowledged. The use of a single gender private school sample from the UK has both positives and negatives. To our knowledge, this is the first investigation of this nature, and modelling the social dynamics of school populations has not yet been done in the UK. In using a single gender, we do not have any gender effects confounding the effects observed. Kretschmer, Leszczensky and Pink (2018) carried out an investigation on gender differences in selection and influence effects for academic achievement and identified that boys and girls do show different patterns. While influence effects are seen in both boys and girls, only girls showed selection effects. Although the variable of interest is different in the case of the current study, the results align in that our identification of influence effects was limited in comparison to the number of selection effects observed. Kretschmer and colleagues argue that this behaviour should be expected,

as girls form different types of social networks compared to boys. Firstly, the networks of girls are characterised by increased need for emotional closeness, followed by a need for fitting into the social context of the group. Also, there are gender differences in the way that girls are more likely to work together cooperatively on school related work compared to boys, while boys tend to show increased competitive behaviour with their peers in comparison to girls. Taken together, this theoretical reasoning describes the selection effects observed in female students (Kretschmer et al., 2018).

The current research furthers this work on gender differences by only focussing on a female sample however, further research can build on the current work by including a gender comparison and building on the models developed here. Further, the use of a private school reduces variation in socioeconomic status of the students attending the school, as those with higher household income are the most likely to send their children to private schools (Ryan & Sibieta, 2010). However, while this is a positive of the research in terms of avoiding confounds, it does limit the generalisability of the findings, as private boarding schools in the UK are not representative of the whole UK school system and are not comparable internationally due to the lack of demographic variance.

4.4.5. Conclusions

The focus on understanding motivation in school students is ever increasing. Adolescents have many influences in their lives that provide opportunities for motivation to increase or decrease, one of these strong influences being their peers. At school, students spend a lot of free time interacting with one another, providing the perfect environment for friendships to form and influence to spread. New techniques for modelling the processes in these friendship dynamics have enabled us to further understand selection and influence processes in social networks. The current research applied this sophisticated technique in order to break down the components of similarity in motivation between friends at school. It appears that the boarding status of a friend plays a large part in the selection of a friendship, along with selection effects being identified for levels of value for learning. In terms of influence effects, it appears that student's perseverance of effort is influenced to be in line with their friends over time. These findings contribute to the growing literature on selection and influence effects in education and provide new perspectives from a specialised school sample.

- Chapter 5 -

5. Investigating social contagion and motivation in the adolescent brain: Do friends show similar levels of brain activation in rewarding tasks?

5.1. Introduction

Social contagion, described as the involuntary 'catching' of behaviours and attitudes through connected individuals (Levy & Nail, 1993), is a relatively underexplored concept in the field of neuroscience. It is a complex process, with many components that must act together in order for contagion to occur. As outlined in the opening review (Chapter 1, section 1.1.) of this thesis, neuroscience can contribute to our understanding of social contagion in several ways. Firstly, the literature on automatic mimicry and imitation, underpinned by mirror neurons (di Pellegrino et al., 1992; Iacoboni, 2009; Rizzolatti & Craighero, 2004), gives a basic biological mechanism for the automated and unconscious aspect of contagion. Mirror neurons are implicated in executing goal-directed actions or experiencing emotions and observing similar actions or emotions in others, contributing to our social cognition (Gallese, Keysers, & Rizzolatti, 2004). Secondly, research on the social brain investigates the neurological basis of social conformity, in terms of structures that contribute to the more conscious decision-making processes that occur in the brain when we are deciding whether or not to 'follow the crowd' (for a review see Stallen & Sanfey, 2015).

Further, it is important to consider how we store and maintain mental representation of the social network that we are a part of, with recent research exploring how we retrieve and recognize those more familiar to us within the scope of our broader social network (Parkinson et al., 2017). It has also been suggested that social distance between members in a social network can be predicted by similarity in the activation of various networks in the brain, when participants view naturalistic stimuli (Parkinson et al., 2018). This finding supports the idea that similarity is not only based in the behaviour of friends but also occurs in neurological patterns representing connected friends.

5.1.1. Contagion in children and adolescents

So far, the majority of research that supports the perspectives outlined above are based on research in a wide range of sample populations. For the purposes of the current chapter, it is important to consider the findings of research on children and adolescents. In terms of mirroring, Pfeifer, Iacoboni, Mazziotta and Dapretto (2008) identified that when imitating and observing the emotions of others, children show activation in areas of the brain related to the mirror neuron system, demonstrating a

link between this system and social functioning (such as showing empathic behaviour) in typical development.

Further, this difference in behaviour and brain development translates to research on social conformity. Work in older adolescents has shown enhanced activity in the subcortical reward system of the brain as a product of peers being present and the associated potential reward value of partaking in risky behaviours (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011). Similarly, it has been recognised that social media platforms play a role in the social influence of neutral and risk-taking behaviour, in that viewing social media posts with more 'likes' is related to increases in activation in brain areas associated with reward processing and imitation (Sherman, Payton, Hernandez, Greenfield, & Dapretto, 2016). Therefore, the neural reaction to seeing material that is more popular in terms of 'likes' and also riskier in terms of content has implications for peer influence processes during adolescence (Sherman et al., 2016). Additionally, adolescents are unique in that, during development from childhood to adulthood, they demonstrate non-linear changes in their behaviour. This is characterised as increases in impulsive or risky behaviours, explained by delayed development of top down prefrontal regions in comparison to subcortical regions, such as the ventral striatum (VS), that is involved in emotions such as desire, and the amygdala which is involved in processing fear (Casey et al., 2011). For a further review on the social neuroscience behind risk taking behaviours during adolescence, see Steinberg (2008).

5.1.2. Motivation in the brain

The reward system in the brain has numerous roles, not only in risk taking, but for many other motivated behaviours. One of the areas of the reward system that is well recognised for its role in motivation and learning reinforcement is the striatum (Robbins & Everitt, 1996). Along with its broad role in many other aspects of cognitive functioning, the striatum is implicated in learning to predict reward and acting to receive those available rewards (Shohamy, 2011). In existing literature, there is a distinction made between the role of the VS (nucleus accumbens) and dorsal striatum (DS) (caudate nucleus and putamen). The VS is implicated in response to reward prediction errors, with the DS being implicated in the actions that we take in order to seek reward or to resolve the errors; by this mechanism, the striatum supports the learning process (Bornstein & Daw, 2012).

Areas of the frontal cortex are also implicated in reward and goal-based learning and motivation. The orbitofrontal cortex (OFC) has been associated with goal-directed behaviours, or, motivated behaviours (Rangel & Hare, 2010), complementing the more reflexive activation of the striatum to complete various forms of learned behaviours (Shohamy, 2011).

5.1.2.1. Incentive tasks as measures of reward in the brain

One of the most common tools to measure response to reward in neuroimaging research is the Monetary Incentive Delay (MID) task (Knutson, Westdorp, Kaiser, & Hommer, 2000). In the version of the task that is usually administered to adults and young adults, participants are typically shown a cue indicating the amount of reward available to them in a given trial. Following this, a speeded response must be made to a target, after which success or fail feedback is provided indicating whether the reward will be received or not. In a series of studies using the MID task, the same cluster of brain regions, notably in the striatum, are consistently identified as showing increased brain activation in response to reward cues that are associated with higher value, or stronger incentive for pursuit of the reward (Knutson, Adams, Fong, & Hommer, 2001; Knutson, Fong, Adams, Varner, & Hommer, 2001; Knutson, Fong, Bennett, Adams, & Hommer, 2003; Knutson et al., 2000).

Through use of the MID task, it has been shown consistently that the anticipation phase of the task activates ventral striatal regions of the brain, while receiving the reward following the anticipation activates areas including and surrounding the ventromedial frontal cortex (vmPFC) (Breiter, Aharon, Kahneman, Dale, & Shizgal, 2001; O'Doherty, Deichmann, Critchley, & Dolan, 2002; Rademacher et al., 2010). By breaking up the components of reward processing in this way the MID task allows different elements of the process to be examined, and variations to the task to be introduced in order to assess different parts of the process (for a review see Lutz & Widmer, 2014).

In one such variation, Izuma, Saito and Sadato (2008) compared activation elicited by social and monetary reward delay tasks. In the social variation, the focus was on the reputation of the individual participating in the research, eluded to have been formed by other participants, while the monetary reward task was a basic gambling paradigm. Notably, activation was present in reward-related areas for both tasks. Both the monetary reward task and the social reward task replicated the results of previous literature in showing reward-based activation in areas such as the striatum, while the monetary reward task also showed activation in the OFC, in line with past research using this specific paradigm.

5.1.3. Reward as a pathway to contagion

In keeping with the motivation perspective that was provided at the outset of this manuscript, theories of motivation provide a clear mechanism through which social contagion can occur. In the example of self-determination theory (SDT; Ryan & Deci, 2000), a person may want to assimilate the behaviours and values of another person in order to feel more related to them, or, a person may wish to become similar to others

in order to gain some form of rewarding feeling via intrinsic or extrinsic motivation. Further to this, social learning theory would suggest that similarity may occur due to vicarious experience: observing someone else find something rewarding may increase that persons own sense of reward for the particular task. By extension, it is natural to assume that social contagion occurs, especially in the reward network. For example, research by Mobbs et al. (2009) investigated the idea that as humans, we have a prosocial tendency that enjoys watching others succeed. In a study based on a game-show style paradigm, the authors identified that similarity is important for the experience of vicarious reward in that when a participant perceives themselves to be similar to the actor being rewarded, activation in the ventral anterior cingulate cortex increases. This region is associated with emotion and self-relevance and projects to the ventral striatum. These findings lead to the question: if you learn to experience intrinsic reward vicariously, will you then show similar neural response to reward as your friend?

Research on social preference has shown that our preferences are influenced by what others favour, but only when the other person is someone that we like. During times when there is dissonance between the subjects' own preference and the preferences of other people, there is increased activity in the dorsomedial prefrontal cortex (dmPFC) (Izuma & Adolphs, 2013). This finding supports the idea that those who are connected via friendship might share both similar beliefs or attitudes to others and therefore similarities in underlying brain activity (see also, Campbell-Meiklejohn, Bach, Roepstorff, Dolan, & Frith, 2010). Further, the dmPFC and dorsolateral prefrontal cortex (dlPFC) are implicated in the learning and prediction of others' decisions as part of our social cognition processes, evidence of the processing of others' actions to inform our own (Burke, Tobler, Baddeley, & Schultz, 2010; Suzuki et al., 2012).

Moreover, research by Davey, Allen, Harrison, Dwyer and Yücel (2010) has shown that the experience of being liked by another – as experienced in a friendship – activates primary reward centres in the brain (including the nucleus accumbens, midbrain, vmPFC, posterior cingulate cortex, amygdala, and insula/opercular cortex). Moreover, the level of regard for the person provided information on their like for the participant affected level of activation in the vmPFC and amygdala. By attempting to demonstrate these reactions to socially driven behaviours in friendships, the study presented here has the potential to build a case for the presence of similarity in patterns of brain activation between these connected individuals.

5.1.4. Current research

The current study aims to address the question: Do the brains of friends react similarly to intrinsic reward compared to those who are not friends? Based on the findings of previous behavioural research and the combined conclusions that can be drawn from the neuroscientific literature presented above, it is predicted that the brains of socially connected individuals will show correlated levels of reactivity in the striatum in reaction to the cue phase of a MID task (Knutson et al., 2000). Further, in response to the feedback phase of the task we expect to find differences in observed correlation between levels of reactivity in friends and non-friends in the OFC/vmPFC (Knutson et al., 2003).

5.2. Methods

5.2.1. Sample

Participants were 62 female adolescents (mean age = 12.73 years), recruited from a small independent day and boarding school for girls in the UK as part of a wider investigation on the relationship between friendship networks and motivation at school (as covered in Chapter 2, 3, & 4). The sample consists of students from two different year groups (Year 8 & Year 9 in the UK schooling system), providing two independent social networks, analysed separately in the following analyses. Of the whole sample population, data from 11 subjects were excluded from the analysis due to artefacts in the data caused by fixed dental braces. The remaining 51 participants had the following ethnic composition: White = 84%, Asian = 2%, Black = 10%, Mixed = 4% (92% British/English nationality). Final breakdown of year group numbers was as follows: 12-13 years; *n* = 23, 13-14 years; *n* = 28. In terms of participation rates, this equated to 34.3% representation of the 12-13 years cohort and 45.2% representation of the 13-14 years cohort.

All participants were screened to check their eligibility to enter the magnetic resonance (MR) environment. Legal guardians completed magnetic resonance imaging (MRI) screening procedures with trained members of staff from the Centre of Integrative Neuroscience and Neurodynamics (CINN) (copies of screening forms in Appendix 8.15. and 8.16.). This provided a clean bill of health with no known neurological problems for all participants. Informed consent was obtained first from each participant's legal guardian (information sheet and consent form in Appendix 8.17. and 8.18.) after which all participants provided informed assent (information sheet and assent form in Appendix 8.19. and 8.20.). The study was approved by the University of Reading Research Ethics Committee, UK (UREC 17/07; Appendix 8.21.).

5.2.2. Procedure

Data were collected in a single visit to the University of Reading. During a visit, participants completed a 30-35 minute MRI scan and also provided their social network information via an online questionnaire. Following the functional scan, participants completed a sort post-scan survey about their experience of the task.

5.2.2.1. Network measures and characteristics

To measure the students' friendship connections, participants were asked to nominate up to five people from their year group to whom they considered themselves to be closest (Coie et al., 1982). The resulting data is used to construct a directed binary adjacency matrix for each social network, in which the presence of a tie is represented by a '1' and no tie represented by a '0'. These adjacency matrices are then included in later assortativity analyses to assess similarity in brain activation between socially connected individuals in comparison to those who are not socially connected. In this analysis, only students included in the MRI sample are included in the matrices. These students nominated an average of 2.49 friends each after removing nominations to friends who were not part of the scanned sample. Students in the lower year group nominated 2.43 friends while those in the upper year group nominated 2.53 friends each.

5.2.2.2. Experimental task

The piñata task (Helfinstein et al., 2013) was used as the template for the experimental task. This task was developed as a child suitable version of the MID task, originally developed by Knutson, Westdorp, Kaiser and Hommer (2000). In keeping with our research question, we wanted to investigate implicit motivation and the internal sense of feeling rewarded, therefore we removed the external monetary incentive aspect of the task. As shown in Figure 4, each trial is comprised of three stages: anticipation, response to target and feedback (See Figure 4, for details). At the beginning of the trial, the participant is presented with a cue which indicates the potential level of reward of either no stars, 1 star, 2 stars or 4 stars. This is followed by an anticipation phase, after which the participant is presented with the target piñata and is required to press a button press within a specific time window to release their reward. The success of their response is indicated by the number of sweets that fall from the piñata in the final feedback phase of the trial. To be successful in the trial, the participant must press the response button in the specific time window, the range of which is decided by participant response times during a 22-trial practice carried out outside of the scanner, prior to the scan.

All trial parameters remained consistent with the original child-friendly MID task (see Helfinstein et al., 2013, for full details). The initial reward cue was presented for

1500ms, followed by an anticipatory period of between 1000 and 2000ms. Next, there was a pre-determined but varying time interval for the target response with a subsequent delay period which totalled 1500ms. Finally, feedback was presented for 1500ms. Between trials there was an inter-trial interval (ITI) of between 1000ms and 2000ms. The task consisted of one practice run of 22 trials (carried out pre-scan), with four blocks of 22 trials completed in the imaging phase, giving a total of 88 task trials to be analysed.

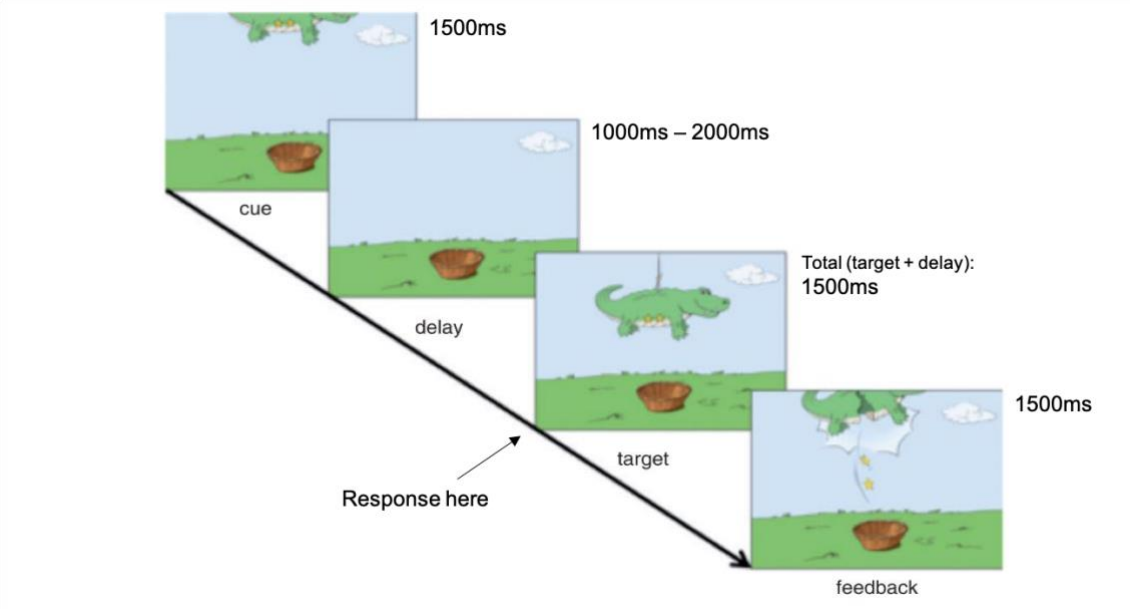

Figure 4. Trial structure of the piñata task.

5.2.3. Image acquisition

Participants were scanned in a Siemens MAGNETOM Prisma 3 Tesla whole body MRI scanner using a 32-channel head coil. The task stimuli were back projected via a head coil mounted mirror onto the screen at the head of the scanner table. Foam padding was used to restrict head movement. Behavioural data were collected via a four-button response box (Current Designs, Inc., Philadelphia, PA, USA).

Scanner parameters were as follows: T2*-weighted Siemens two-dimensional multiband gradient-echo echo-planar sequence (repetition time, 1500ms; echo time, 30ms; multiband slice acceleration factor, 4; GRAPPA, 2; flip angle, 66°; echo spacing, 0.93; EPI factor, 96; phase-encode direction, posterior > anterior; slices, 68; 96 x 96 matrix; field of view, 192mm; voxel size, 2mm x 2mm x 2mm). Scans varied in length between participants, with the sequence being manually stopped at the end of the task. For this reason, the total number of volumes collected for each participant varied. Additionally, a high-resolution structural image was collected from each participant using a T1-weighted MP-RAGE sequence with the following parameters; 176 0.94mm

axial slices; repetition time, 2300ms; echo time, 2.29ms; flip angle 8°; 256 x 256 matrix, field of view 240mm; in-plane resolution 2mm x 2mm; bandwidth 200 Hz/Px.

5.2.4. Imaging processing and analysis

5.2.4.1. Pre-processing

All image processing and data analysis were performed using the FMRIB Software Library (FSL; FMRIB, Oxford, UK; Jenkinson, Beckmann, Behrens, Woolrich, & Smith, 2012). Following visual inspection of all EPI images all images went through the following pre-processing. Firstly, all structural images were reoriented to fit a standard viewing orientation. Following this, brain extraction (BET: Smith, 2002) was performed. At this stage the quality of the brain extraction was checked manually and adjusted to the best fit for each participant. Once all brain extractions were complete, a study-specific template was created to ensure the template would be representative of the ages in the sample population, in order to increase spatial normalisation accuracy.

To do this, linear and non-linear registration were performed using FSL's FLIRT and FNIRT functions (FLIRT: Jenkinson, Bannister, Brady, & Smith, 2002a; Jenkinson & Smith, 2001; FNIRT: Andersson, Jenkinson, & Smith, 2010). Each participant's structural image was registered to one randomly assigned participant's structural image, followed by registration to the average of all participants. The last step of the registration was repeated to ensure that all participants were equally represented, with no over-representation of the randomly assigned participant to whom everyone else was registered in the first stage. Once the study-specific template had been prepared it was used as the standard reference image in further stages of analysis, additional pre-processing being carried out using FEAT (Woolrich, Ripley, Brady, & Smith, 2001). MCFLIRT (Jenkinson et al., 2002) was used for head motion correction.

MELODIC ICA (Beckmann & Smith, 2004) data exploration was selected as part of the FEAT set-up to be used as a tool for implementing user defined training files to be entered into FMRIB's ICA-based de-noising software, FIX (Griffanti et al., 2014; Salimi-Khorshidi et al., 2014). FIX aims to separate 'good' from 'bad' components in the data, removing the 'bad' or noisy signals such as those from movement, scanner artefacts, blood vessels or cerebrospinal fluid. In order to prepare training data for FIX, the independent components from 10 participants were classified by hand as either noise or signal and verified by another researcher for reliability. Once classification of training data is complete, FIX works in three stages: first the features of the training data are extracted, determining the best threshold for the following second stage where all ICA components are classified before the final stage where data clean-up is applied. Following FIX, spatial smoothing was performed using a 5mm full-width half-maximum Gaussian smoothing kernel using the FSL fslmaths sigma (-s) function.

5.2.4.2. First level analysis

At the first level analysis, six explanatory variables were included in the general linear model. These were responses to trials that had: zero stars; 1 star; 2 stars; 4 stars; hits and misses. The star level corresponds to the cue element of the task and the hit or miss trials correspond to the feedback phase of each trial. One contrast examining the linear relationship of the star cue was investigated for the cue phase of the task. As the cue incentive increased through zero, one, two and four stars, the linear relationship was defined as -7, -3, 1 and 9 for this contrast. The second contrast examined hit over miss trials, to investigate the feedback phase of the trials.

5.2.4.3. Second level analysis

Analysis was carried out at the group level using pre-thresholding masks of the striatum and OFC to investigate whether there was significant group level striatal activation in response to the cue phase of the task (linear stars contrast), and whether there was significant group level OFC activation in response to the feedback phase of the task (hit<miss contrast). Additionally, exploratory whole brain analysis was conducted using the two contrasts of interest, to establish other areas of the brain that showed significant activation during each phase of the piñata task, at group level.

To create the striatal and OFC masks used in this stage of analysis, anatomical maps of the striatum and OFC regions of interest (ROIs) were defined using the Harvard-Oxford Cortical and Subcortical atlases in Montreal Neurological Institute (MNI) 2mm brain space. For the striatal mask, the nucleus accumbens, caudate, putamen and pallidum were all included. Further, this mask included the lentiform nucleus to ensure that the caudate and putamen were connected, in line with the mask created by Helfinstein et al. (2013) in their validation analyses. These masks were then transformed into the study-specific group space using FLIRT, FNIRT, INVWARP and APPLYWARP functions within FSL. The single masks created were converted from MNI space to group space and used in later analyses.

To do this, firstly, FLIRT, for linear registration, followed by FNIRT, for non-linear registration, was applied for the registrations between the study-specific template (as created during pre-processing) and standard space. The non-linear registration (FNIRT) produces the warpfield files required to create an inverse of this transformation. The inverse warpfield file was then created using the INVWARP function, producing a standard space to study-specific group space warpfield, as an output. Finally, APPLYWARP was used to apply this inverse warpfield to the MNI brain space defined masks (construction outlined above), producing striatal and OFC masks that are transformed into the study-specific group space.

These masks were then entered in two separate second level analyses as pre-thresholding masks. The first analysis used the striatal group mask with the contrast representing the linear relationship of cue level, with the second analysis using the OFC group mask with the hit over miss feedback contrast. For clarification, the same group space striatal and OFC masks are used for each individual in the second-level analysis. A cluster threshold of $z = 2.3$, $p < 0.05$, was applied.

5.2.4.4. Similarity analyses

In order to address the question of whether connected individuals show greater levels of similar striatal activation to the cue phase of the task, and or, similar levels of OFC activation to the feedback phase of the task compared to non-connected individuals, individual levels of brain activation were used in a series of assortativity analyses. To do this, activation values were extracted from each participant, using the output of the first level analysis. To extract these values, firstly, anatomically defined and functionally defined masks of the striatum and OFC were created. The functionally defined masks were defined from the second-level outputs that generated a binary mask of striatal and OFC clusters. The anatomically defined masks were those transformed from standard MNI space to the study-specific group space (as described above section 5.2.4.3.).

As the above masks were all in study-specific group space, they needed to be warped into each participant's functional space before the extraction of activation (beta) values. To do this, INVWARP and APPLYWARP functions within FSL were applied. Firstly, INVWARP was used to obtain the inverse warpfield from standard subject space to functional subject space using each participant's functional to standard registration file. Following this, APPLYWARP was used to apply the inverse warpfield to the different masks. For clarity, input for the APPLYWARP functionally defined masks were the binary striatal and OFC cluster masks from the outputs of the second, group level analysis and input for the anatomically defined masks were the same as those used as input for the second-level analysis; the anatomical masks transformed into study-specific group space from standard MNI brain space.

The above masks were then used to extract maximum and mean intensity values across all voxels within the defined ROIs. Using fslmaths and fslstats, the masks can be applied to each participant's unthresholded stats files for each contrast. Fslmaths applies the mask to the data, and fslstats extracts the maximum and mean intensities. Assortativity analyses were run on the extracted values using the package *assortnet* in R (*v0.12*, Farine, 2014) to determine similarity of activation in the striatum and OFC, between friends.

5.3. Results

5.3.1. Confirmatory analyses

In order to investigate activation in the striatum, the contrasts included in the general linear model for the analysis were based on the cue phase of the task. Here, one contrast was included assessing the linear parametric relationship between the stars; through 0 stars, 1-star, 2-stars and 4-stars. The contrast to assess the OFC activation investigated the feedback phase of the task and assessed the hit over miss trials. These two contrasts were included in all following confirmatory analyses.

5.3.1.1. Task activation

In order to establish whether the results of previous research (Knutson et al., 2003, 2000) could be replicated in the current sample at the group level, the activation in the striatum in reaction to the cue phase of the task, and in the OFC in reaction to the feedback phase of the task was investigated. To do this, second level analysis on the group data was performed using masks of the striatum and OFC. The results of these second level analyses are presented in Table 21 below.

Two significant clusters representing bilateral activation were identified in striatum for the linear incentive cue-based contrast and one left lateralised cluster identified in the OFC for the hit versus miss contrast. Significant clusters are displayed respectively in figures 5 and 6. These results, though more lateral in the OFC than previously reported, are consistent with the previous literature using the MID task (Helfinstein et al., 2013; Knutson et al., 2003, 2000).

Table 21. Z-scores and MNI coordinates of foci of activation in the striatum and OFC from ROI analysis on each of the contrasts. Coordinates are in voxels (study subject space).

Contrast	Region	Cluster size (voxels)	Coordinates (X, Y, Z)	Peak activation
Linear stars	Striatum	2035	-14.4, 23.7, 9.71	4.03
	Striatum	1795	7.97, 21.5, 23.2	4.72
Hit > miss	Orbitofrontal Cortex	1009	-16.7, 51.2, 12	5.31

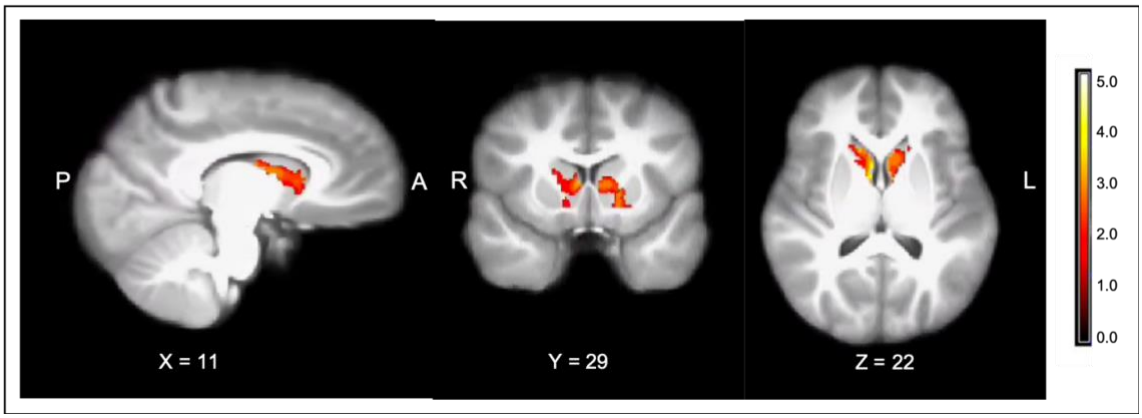

Figure 5. Striatal ROI fMRI results for linear parametric contrast showing bilateral striatal activation, z = 2.3, p < 0.05, corrected.

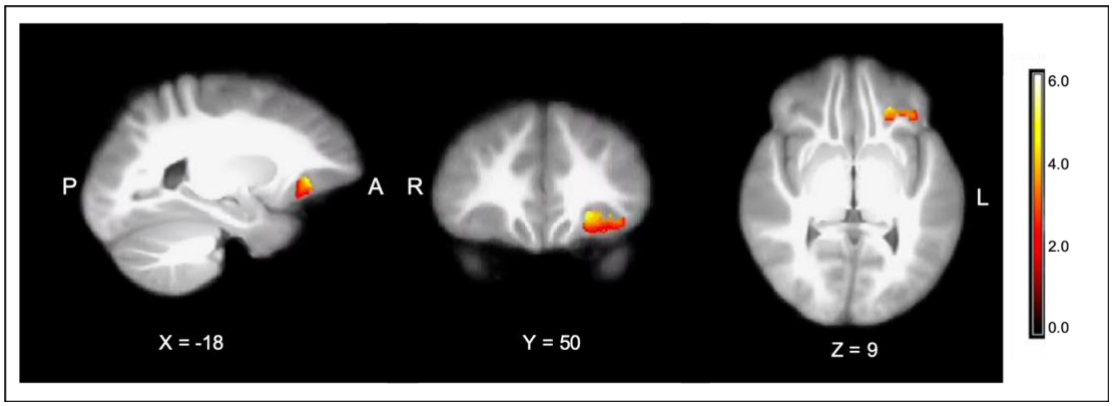

Figure 6. OFC ROI fMRI results for hit > miss contrast showing left lateralised OFC activation, z = 2.3, p < 0.05, corrected.

5.3.2. Similarity analysis

Following the identification of striatal and OFC activation in response to the piñata task, assortativity analysis was conducted to assess the level of similarity between connected individuals in these two brain regions. Maximum and mean voxel intensity levels were extracted from the striatum and OFC using both anatomically defined and functionally defined ROI masks. Following this, assortativity analysis was carried out on each year group separately, due to the independence of social networks. Results from this initial analysis from the different contrasts are presented in table 22 and 23. Table 22 shows the results from the anatomically defined masks, and Table 23 shows results using the functionally defined masks.

Table 22. Assortativity analyses, calculated using maximum and mean activation values, extracted using anatomically defined masks specified to the subject space. Masks of the striatum were used for the linear star contrast, relating to the cue

incentive, with masks of the OFC used for the hit > miss contrast, related to the task feedback phase.

	r	*se*	*p*
Linear stars (striatal activation)			
Maximum Activation Value			
12-13 years	0.34	0.10	0.00***
13-14 years	-0.04	0.12	0.75
Mean Activation Value			
12-13 years	0.25	0.10	0.01*
13-14 years	-0.04	0.08	0.66
Hit > Miss (OFC activation)			
Maximum Activation Value			
12-13 years	-0.07	0.14	0.61
13-14 years	-0.18	0.12	0.15
Mean Activation Value			
12-13 years	-0.10	0.13	0.42
13-14 years	-0.12	0.12	0.28

** p < .05 ** p < .01 *** p < .001*

When extracting beta values using anatomically defined masks of the striatum, mean activation was significantly similar between connected individuals in the 12-13 year old group for parametric incentive cue-based activation (r = .25, p = .01). Further, in the same group, levels of maximum activation were significantly similar across the parametric incentive cue-based activation (r = .34, p < .001). Assortativity indices in the older year group (13 -14 years) were for the most part negative, indicating that friends tend to be opposite in their levels of activation for a given contrast, however, none of these correlations reached the significance threshold. Additionally, it appeared that activation in the OFC in response to feedback during the task did not show significant similarity or dissimilarity between friends in either group.

Table 23. Assortativity indices, calculated using mean activation values, extracted using functionally defined masks specified to the subject space (maximum values are identical to functionally defined masks). All other detail as seen in table 26, above.

	r	*se*	*p*
Linear stars (striatal activation)			
Mean Activation Value			
12-13 years	0.18	0.08	0.02*
13-14 years	0.03	0.11	0.82
Hit > Miss (OFC activation)			
Mean Activation Value			
12-13 years	0.09	0.12	0.44
13-14 years	-0.18	0.12	0.12

** p < .05*

Following the identification of activation in response to the task in both the striatum and OFC at the group level, the assortativity analysis was also carried out using a functionally defined map of the clusters that were identified in these regions. Using this method, only mean parametric incentive cue-based activation was identified to be significantly similar between friends (r = .18, p = .02).

Following the analysis of each social network separately, a fixed effects meta-analysis was performed in order to see any effects that were consistent across both year groups (i.e. social networks). The results from these meta-analyses for each contrast of interest can be seen in Table 24.

Table 24. Output from the meta-analyses of the assortativity indices for each contrast of interest. Results from both anatomically defined ROIs and functionally defined ROIs are included.

	r	*se*	*p*	*CI (Lower)*	*CI (Upper)*
Anatomical Masks					
Linear stars (striatal activation)					
Maximum Activation Value	0.182	0.07	0.015*	0.036	0.329
Mean Activation Value	0.080	0.06	0.213	-0.046	0.206
Hit > Miss (OFC activation)					
Maximum Activation Value	-0.129	0.09	0.157	-0.309	0.050
Mean Activation Value	-0.115	0.09	0.180	-0.283	0.053
Functional Masks					
Linear stars (striatal activation)					
Mean Activation Value	0.130	0.06	0.0422*	0.005	0.256
Hit > Miss (OFC activation)					
Mean Activation Value	-0.052	0.08	0.541	-0.217	0.114

** p < .05*

As is shown in Table 24 significant similarity was identified across both year groups when assessing the parametric incentive cue-based activation in the linear stars contrast for both the maximum activation value when using an anatomical mask, and mean activation value when using the functionally defined mask (r = .18, 95% CI = [0.04, 0.33] p = .015; r = .13, 95% CI = [0.005, 0.26] p = .042, respectively). No other significant effects were identified through meta-analysis of the year groups.

5.3.3. Exploratory analysis

5.3.3.1. Whole brain analysis

For completeness, whole brain analysis using the linear stars contrast and hit over miss contrast revealed further significant clusters that were active in addition to the expected ROI clusters, giving an overall indication of all brain regions that are involved in the cue and feedback phases of the MID task. In this analysis, five main clusters were identified in the linear stars contrast, and seven clusters identified in the hit > miss contrast (detailed in Table 25 and displayed in Figure 7 & Figure 8).

In the linear stars analysis, the visual cortex was strongly activated as participants processed the varying star reward values presented in the piñata task. The activation is represented by the two largest bilateral clusters in the left and right visual cortex (peak activation in the left and right occipital poles). As in previous research, the cue phase of the task elicited activation in the caudate nucleus – part of the striatum. Additional to these regions, the analysis also showed activation in the left pre- and post-central gyri, most likely in response to participants' preparation to respond to the task, ahead of receiving feedback.

When receiving feedback, a large cluster is present spreading laterally across the occipital and temporal lobes (peak activation in the left occipital fusiform gyrus). This region is associated with higher level visual processing. Clusters were also identified in the left and right OFC, supporting the findings of previous studies implementing the MID task. Additional clusters in reaction to the feedback phase of the task include the middle and superior frontal gyri and the precentral gyrus – areas related to higher level processing.

Table 25. Z-scores and MNI coordinates of the activation present in the linear star and hit > miss whole brain analysis. Coordinates are in voxels (study subject space).

Contrast	Region	Cluster size (voxels)	Coordinates (X, Y, Z)	Peak activation
Linear stars	Left occipital pole	60203	-11.7, -72.8, -6.48	8.99
	Right occipital pole	39616	21.3, -70.2, -0.856	9.34
	Left precentral gyrus	32079	-39.9, -3.83, 66.5	4.65
	Right caudate	14392	6.15, 24.4, 23	5.09
	Left postcentral gyrus	5380	-7.07, -53.1, 59.6	4.41
Hit > Miss	Left occipital fusiform gyrus	265969	-22.9, -64.9, 5.95	8.5
	Left orbitofrontal cortex	17318	-16.7, 52.1, 11	5.32
	Right caudate	5447	12.9, 33.3, 19.4	4.65
	Right orbitofrontal cortex	3454	28.5, 52.8, 9.36	6.9
	Right middle frontal gryrus	2896	52.6, 48.3, 39.1	4.77
	Left superior frontal gyrus	2133	-18.3, 43.1, 71.1	3.88
	Left precentral gyrus	2098	-38.3, 19.8, 45.7	4.56

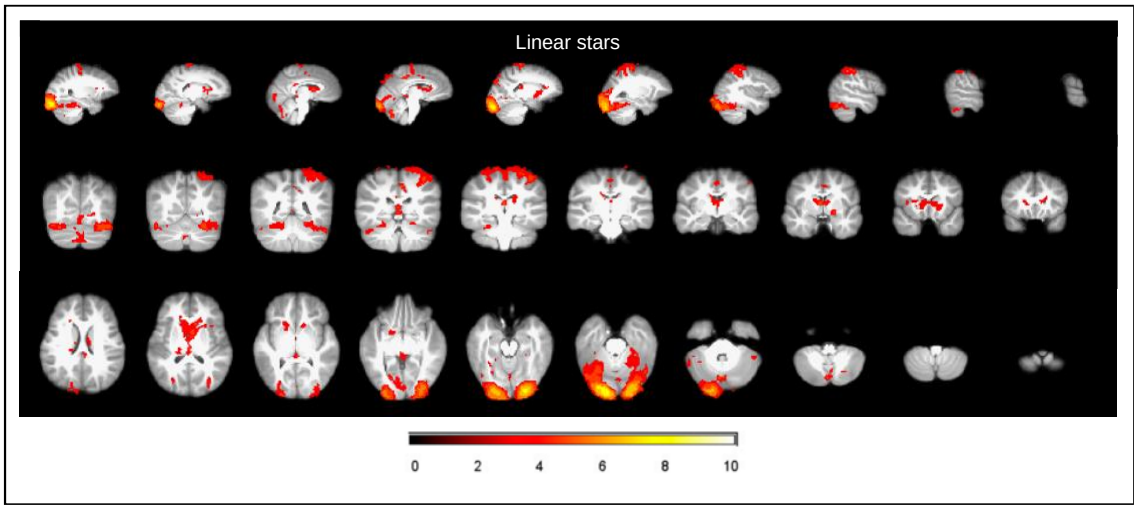

Figure 7. Whole-brain fMRI results. Regions showing parametric incentive cue-based activation (linear stars), z = 2.3, p < 0.05, cluster-level FWE corrected.

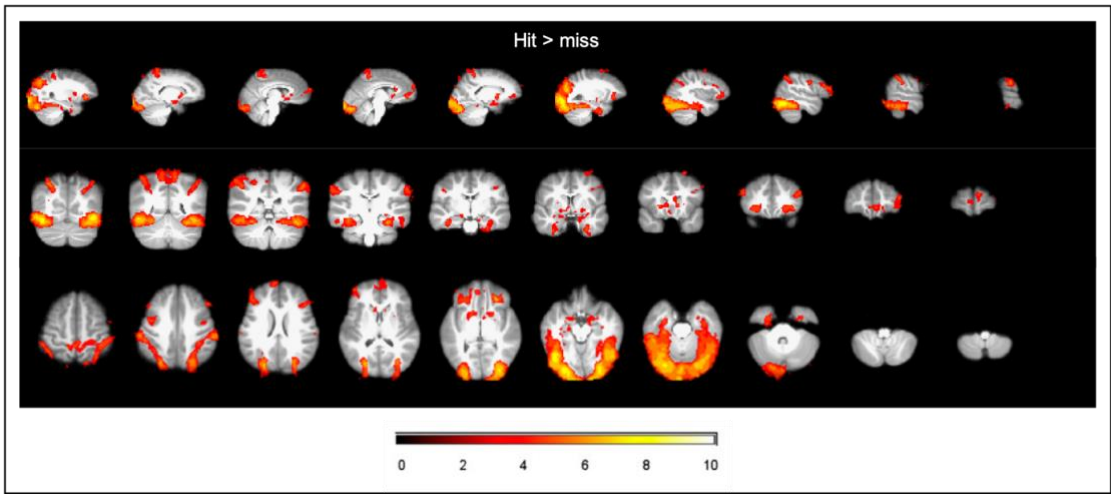

Figure 8. Whole-brain fMRI results. Regions showing hit over miss activation (reaction to feedback), $z = 2.3$, $p < 0.05$, cluster-level FWE corrected.

5.4. Discussion

The current research aimed to explore the relationship between friendship connections and motivation, looking to investigate whether levels of motivation are more similar between friends than between non-connected individuals. Social network data was collected from students in a school-based social network (defined as the year groups in the school) and a subset of these students were invited to participate in an MRI study where functional data was collected from students during a reward-based task – the piñata task.

Overall, the current study was able to replicate the findings of Helfinstein et al. (2013) who validated the piñata task as a child friendly version of the MID task (Helfinstein et al., 2013). The current study replicated the common finding that the cue phase of the task elicits activation in the striatal regions of the brain, with the feedback phase of the task showing activation in the OFC. Following this successful replication, the current research explored whether this activation is more similar between friends compared to non-connected individuals. Through using the same assortativity analysis method as used in Chapter 2 and Chapter 3, mean and maximum levels of striatal and OFC activation in each individual could be used as the variable of interest in the similarity analysis. These values were extracted from the imaging data using both anatomically and functionally defined masks.

Results from this analysis were varied in that no clear pattern of similarity emerged across the different forms of ROI masking. When assessing the similarity in parametric incentive cue-based activation, the 12-13 year old year group showed significantly similar levels of activation for both mean level of striatal activation and maximum intensity level within the defined striatal ROI. In this case, the positive

significant assortativity indices suggests that the connected dyads within the network have significantly greater correlated levels of activation in the striatum, based on the parametric incentive. These significant findings provide partial support for the original hypothesis that friends will show similar levels of activation in the piñata task. However, in the older year group (13-14 years), none of the investigated contrasts yielded significantly similar activation between connected individuals. The lack of significant finding in either direction (towards assortativity or towards disassortativity) indicates that there is neither strong similarity nor dissimilarity within friendship ties in the 13-14 year old group for activation of the striatum, partially refuting the hypothesis.

In regard to the analysis of the hit versus miss trials, activation in the OFC in response to the hit feedback showed non-significant findings across both year groups for both maximum and mean activation of the ROI. This finding was the same regardless of the method of ROI masking.

In fact, significant similarity in parametric incentive cue-based activation was the only effect to be sustained across the two methods of masking. Additionally, when meta-analysing the results across the two year groups the same effect (i.e. significant similarity in parametric incentive cue-based activation) was the only effect to show significant similarity when synthesising the two cohorts together – this effect was present in the meta-analysis for both anatomical and functional masking of the ROI (in this case the striatum).

Finally, in exploratory whole brain analysis, five main clusters were identified in the analysis of the cue phase of the task, with seven main clusters identified for the feedback phase. In addition to clusters in the striatum for the cue phase analysis, and OFC for the feedback phase analysis, clusters were identified in visual cortex, motor and somatosensory cortices and various parts of the frontal cortex. The other brain regions that were activated by participation in the piñata task would be expected due to the visual nature of the task and the preparation and performance of the response during the task. Frontal regions in the brain are also related to the processing of the feedback, as shown by the clusters identified in the hit greater than miss whole brain analysis.

5.4.1. Similarity in motivation

Previous research has suggested that neural homophily exists between friends when viewing naturalistic stimuli (Parkinson et al., 2018). In the current study this idea is extended by exploring the homophily of activation in response to reward as a measure of the motivation of individuals. From this investigation, it appears as though neural homophily in terms of motivation may be somewhat similar between friends but shows a high level of variation between groups and different social networks. This

insight that motivation is common between friends gives understanding into not only the social brain but also the mechanisms behind the motivation to learn. If certain pairs of friends show similar levels of response to different levels of incentive, then this similar characteristic may drive their classroom behaviours. However, this apparent similarity was only found in one of the samples included and only for the cue phase of the task – eliciting activation related to the dorsal striatum and reward seeking behaviours. Nevertheless, by comparing the brain activity of connected friends, this current research compliments the neuroscientific work on social cognition by adding a new peer perspective to the current body of work.

As mentioned, the main significant findings that emerged from this research were from the younger year group. Similarity was present in the reaction to the cue phase of the task, with more similar responses in connected individuals to the parametric cue-based activation as the star reward value increased from one to four stars. However, in the older year group no such similarity existed (apart from when meta-analysed with the younger group). In older students, research has shown that the reward system is activated in the presence of opportunity to partake in risky behaviours with peers (Chein et al., 2011); something that the current task did not directly address. Therefore, in a task where actual peer interaction is more central to the design, similarity in activation may be more prominent. Furthermore, it has been shown that there are differences in the way that curiosity effects learning and memory between children (10-12 years old) and adolescents (13-14 years old), providing another example of the developmental differences that exist within these small age increments (Gruber & Fandakova, 2019).

Considering the concept of reward as a pathway to contagion, the mixed findings of the current research can be further explained by this idea. While some individual students may be highly susceptible to the vicarious experience of their peers' motivational and reward behaviours within a friendship pair, others may be less so. Zimmerman (2000) discusses how the effectiveness of vicarious experience depend on a person's self-comparison with others by whom they may be influenced, and the achievement levels of those they observe. As such, larger differences between the observer's potential outcomes and the person they are modelling themselves on may lead to differences in the way that the vicarious experience evolves.

5.4.2. Limitations and future directions

This study has some limitations in its design. By using assortativity analysis, the connections that students reported to those outside of the scanned network (i.e. those in the wider social network that were not included in the MRI study) are not considered in the analysis. Although the cohorts within the wider network and other network

characteristics were well represented in the MRI network included here, all true connections are not measured. This may be an explanation for the weaker and inconsistent effects identified in this research, as a lower number of dyads have been included in the assortativity index than would be had the whole year group been part of the MRI investigation. Therefore, with a larger and more comprehensive MRI dataset that can account for a higher proportion of the complete social networks, the findings would be more robust. In fact, the current investigation has been ongoing, and we plan to add an additional cohort of data to the current analysis in order to build on the present findings.

Further, the task that the participants carried out, though validated as a monetary incentive delay task, was used in this context without the monetary incentive and is not related to the general social context that friends have, nor is it in the context of friends performance – either of these factors that could influence the social cognition aspect that may contribute to the similarity in brain activation. In the current study, we make the assumption that individual performance on this task will show correlated levels of activity between friends on the basis that friends will experience intrinsically rewarding activities in a similar manner, an assumption made on the foundation of the motivational perspective held as an assumption throughout this thesis (i.e. section 1.1.6.). It is also possible that the students in the upper year group – where no correlations were identified – were not as engaged in the task. This suggestion is made on the basis that in the original validation study (Helfinstein et al., 2013), students were aged between 8 and 13, meaning that there is not yet data to validate the use of this task with our oldest students (age 14). Due to the small number of 14-year olds in this sample, it is not currently possible to comment on the strength of the activation for this subsample.

Therefore, considering these limitations, it is sensible to suggest that further research could develop this initial work. At present, it is difficult to gain a complete view of the dynamics of the whole social network, not only in that many members were discounted from the network due to not participating in the MRI study, but also because the current research only contains one time point. By broadening the sample and having more MRI data it would be possible to give a more ecologically valid reflection of the broader network. Additionally, including a follow up time point and collecting longitudinal data may give greater impressions of the dynamics over time, allowing us to gain perspective on whether similarity and neural homophily develops and changes over time as a product of friendship, or is a similarity that exists as a consistent characteristic of a friendship.

5.4.3. Conclusions

Overall, the findings from this research contribute to our understanding of the neural basis of social interactions and the shared behaviours of friends. The study shows inconclusive findings that partially support the hypothesis that friends may have similar neural activation to their friends when participating in a reward-based task – a measurement of their levels of motivation. This finding contributes to the literature on the neural aspect of social cognition and supports the development of further research that can expand our understanding of the dynamics of motivation and friendship.

- Chapter 6 -

6. General discussion

The overall aim of this thesis was to investigate the social contagion of motivation in school social networks. Social contagion is a complex process, suggesting that connected individuals become more similar over time, as a result of being influenced by their friends (Levy & Nail, 1993). However, research also shows that connections with others are developed on the basis of prior similarity (i.e. homophily) in various characteristics, beliefs or attitudes, using a selection-based mechanism (Brechwald & Prinstein, 2011). The first chapter in this thesis reviews the literature related to the concept of social contagion within schools (e.g. negative peer influence, teacher contagion) and also addresses the more recent methodologies that can be used to fully disentangle the complex dynamics that exist within friendship networks.

Therefore, in order to investigate whether contagion of motivation occurs over time, the initial task was to establish whether motivation is similar between friends at one single time point. Chapter 2 and Chapter 3 both use single time point data to explore similarity in motivational traits between sixth form students aged 16-19 (Chapter 2) and then similarity in motivational traits between students across all school years in a single school (11-19 years) in Chapter 3. Chapter 4 uses an additional timepoint to create longitudinal data with which to model changes in motivation over time as a product of changes in friendship dynamics. Finally, Chapter 5 addresses the overall aim of the research from a different angle and explores whether similarity effects that are observed in behaviour can be identified in the brain.

This current chapter will review the main findings of the preceding chapters and discuss their conclusions in relation to literature across the education, motivation and neuroscience fields. Further, implications of the work are included with a focus on the contribution to educational practice. Finally, limitations and future directions are discussed.

6.1. Summary of findings

Mixed findings emerged from all studies included in this thesis. In the first study (Chapter 2 section 2.), the hypothesis that friendship dyads would be similar on the multiple measures of motivation examined (boredom, interest, competence, autonomous motivation, value, grit, mindset) was partially supported across the three sixth form samples that were analysed. However, an inconsistent pattern emerged in the similarities that are present within the independent school samples, resulting in no clear pattern of results between the sample populations as a whole. In cohort 1 (mixed gender sixth form sample from inner city school), connected students were significantly

similar in their level of mathematics interest, autonomous motivation in mathematics, value for learning and perseverance of effort (grit), where in cohort 2a (all female sixth form sample from suburban school) a different pattern emerged whereby similarity was present between connected students in English interest, boredom and competence along with value for learning. Finally, in cohort 2b (all female sixth form sample from suburban school), similarity was identified for mathematics interest, boredom and competence along with mindset. The same hypothesis pertained for the second study (Chapter 3 section 3.) that applied the same methodology with a larger and more broadly aged sample. In this study, fewer measures of motivation appeared to be similar between friends when results were synthesised across the whole school sample. Here, English interest was the only measure that showed significant level of similarity between friends.

In addition to the assortativity hypotheses, both Chapter 2 and 3 also included hypotheses surrounding the centrality of each student in the network. Across both chapters, the hypothesis was that level of motivation would be successfully predicted by level of degree (i.e. number of incoming nominations) and eigenvector (i.e. how far nominations spread and indicate influence) centrality of the students in the social network. Again, this hypothesis was partially supported in both studies. In the sixth form samples, eigenvector centrality appeared to be the strongest predictor. In cohort 1, eigenvector centrality predicted high levels of mathematics interest (and low levels of boredom), perceived competence in mathematics and general perseverance of effort (grit). On the other hand, in cohort 2a only low levels of growth mindset were predicted by high degree centrality. For cohort 2b, high eigenvector centrality was a significant predictor of autonomous motivation for mathematics while also predicting high levels of boredom and low levels of interest in mathematics – a somewhat contradictory finding. In Chapter 3, the significant findings were more scarce when examining a whole school sample. Here, high eigenvector centrality significantly predicted only high levels of English interest and low levels of English boredom. Further high degree centrality was able to significantly predict higher levels of boredom for mathematics classes.

After determining that similarity and level of network centrality in relation to motivation is present, although variable, the next chapter (Chapter 4 section 4.) of this thesis addresses questions about the dynamics of this similarity. Longitudinal modelling was used to address research questions about the selection and influence processes that occur with the motivation variables tested. The hypothesis was that selection and influence effects would be identified for motivation variables and for boarding status (a constant variable included in the model). Results demonstrated that

friendships are selected based on similarity in levels of value for learning, and friends are influenced by each other's level of perseverance of effort. Further, strong effects of boarding status were identified, students with the same boarding status were more likely to be nominate each other as friends and were also more likely to be nominated as friends compared to day students.

Finally, the work closes with an MRI study (Chapter 5 section 5.), designed to explore whether similarity that is observed between friends at a behavioural level can also be identified at a neural level. The results from this study were also mixed, some supported the hypothesis that friends would show similar reaction to reward whereas the findings were less conclusive in other places. The monetary incentive delay (MID) task is made up of various phases that activate different areas of the brain. The striatum commonly activates during the cue phase of the task in anticipation of the reward that is to come, with the OFC activating commonly in response to the feedback element of the task. Analysis for this study extracted beta-values from each individual brain activation map and correlated them using the assortativity method from Chapters 2 and 3. When synthesising the results across both year groups included in the study, the results showed that activation to the cue phase of the task was significantly more similar between friends than non-connected individuals in the youngest year group tested, an effect that was sustained using a meta-analysis of the findings including the older year group.

6.2. Discussion of findings

There are several different perspectives to consider when interpreting the findings summarised above. In the following, suggestions for the varied findings are provided in detail.

6.2.1. Impact of individual motivation orientation on similarity

Considering the variability in the findings when taken together, the main take home message from the combined results is that they provide evidence for how individual differences drive different characteristics within social networks. It has been previously noted that the overall motivational orientation of a group is guided by the individual motivational orientations of those inside the group (Urdan & Schoenfelder, 2006). This finding seems logical and the centrality of those within the group may also contribute to this finding, in that those within a group who are the most central will have an increased opportunity to influence those around them both within their group, but also beyond the group (Wölfer, Faber, & Hewstone, 2015). Additionally, those with high degree centrality are the most nominated as friends by other students; an indicator of their popularity (Rachman, Maharani, & Adiwijaya, 2013). In the current research, we

examined whether centrality of a person is related to their level of motivation. As shown, in some cases this prediction is accurate, and when considering the individual level of motivation of those most central it is therefore possible that those with the highest centrality may also carry the most weight in impacting on the motivational orientation of the group as a whole. While there is little previous research that has studied the effects of centrality and motivation at school, the research presented in Chapters 2 and 3 suggests that the most popular students (in terms of degree centrality), and the most central students (in terms of eigenvector centrality) do not always look the same in terms of predictions about their level of motivation. This is in the sense that few patterns in the type of motivation predicted by centrality are observed across these two chapters. For example, in Chapter 3, cohort 1 show an effect where degree centrality is a significant predictor of mathematics boredom, whereas in Chapter 2, this finding is only identified for one cohort, cohort 2b. On the whole across chapters, eigenvector centrality was the more frequent predictor of motivation level, indicating that the most influential students in the network have the opportunity to spread their levels of motivation, either high or low. While this potential for influence is identified, the true measure of actual influence was accessed in Chapter 4 with the longitudinal data, again where results were highly inconsistent. Overall, the case for individual differences impacting on the results is common across each chapter.

6.2.2. Developmental differences in friendship

When comparing the results across Chapter 2 and 3, it is evident that there are more similarities in motivation between friends in the sixth form social networks in Chapter 2, compared to the whole school samples reported in Chapter 3. In each chapter, the separate year groups are meta-analysed, meaning that the effects between the separate year groups are combined. In doing this, the whole sample is considered in one analysis. In Chapter 2, the age range is smaller, including only students aged 16-18 years, whereas Chapter 3 covers a range from 12-18 years. It is possible that more similarity is observed in the sixth form samples due to the smaller age range analysed. Different types of motivation may play more or less of a role in friendship during different stages of school life, as adolescents go through developmental changes. Erdley and Day (2017) explain that children's experiences of friendship change as a product of the different stages of development. In preadolescence, as students make the transition from middle school to high school, the primary focus is to seek acceptance and companionship, often from same-sex friendships. Then, during adolescence, there is an increase in the social needs, and needs related to sexuality, where opposite-sex friendships are often sought out. These

different developmental stages could be a reason for the variability in findings when looking for commonalities across the age ranges.

However, Erdley and Day (2017) describe friendships more generally and refer to similarities between friends as being a regular component. Here, one of the main characteristics of friendships is the presence of similarities in various demographic and behavioural qualities, a common finding across other research (i.e. Brechwald & Prinstein, 2011). Although, in the case of the current findings, the differences between demographic factors and observed behaviours, versus motivational and value related factors should be considered. it is possible that certain aspects of motivation such as our value for learning and academic self-concept are less observable to peers (i.e. held within the self) and therefore less likely to be similar between friends or be influenced by friendship over time (Marsh & Shavelson, 1985; Wigfield & Eccles, 2000). Further, considering the literature on academic self-concept (Shavelson et al., 1976), our self-concept is something that changes during development, therefore for this variable in particular, the difference in developmental stage may be an explanation for the limited findings.

6.2.3. Context dependant similarity

Of the similarities that were observed between friends across Chapters 2 and 3, the majority were in subject specific measures of academic motivation, making the observed similarities context dependant. While it should be noted that these results were not consistently significant, the finding that higher similarity was observed between friends compared to non-connected individuals in subject specific measures of motivation supports the literature that describes homophily in friendships for specific interests. McPherson et al. (2001) discuss the concept of value homophily, describing a form of homophily that goes beyond the surface level sociodemographic and behavioural dimensions from which homophily can occur. Value homophily is most closely related to the attitudes, beliefs and aspirations that we hold, and therefore are able to assess where people might be attracted to form friendship ties with those who have similarities to them in these deeper traits. In the current research, findings demonstrated that similarity was most often observed between friends in regard to their attitudes (interest and boredom) towards mathematics and English studies, providing support for the idea of a more specific type of homophily in this sample.

Further support for this interpretation stems from the similarities in sociodemographic dimensions that are present across the whole of the current sample (disregarding sixth form cohort 1). Since factors like gender, socioeconomic status and race are somewhat uniform across this sample, value homophily may play more of a role compared to general measures of motivation in distinguishing students from one

another and informing their friendship selections (McPherson et al., 2001). This phenomenon may be even stronger in schools that use tracking systems to organise their classes. Here, children of similar backgrounds, ability and achievement level are grouped together, resulting in the increased formation of homophilous ties due to proximity to similar others (Kubitschek & Hallinan, 1998), another possible mechanism driving the observed similarities in the present chapters.

6.2.4. Peer interaction in STEM subjects

Similarity in motivation for mathematics, in terms of mathematics interest and boredom, competence and autonomous motivation, was a repeated finding across Chapters 2 and one finding in Chapter 3. Mathematics was the only science, technology, engineering, and mathematics (STEM) subject covered in the present research, but an increasing amount of work focusses on the perception of STEM subjects in schools, especially assessing gender differences.

Robnett and Leaper (2013) investigated friendship group characteristics, motivation and gender in relation to STEM career interest. In friendship groups where there was a high level of support and motivation for STEM subjects (as opposed to English studies), careers interest in STEM areas were more prevalent. Further, where friendship groups were predominately same-sex, differences in STEM career interest were strongest. In this study, predominately female groups of friends with low STEM support reported low interest in a STEM career, despite differences in their individual levels of motivation for these subjects. Further, in terms of mathematics competence, it has been shown that self-perception of competence in STEM areas is often derived from contact with class peers, with feelings of relatedness to peers being important for female students in terms of their commitment to complete their science studies (Hilts, Part, & Bernacki, 2018). This need for relatedness is one of the features of the self-determination theory (SDT; Ryan & Deci, 2000), one of the theories suggested at the outset of this thesis as a motivational mechanism for social contagion to occur. Together, these findings demonstrate the importance of social groups and their potential influence in the area of STEM, providing support for the occurrence of similarity between friends in mathematics across Chapter 2 and 3.

When considering the type of motivation required for similarity to occur, for mathematics, these motivational mechanisms may play even larger roles. Students often approach mathematics with a negative attitude from a young age, since it is possible to experience frustration. This can be combined with a lack of understanding about why this is a subject that everybody needs to study (Larkin & Jorgensen, 2016). This common feeling in the classroom can lend itself to increased relatedness between students (Ryan & Deci, 2000); the negative (or positive in some cases) feeling towards

mathematics being a source for homophily between students. Additionally, students observe each other's frustrations or successes in the classroom, and learn vicariously from their peers (Bandura, 1977, 1986). This vicarious experience can lead to the motivation of students becoming similar, either over time as influence, or as an observation that leads to friendships forming on the basis of similarity in their experience.

6.2.5. Similarity, selection and influence

In Chapter 4, the longitudinal effects on friendship and motivation are considered. Here, selection and influence effects are examined with the aim of identifying which types of motivation are important for homophily between friends, and which types of motivation are socially contagious between friends. The methods used in this analysis are different to that of the cross-sectional chapters (2 & 3), yielding different findings and interpretations. In analysing the data longitudinally, the different dynamics that build up to create overall similarity are separated out into their different components and predictive models are constructed that can estimate the changes that occur between time points.

Additionally, the interpretations are different between cross-sectional and longitudinal studies because of the way that the social networks are sampled between the different types of analysis. In assortativity analyses, the social network is broken up into dyads and the scores of those dyads are correlated to attain the extent to which similar scores exist within those relationships (Newman, 2002). In comparison, stochastic actor-based modelling (Snijders et al., 2010) is a method that considers all ties in the network, modelling each individual change in the network between time points of data. Perhaps as a result of the differences in methodology, the results are not consistent across the studies in this thesis. While in Chapter 2, motivation related to mathematics appeared to be most similar, and in Chapter 3, significant similarity related mostly to English classes, in Chapter 4, neither selection nor influence effects appeared to be present across the subject specific measures. Rather, selection effects were noted for general levels of value for learning and influenced by levels of perseverance of effort. Overall, it appears that the general trends of similarity that are observed in Chapter 2 and 3 are largely explained by boarding status selection as opposed to motivation related influence effects.

The cross-sectional and longitudinal analyses presented within this thesis both have their strengths and weaknesses. While cross sectional data cannot disentangle selection effects from influence effects, it is possible to identify the overall trend. In the current findings, when breaking up the processes and examining the data using a longitudinal method, the strength of the overall trend is weakened in subject specific

measures and the individual effects of these processes (i.e. selection or influence) are strengthened in the case of value and perseverance of effort. This is because observed cross-sectional effects consist of a mixture of different selection and influence processes in one snapshot, whereas longitudinal data show the selection and influence effects that occur over one year. This time distinction is the reason for the difference in findings, as the effects are all collapsed to give an overall trend when looking at the cross-sectional data.

6.2.6. Neuroscientific contributions

A further biological perspective is provided by the results of the MRI investigation in Chapter 5. Here, the overall results again reflected the individual differences within each social network as evidenced by the variability in the findings. Reactions to cued rewards were neurally similar in one of the networks, consistent when meta-analysed across both networks tested. However, when looking at response to feedback following a successful trial versus a missed trial, no similarities appeared. It is possible that the developmental argument discussed previously also applies in this case as an explanation for the findings. While significant similarities were identified in the younger year group (12-13 years), the older year group (13-14 years) showed no similarity. It has been shown that the adolescent brain goes through many changes throughout this period of development, especially in terms of response to reward (Casey et al., 2011). Therefore, in the present research it is possible that individual variations in developmental stages can lead to varying levels of potential activation for each participant within the examined social networks. This variation may limit the effects and add a confound to the assessment of the social dynamics.

Nonetheless, though the current findings should be interpreted with caution and further work is needed, activation in the striatum was significantly more similar between friendship pairs in comparison to non-connected individuals. This finding furthers our knowledge about the neural aspect of social relationships, giving new insight into how our brains react in similar ways to those we nominate as friends. To date, the majority of MRI research that investigates activation during social tasks uses arbitrary pairs of adults in two-person neuroscience experiments (2PN; Hari, Henriksson, Malinen, & Parkkonen, 2015) rather than real-world social networks on a wider scale (exceptions; Parkinson, Kleinbaum, & Wheatley, 2017, 2018). By including real world adolescent social networks in the current MRI study, we provide new perspectives on the adolescent social brain and how it interacts in peer relationships. Further, this is the first work that has examined neural homophily in school social networks and also the first that has implemented an experimental task in its design (as opposed to naturalistic stimuli; Parkinson, Kleinbaum, & Wheatley, 2018).

6.3. Implications with regard to educational practice

The work presented in this thesis has wider implications in the field of education in terms of its contribution to research on the effects of ability grouping or streaming students. There is an ongoing debate in UK education as to whether ability grouping has any significant benefit to students, with researchers and policy makers often holding opposing views surrounding the costs and benefits of this approach (Francis et al., 2017). Frequently, research shows little overall benefit of between-class ability grouping (for meta-analysis see Steenbergen-Hu, Makel, & Olszewski-Kubilius, 2016). However, little research investigating the effects of ability grouping in the last decade includes consideration of the social relationships and friendship dynamics that occur within the classroom.

In the current research the relationship between friendship and academic motivation was examined, since academic motivation has been closely linked to academic performance. In a recent paper by Smirnov and Thurner (2017), homophily and social networks were examined in relation to academic performance and it was found that students re-organise their friendship groups in terms of performance, selecting friends over time based on their level of attainment. This is similar to the current findings where selection effects were more prominent than influence effects. While Smirnov and Thurner (2017) showed that friends are selected over time based on their academic performance rather than influencing one another's performance, the current research showed that friends were selected based on similar boarding status with some limited selection and influence effects in terms of motivation variables. If students are more likely to select friends that have similar levels of certain types of academic motivation to themselves and also who have similar academic performance, then the case for ability grouping may be further informed in that students are naturally forming their social networks in this way. Therefore, the relationship between the naturally occurring social networks and the prescribed nature of ability grouping would be an interesting area for future study. However, considering the longitudinal results from Chapter 4 of this thesis, the findings would suggest that those at the higher end of the ability distribution would reduce in their motivation over time whereas those in the lower end of the distribution would benefit from being exposed to their more highly motivated peers, in the case that reciprocal friendships are established between them. This finding is different from that of Smirnov and Thurner (2017), as they measured academic performance, however, as a closely linked concept, the findings provided from the current research provide another consideration for the debate on introduction or dissolution of ability grouping in schools, highlighting the potential implications.

The research presented in this thesis has implications for classroom interventions such as peer led activities and peer teaching, and also the use of seating plans. Previous research suggests that peer led activities often lead to positive educational outcomes. In high schools peer led interventions have led to increases in pass rates for STEM subjects (Thomas, Bonner, Everson, & Somers, 2015), improved reading skills (Veerkamp, Kamps, & Cooper, 2007), and increased access to the general curriculum for students with disabilities (Carter & Kennedy, 2006). While the impact of such interventions on academic outcomes is clear, the social environment of the students participating in these interventions and schemes is not often considered. In one piece of research by Audrey, Cordall, Moore, Cohen and Campbell (2004) a peer-led intervention to prevent smoking was designed using students established social networks. While this research was not based on academic outcomes, the work focussed on encouraging change by training a group of students who had been identified as the most influential by their peers. The training aimed to equip these students with the skills and confidence that they might need to encourage their peers not to smoke. The intervention was successful in reducing the odds that adolescents would become regular smokers and was therefore suggested to have long-term health-benefits for young people. In support of research of this nature, the findings from this thesis show support for using social networks to inform academic interventions to increase the motivation of students. However, on a class to class basis due to the variability between different social networks. In using techniques such as centrality of a network it would be possible to build interventions in a similar way to Audrey et al. (2004), with the results from the present work directing the areas of academic motivation on which to focus.

With respect to the use of seating plans in lessons, while seating plans provide more structure to a classroom and greater control for the teacher (Fernandes, Huang, & Rinaldo, 2011), they have also been found to restrict natural opportunities for intergroup friendship formation (McKeown, Stringer, & Cairns, 2016). This can be compared to the advantages and disadvantages of using ability grouping. If students are placed into structured seating within classes where they are also grouped by ability, the opportunity for natural friendship group formation is more restricted. However, the benefit of using social network data to inform decisions about seating plans may encourage constructive friendship formations and those in which positive improvements are noted in both students. In comparison, in a classroom where ability grouping is not implemented and a seating plan is not used, the natural friendships formed could lead to high achieving students reverting to the class average over time,

and lower achieving students increasing their performance up to the class average, as suggested by results in this thesis.

6.4. Limitations

While the research presented in this thesis provides strong contribution to the wider literature on social contagion in education, it is not without limitations. Firstly, the sample that was included for the larger behavioural study spanned the full secondary education spectrum, with insufficient participants in individual year groups to provide sufficient power for individual year group analyses. Therefore, a large developmental period is covered by grouping all year groups together in the analyses in Chapters 3 and 4. Considering the variation in developmental stages that is condensed across this analysis, the differences in levels of self-concept and other unstable qualities that change and become more established during adolescence could be distorting the results. Furthermore, age may also be an issue in the MID task results from Chapter 5, as the older year group showed little similarity in activation while the younger one did. It is possible that this is because the age range used was slightly too high for the child version of the task to be appropriate. In the original validation children aged 8 to 13 years were recruited (Helfinstein et al., 2013), whereas in the current work we used students aged 12 to 14 years. To overcome this issue, future investigations could be conducted using the adult version of the MID task for comparison.

In all chapters, analyses restrict students' social networks to the year groups that they are in. In a more realistic case, students' social networks extend beyond that of their year group peers, with extracurricular activities meaning that year groups frequently mix, and out of school activities lead to friendships with out of school peers. Witkow and Fuligni (2010) highlighted that much of the education research interested in peer interaction focusses on in-school friendships and showed in their investigation that there are differences in the academic outcomes of students who have more friends in school versus out of school. Academic achievement was found to be higher in those with a denser social network at school (i.e. more in-school friends), although the social aspects of friendship, such as time spent with friends, or time spent engaging with activities with friends, were consistent regardless of the quantity of in versus out of school friends. Research such as this shows the importance of considering the wider social connections that adolescents hold, however the focus on academic factors in the research included in this thesis supports the case for only focussing on school social networks.

As a final limitation, the time points included in the current research were measured one year apart, and therefore the data is unable to accurately account for changes in shorter time frames. Despite this, the strength of stochastic actor-based

modelling is that it is based on the assumption of continuous-time network evolution, so can account for many of the continuous changes that happen between discrete time points (Snijders et al., 2010; Steglich et al., 2010). In this way, the behavioural dynamics should be accurately represented. However, with an additional mid-way time point the modelling would be more robust. This should be a consideration in future research designs implementing stochastic actor-based modelling.

6.5. Future directions

Throughout this discussion, several areas of future research have been highlighted. In the following section the ongoing work briefly described in the closing discussions of the preceding chapters is elaborated upon, and areas of potential future study are explained. Inclusion of the additional data discussed in the following section was beyond the scope of this thesis.

6.5.1. Ongoing research

Presently, the inclusion of only two timepoints in the longitudinal model only captures changes that occur over one year. This potentially limits the conclusions that can be made by limiting the number of changes observed. Although it is a limitation that the data collection points were not closer together and do not accurately account for smaller changes that occurred between time points, it is also possible that more time is needed for the contagion of motivation to occur. Following data collection for this thesis, a third time point of data was collected that can be added to the current two time points to model changes in five year groups over three school years. The hypotheses for this research would remain consistent with the currently presented work in Chapter 4, with the overall aim remaining; to assess the selection and influence effects for the interaction of social networks and level of motivation.

In addition, at present Chapter 5 only includes cross-sectional data. However, it is not yet known whether there are any longitudinal effects relating to neural similarity and friendship networks. To investigate the selection and influence effects that may be present in the MRI sample, follow up scans were collected at the end of the academic year, to be used in longitudinal modelling. Here, the research aim is to investigate how response to reward in the brain changes in relation to social connections and friendship dynamics. Following the same arguments presented in the outset of Chapter 5, it is expected that similarity will be present between friends in response to a rewarding task, and that the similarity can be broken down into its component dynamics; namely selection and influence effects. Moreover, an additional two time points of MRI data were collected from a different cohort, from the same school; data

which can also be included in the longitudinal sample and modelling in support of this research question.

In further investigations, the additional measures that were collected (stated in section 1.4.7.) will be explored and incorporated into the current studies and further publications. As they do not directly measure motivation, these measures were not included in the current thesis. However, they still measure forms of academic adjustment, or are related to measures of academic adjustment, being valuable measures to be examined in terms of friendship similarity and dynamics over time. As well as additional measures to explore, there are also other forms of social network data that were not included in this thesis. Alongside the nomination method of data collection, a round-robin roster method was also included. By having these different types of social network data, we can weigh the relationships and carry out further analysis to see if the strength of friendship is related to any of the concepts mentioned throughout.

6.5.2. Future research

Some of the above limitations are not addressed by the ongoing research and would be better overcome by alterations to the design of the research. To address limitations surrounding the developmental trajectory that cannot be commented on with the present data, further research could focus on a smaller age range sample and model the changes over a longer longitudinal period with a larger sample. Research by Gremmen, Dijkstra, Steglich, & Veenstra (2017) carried out research of this nature, looking at the developmental differences in selection and influence effects in terms of students' academic achievement. Differences were identified between the two age groups (first and second year of high school) and it was identified that students initially tend to select friends on the basis of having similar grades. However, influence processes appeared later in the second year of high school, where grades became more similar between connected friends over time. If future research were to build on this design and incorporate motivational variables, or other variables known to alter through adolescence, then a clearer picture of the developmental dynamics in friendship would be identified. Further, by collecting larger or multiple samples from the same school year but from different schools, the generalisability of the research would also be improved.

Another interesting area that is not addressed in this thesis is the impact that teachers and parents have on the social dynamics that occur at school. As noted in the implications section above, by using seating plans and ability grouping, teachers have more control or influence over the friendship ties that form, by narrowing opportunities for friendships to form naturally (McKeown et al., 2016). Further, it is the combined

social support system of students that supports their overall adjustment and participation in school activities. Rosenfeld, Richman and Bowen (2000) identified that students who perceive to have strong support from a combination of their peers, parents and teacher are more likely to spend longer studying, display less disruptive behaviour and have higher self-efficacy and satisfaction at school. To include the perspectives of teachers and parents in follow up investigations would provide a clear impression of their interactions with the classroom and the impact on changing network dynamics within the classroom.

One final direction for future study would be to adjust the way that social network data is collected. Understanding the social connections in a social network and the structure of the network has been shown to be a valuable source of information throughout this thesis, however, further questions can also be asked that reveal additional traits within the network. Asking for levels of popularity, or perceived level of influence of the members within the network allows for additional interpretations of centrality data and also data within longitudinal models. As emphasised in preceding sections, different forms of centrality do not lead to the same interpretation, so additional data that attempts to validate the centrality values in the network would be an interesting line of enquiry. Dijkstra, Cillessen and Borch (2013) investigated popularity and adolescent friendship networks and revealed the selection and influence effects that reinforce high-status peers to remain in their high-status positions. In this study, adolescents preferred to befriend those with a similar or higher popularity status, and were influenced over time, increasing in popularity and becoming more similar to their friends. As a result, this study demonstrated popularity dynamics as an element of adolescent social networks, and this, in combination with measures of academic motivation would provide a different perspective on the contagion of motivation in schools.

6.6. Overall conclusion

The overall aim of this thesis was to investigate the social contagion of motivation in school settings. The data used was collected in one large project primarily involving two different schools. Throughout the chapters, the similarity between friends on measures of motivation was assessed, including measures of assortativity and centrality, providing different interpretations as to the impact that social ties have on academic motivation. In the final behavioural chapter (Chapter 4), a longitudinal analysis is carried out to model the dynamic process of friendship over time in relation to levels of academic motivation. Finally, an MRI experiment is presented in Chapter 5, extending the research question by asking questions about biological similarity as opposed to observed behavioural similarity.

In all chapters, the similarity findings were varied; in some cases, similarity in motivation was evidenced between friends, whereas in other measures of motivation, no such relationship emerged. This leads to an interesting discussion that has focussed on the developmental differences between year groups at school, the differences between subject specific and subject general motivation and also the new perspective that the MRI research provides. To conclude, this work has contributed to the fields of motivation and education research, social network science and neuroscience. While the contagion of motivation did not emerge consistently as a concrete finding, through the combination of research areas, new conclusions have been drawn and new avenues for future study have been highlighted.

7. References

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8. Appendix

8.1. List of constructs and related scales measured not for inclusion in this thesis

Included in all waves of data collection:

- IQ (Shikishima et al., 2011)
- Self-esteem (Rosenberg, 1979)
- Study Strategies (Pintrich, Smith, Garcia, & McKeachie, 1991)
- Learning Climate (Black & Deci, 2000)
- Mathematics Anxiety (Ramirez, Gunderson, Levine, & Beilock, 2013)
- Gender stereotyping (YouGov; Dahlgreen, 2015)
- Gender Implicit Association Task (IAT) (Dasgupta & Asgari, 2004)

Included only in wave 1 of data collection (Chapter 2, cohort 1 & cohort 2a; Chapter 3, cohort 1, Chapter 4, cohort 1):

- Agentic Engagement (Reeve, 2013)
- Showing/demonstrating intelligence (original items)
- Patriotism (adopted from; Huddy & Khatib, 2007)
- Interest for English classes (Wigfield & Eccles, 2000)
- Boredom for English Classes (Pekrun et al., 2002)

Included only in wave 2 of data collection (Chapter 2, cohort 2b; Chapter 3, cohort 2; Chapter 4, cohort 2)

- Work and Family Orientation (WOFO; Spence & Helmreich, 1983)
- Achievement goals (Elliot & Murayama, 2008)
- Perceived competitiveness (Murayama & Elliot, 2012)

8.2. Information sheet for students aged 14-18 years (survey research)

University of Reading

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The spread of motivation among peers in schools

Principle Investigator: Kou Murayama PhD
Project entitled **"Motivation and Peer Relationships"**

Information for Participants: L5, U5, L6, U6

You are being invited to take part in a University of Reading research study into how motivation spreads between friends. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Talk to others about the study if you wish.

- *Part 1 tells you the purpose of the study.*
- *Part 2 tells you what will happen to you in this study if you take part.*
- *Part 3 gives you more detailed information about the way the study is managed.*

Contact Details
After reading, if you have any queries regarding this study please contact a member of staff at your school. Alternatively, researchers from the University of Reading will be happy to help:
Principal Investigator Dr Kou Murayama, School of Psychology, University of Reading, RG6 6AL
Phone: 0118 378 5558 e-mail: k.murayama@reading.ac.uk.
Researcher Laura Burgess e-mail: l.g.burgess@pgr.reading.ac.uk

Part 1

A bit of background

- Motivation is really important when it comes to learning and achieving in school. In fact, previous research has shown that students' motivation is a better predictor of academic success compared to intelligence.
- Lots of different areas of motivation have been researched. However, only small amounts of work have been carried out on the influences coming from the students' friendships.
- At school you have lots of chances to spend time with others, work in groups, and interact with different students. Through these social activities, students can share motivational experiences with each other, causing individual students' motivation to influence those of their other classmates (and vice versa).
- The aim of the current research is to investigate the spread of motivation within a school environment.
- The University of Reading along with Queen Anne's School, Caversham are carrying out this research, funded until September 2019. The study will be supervised by Dr Murayama and carried out by Laura Burgess, a PhD student at the University of Reading, who will be using the collected data for her studies.

Do you have to take part?

No. It is up to you to decide whether to take part. If you do, you can keep this information sheet and will be asked to sign a consent form before we test you in school. As you are volunteering to take part, you are free to withdraw at any time and without giving a reason.

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Part 2

What will happen if I do want to help with the research?

- We test all participants, whatever their age, in the same way.
- We will carry out the testing at your school, at a suitable time so that your school work is interrupted as little as possible. The research will involve one testing session which will last around 1 hour, taking a maximum of 2 hours. You can have a break during the session if you would like.
- During the session you will be completing a series of questionnaires to assess your academic motivation and also how much academic motivation you perceive your classmates to have. As part of this study we may also ask you to complete a simple computer task that will test your working memory. Additionally, we will ask you to mark on a class list all of the students you spend most of your time with, in order to build up an idea of the social group/s you are a part of in school.
- When filling out the questionnaires we ask that you answer as honestly as you can, and don't spend too long deciding on your answers.
- The testing does not involve anything unpleasant or uncomfortable, though you are free to ask for help on anything that may not be clear.
- The questionnaires have all been designed for school age students.

Are there any risks?

Many of the measures used in this study have been used in past research. Though some items used are unique to the present study, senior staff in your school have seen and approved the content of the questionnaires. This research poses no significant health risks.

Are there any benefits?

The results of this investigation will help us to understand how we can increase academic motivation by allowing us to see who the main influencers are in friendship groups and in turn encourage those students to positively impact on their friends.

The wider benefit of taking part in this research is that you will be involved in a new research approach, helping to gain understanding about the way motivation spreads through a social network in school environments.

We will be offering chocolate and amazon voucher prize draws on the day as thanks for taking part.

Will taking part affect my grades?

This study is in no way performance related and will not have any link to your school studies/grades. You are not marked based on the answers you give, and you will **not** receive a penalty of any kind if you decide not to take part.

What if there is a problem?

Any complaint about the way you have been treated during the study will be addressed. The detailed information on this is given in Part 3.

Will my taking part in the study be kept confidential?

Yes, all information regarding participation will be kept private and confidential, meaning no one will see your answers and only the researchers will be able to trace your unique participant number back to your name. Further details are given in Part 3.

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Part 3

What will happen if we don't want to take part anymore?

You are free to withdraw at any time without giving a reason why.

What if I have a problem with the study?

If you have a concern about any aspect of this study, you should ask to speak with the researchers who will do their best to answer your questions (Dr Kou Murayama on 0118 3785558).

If you remain unhappy and wish to complain formally, you can do this through Head of School of Psychology & Clinical Language Sciences, Professor Laurie Butler. If your complaint is not dealt with to your satisfaction you can contact the Chair of the University Research Ethics Committee. Details can be obtained from the School of Psychology and Clinical Language Sciences.

Confidentiality

All information that is collected about you during the course of the research will be kept strictly confidential and records will be given a unique reference number for analysis. For this reason we are not able to give you individual feedback, if we traced you from your unique number easily, then the information isn't as confidential.

Paper records will be stored securely in a locked room or cabinet and computer records will be password protected. Personal details will be kept separate from research data once the data collection phase has finished and will be destroyed at the end of the study.

If you join the study, some parts of the data collected for the study may be looked at by authorised and statutory bodies from the University, to check that the study is being carried out correctly. All will have a duty of confidentiality to you as a research participant and nothing that could reveal your identity will be disclosed or taken outside the research site. Consent forms and any identifiable records will be kept for 5 years in line with University guidelines.

Participants have the right to check the accuracy of data held about them and correct any errors. All investigators working on this project have had criminal record checks and have been approved by the School to work with children.

What will happen to the research results?

At the end of the study, once we have analysed the data from all the participants, we will send you a newsletter or email to explain the findings. We will aim to publish the findings in international science journals and meetings but no identifiable names will be used without your permission.

Who is organising the research?

Dr Kou Murayama PhD is the Principal Investigator working at the School of Psychology and Clinical Language Sciences at the University of Reading. Professor Patricia Riddell also from the School of Psychology and Clinical Language Sciences will be co-supervising the project. Miss Laura Burgess, BSc(Hons) is a PhD student, and will be using the collected data in her thesis. The research is funded by the South East Doctoral Training Centre (SEDTC) with contribution also from Queen Anne's School, Caversham.

Who has reviewed the study?

This application has been reviewed by the University of Reading Research Ethics Committee and has been given a favourable ethical opinion for conduct.

Thank you very much for reading this sheet and considering taking part in the study.

8.3. Consent form for participants aged 16-18 years (survey research)

University of Reading

Study Number:
Identification
Number for this trial: ……..

School of Psychology & Clinical Language Sciences
Harry Pitt Building
Earley Gate,
Reading
RG6 7BE
phone +44 (0)118 378 5558
email k.murayama@reading.ac.uk

STUDENT CONSENT FORM

Title of Project: Motivation and Peer Relationships

Name of Supervisor/s: Dr Kou Murayama; Prof. Patricia Riddell
Investigators: Laura Burgess

Name of Participant: _____

DOB of Participant: _____

Please initial box

- I confirm that I have read and understand the information sheet dated ??/??/?? (version 1) for the above study. I have had the opportunity to consider the information and discuss it with _____ (if I chose to) and have had any questions answered satisfactorily. ☐
- The nature of the tests have been explained to me and I understand the requirements to take part in the above study. ☐
- I understand that my participation is voluntary and that I am free to withdraw at any time and do not have to explain the reason for my decision. ☐
- I understand that the project has been subject to ethical review, according to the procedures specified by University of Reading Research Ethics Committees, and has been allowed to proceed. ☐
- I understand that all personal information will remain confidential to the investigators and arrangements for the storage and eventual disposal of any named material have been made clear to me. ☐
- **I agree to take part in the above study.** ☐

University of Reading

School of Psychology & Clinical Language Sciences
Harry Pitt Building
Earley Gate,
Reading
RG6 7BE
phone +44 (0)118 378 5558
email k.murayama@reading.ac.uk

Name of Student:

_____

Signature of Student: Date:

_____ _____

I confirm that I have explained the above-mentioned study, as detailed in the corresponding Information Sheet dated ??/??/??, such that, in my judgment, it is understood by the participant.

Name of Researcher:

_____

Signature of Researcher: Date:

_____ _____

When completed, 1 for participant; 1 for researcher site file

8.4. Scales included for analysis from the motivation survey

Interest items (adopted from Wigfield & Eccles, 2000)

1. Mathematics/English is interesting.
2. I like mathematics/English.
3. I found working on mathematics/English interesting.

Scale: 1 Strongly disagree – 7 Strongly agree

Boredom items (adopted from Pekrun et al., 2002)

1. Mathematics/English bores me.
2. I find mathematics/English fairly dull.
3. I get bored.

Scale: 1 Strongly disagree – 7 Strongly agree

Academic self-concept items (Marsh, 1990)

1. Compared to others my age I am good at mathematics/English.
2. I get good marks in mathematics/English.
3. Work in mathematics/English classes is easy for me.
4. I'm hopeless when it comes to mathematics/English (reverse scored).
5. I learn things quickly in mathematics/English.
6. I have always done well in mathematics/English.

Scale: 1 False – 7 True

Learning Self-regulation Questionnaire items (SRQ-L) (Ryan & Deci, 2000)

I will participate actively in mathematics classes:

1. Because I feel like it's a good way to improve my skills and my understanding of mathematics.
2. Because others would think badly of me if I didn't.
3. Because learning mathematics well is an important part of becoming successful.
4. Because I would feel bad about myself if I didn't study this approach.

I am likely to follow my instructor's suggestions for mathematics classes:

5. Because I would get a good grade if I do what he/she suggests.
6. Because I believe my instructor's suggestions will help me effectively.
7. Because I want others to think that I am a good at mathematics.
8. Because it's easier to do what I'm told than to think about it.
9. Because it's important to me to do well at this.
10. Because I would probably feel guilty if I didn't comply with my instructor's suggestions.

The reason that I will continue to broaden my skills in mathematics is:

11. Because it's exciting to try new ways to work in mathematics.
12. Because I would feel proud if I continued to improve at mathematics.
13. Because it's a challenge to really understand mathematics.
14. Because it's interesting to study mathematics.

Scale: 1 Not true at all – 7 Very true

Value items (Wigfield & Eccles, 2000)

1. Some things that you learn in school help you do things better outside of class, that is, they are useful. For example, learning about plants might help you grow a garden. In general, how useful is what you learn in school?
2. Compared to most of your other activities, how useful is what you learn in school?

Scale: 1 Not useful at all – 5 Very useful

3. For me, being good in school is… (not at all important very important)
4. Compared to most of your other activities, how important is it for you to be good at school? (not at all important very important)

Scale: 1 Not important at all – Very important

Mindset items (Dweck, 2000)

1. You have a certain amount of intelligence, and you can't really do much to change it.
2. Your intelligence is something about you that you can't change very much.
3. To be honest, you can't really change how intelligent you are.
4. You can learn new things, but you can't really change your basic intelligence.
5. No matter who you are, you can change your intelligence a lot.
6. You can always greatly change how intelligent you are.
7. No matter how much intelligence you have, you can always change it quite a bit.
8. You can change even your basic intelligence level considerably.

Scale: 1 Strongly Disagree – 5 Strongly Agree

GRIT Scale (GRIT-S) (Duckworth & Quinn, 2009)

Consistency of Interest

1. I often set a goal but later choose to pursue a different one.
2. I have been obsessed with a certain idea or project for a short time but later lost interest.
3. I have difficulty maintaining my focus on projects that take more than a few months to complete.
4. New ideas and projects sometimes distract me from previous ones.

Perseverance of Effort

5. I finish whatever I begin.
6. Setbacks don't discourage me.
7. I am diligent.
8. I am a hard worker.

Scale: 1 Not like me at all – 5 Very much like me

8.5. Additional figures – Chapter 2 histograms

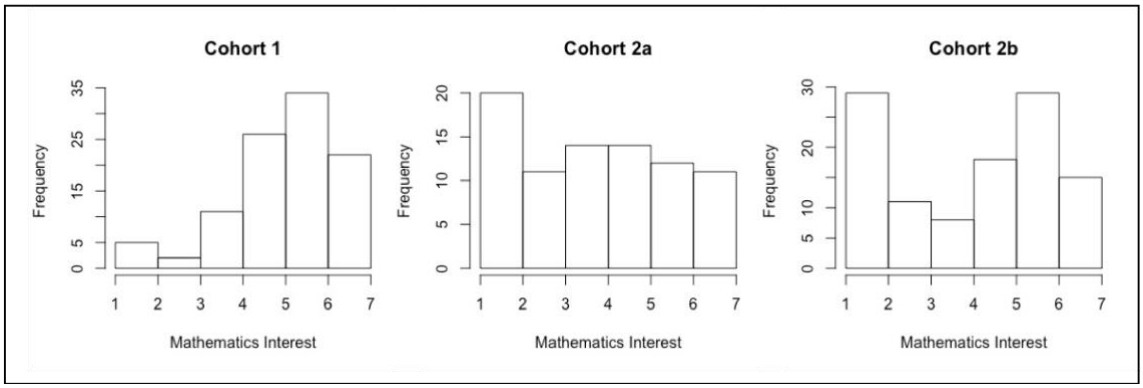


Figure 1. Mathematics Interest score distributions.

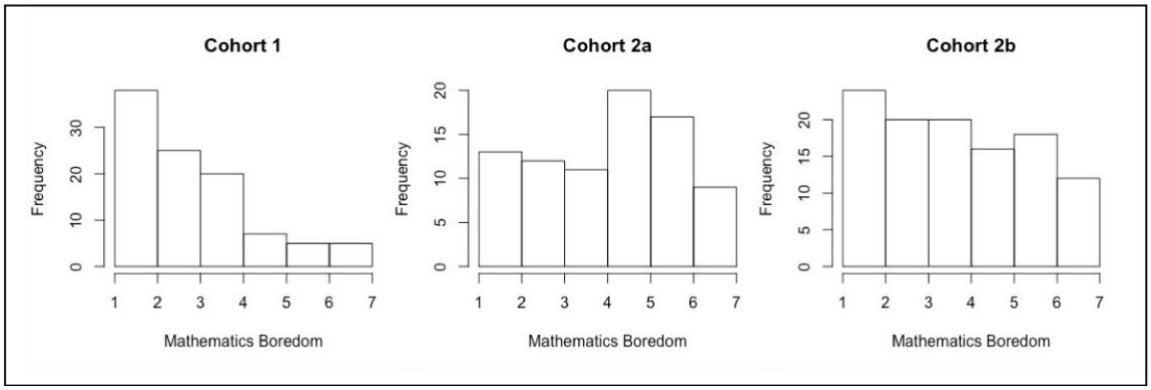


Figure 2. Mathematics Boredom score distributions.

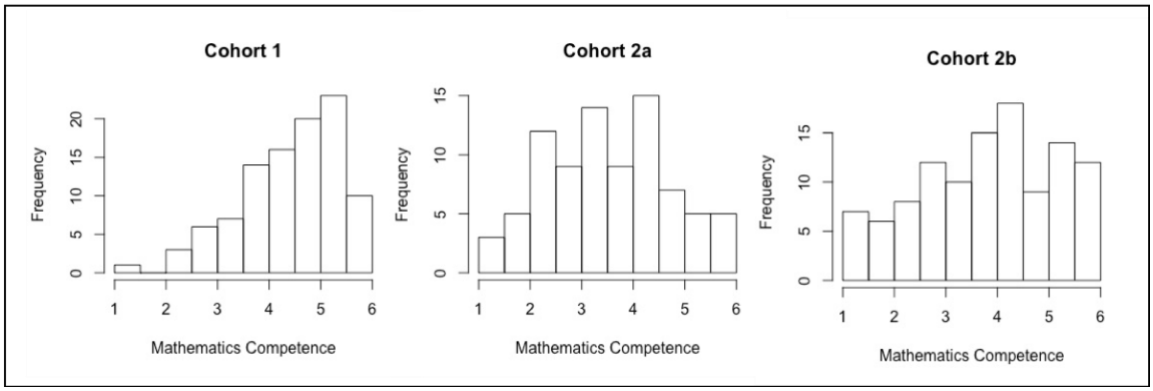


Figure 3. Mathematics Competence (academic self-concept) score distributions.

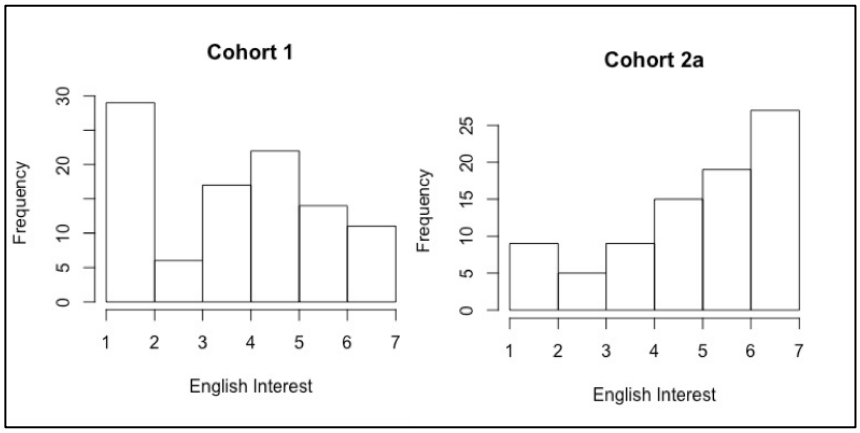


Figure 4. English Interest score distributions.

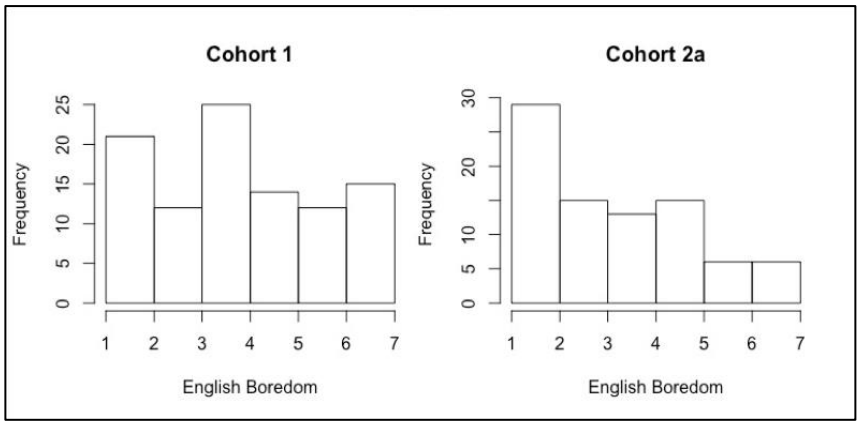


Figure 5. English Boredom score distributions.

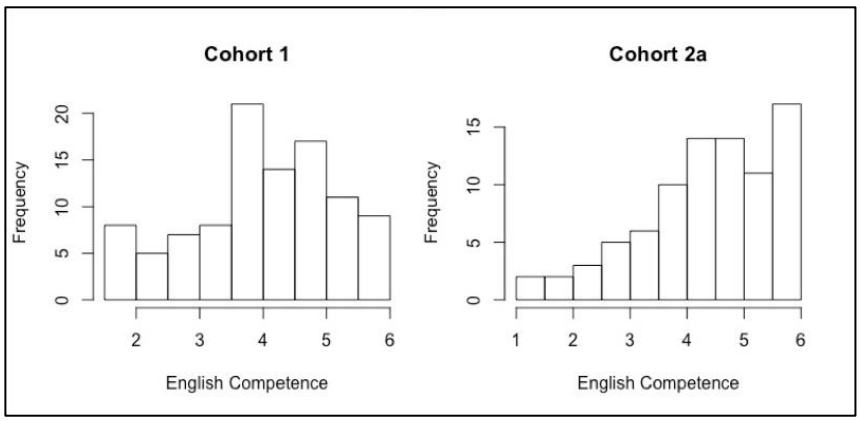


Figure 6. English Competence (academic self-concept) score distributions.

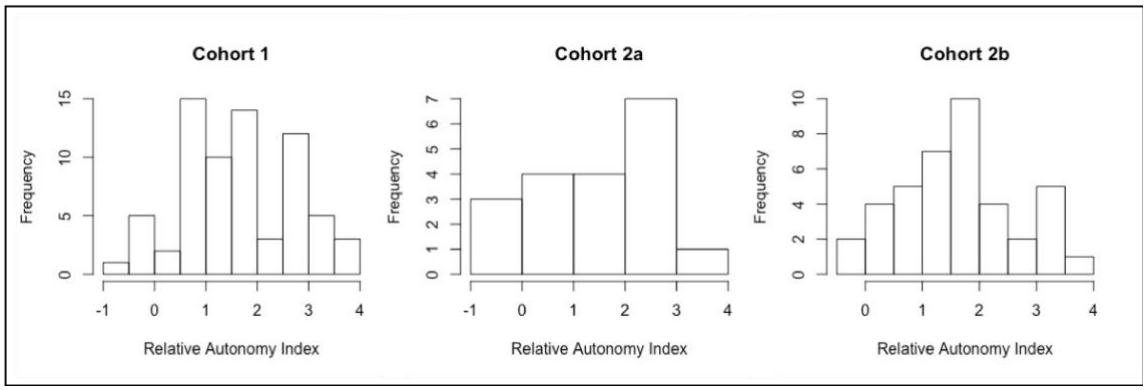


Figure 7. Relative Autonomy Index (measure of autonomous regulation) score distributions.

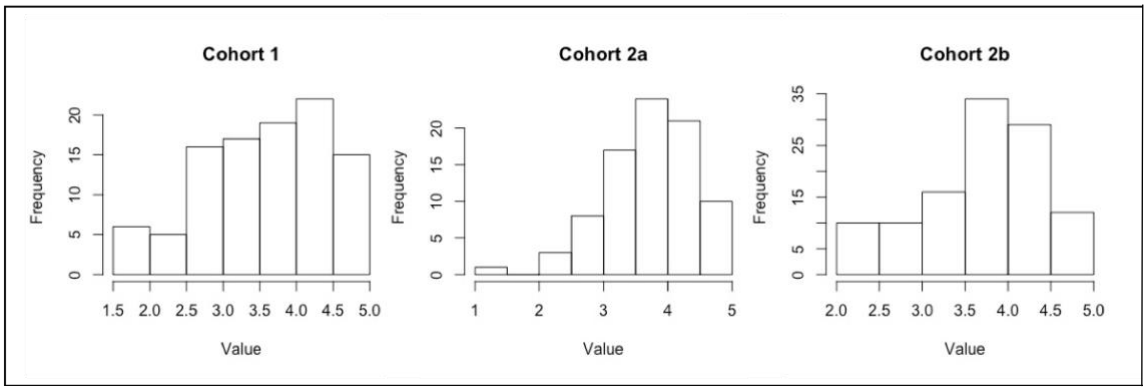


Figure 8. Value score distributions.

Figure 9. Grit subscale for consistency of interest score distributions.

Figure 10. Grit subscale for perseverance of effort score distributions.

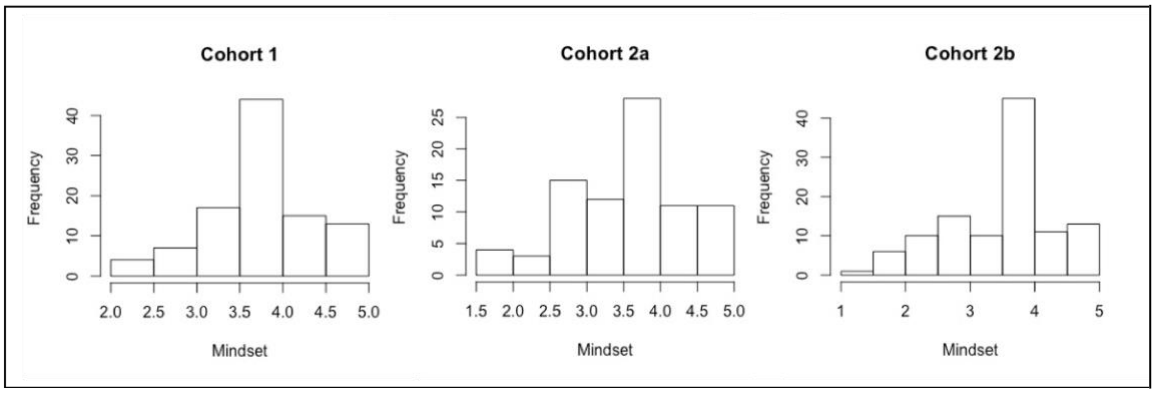


Figure 11. Mindset score distributions.

8.6. Parental information sheet for participants aged 11-15 years (survey research)

University of Reading

Motivation Laboratory
School of Psychology & Clinical Language Sciences
Earley Gate, RG6 6AL
Postcode for SatNav RG6 7BE
phone +44 (0) 118 378 5558
email k.murayama@reading.ac.uk

The spread of motivation among friends in schools

Principle Investigator: Kou Murayama PhD
Project entitled **"Motivation and Peer Relationships"**

Information for Parents or Guardians of Participants

Your child is being invited to take part in a University of Reading research study into how motivation spreads between peers in a school context. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Talk to others about the study if you wish.

- *Part 1 tells you the purpose of the study.*
- *Part 2 tells you what will happen to you in this study if you take part.*
- *Part 3 gives you more detailed information about the conduct of the study.*

Contact Details
If you have any queries regarding this study please contact Principal Investigator Dr Kou Murayama, School of Psychology, University of Reading, RG6 6AL Phone: 0118 378 5558 e-mail: k.murayama@reading.ac.uk. Alternatively contact researcher Laura Burgess e-mail: l.g.burgess@pgr.reading.ac.uk

Part 1

Why do we need to do the research?

- Motivation is a main factor that drives students' learning and achievement in school. In fact, previous research has shown that students' motivational engagement is a better predictor of their marks in school than intelligence test scores.
- In recent years there has been growing interest on how factors like learning environment, teaching styles and parenting styles impact on students' motivation in school. Even though there is more focus on this area, only a small amount of work has been carried out on the influences coming from the students' friendships.
- Schools provide lots of chances for students to make friends, work as groups, and interact with each other. Through social activities, students share their motivational experiences with their friends, causing the students' motivation to influence those of their friends (and vice versa).
- The aim of the current research is to investigate the spread of motivation within a school environment.
- The University of Reading are working together with Queen Anne's school, Caversham to carry out this research, funded until September 2019. The study will be supervised by Dr Kou Murayama and carried out by Laura Burgess, a PhD student at the University of Reading, who will be using the data collected for her studies.

Do you have to take part?

No. It is up to you to decide whether to let your child take part. If you do, you can keep this information sheet and will be asked to sign a consent form on behalf of your child before we test them in school. We will also explain what would be involved to students in a way they should understand and give them an opportunity to say themselves if they would like to take part. As you are volunteering your child to be involved, you are free to withdraw your decision at any time and without giving a reason.

University of Reading

Part 2

What will happen if I do want to help with the research?

- We test all participants, whatever their age, in the same way.
- We will carry out the testing at your child's school, at a convenient time so that their schoolwork is minimally interrupted. The research will involve one testing session which should be completed within 1 hour but will take no longer than 2 hours. Your child can have a break during the session if they would like.
- During the session your child will be completing a series of questionnaires to assess their own academic motivation and also how much academic motivation they perceive their peers to have. As part of this assessment we may ask them to do a simple computer task which gives us information on their working memory. Additionally, we will ask them to mark on a class list all of the students they 'spend most time' with, in order to sensitively build up an idea of the social group/s they are a part of in school.
- The testing does not involve anything unpleasant or uncomfortable, though your child will be reminded that they do not have to provide an answer unless they are happy to.
- Students are free to ask for help on anything that may not be clear to them, at any point.
- The questionnaires have all been designed for school age students

Are there any risks?

Many of the questionnaires used in this study have been used in research settings in the past. Though some items used are unique to the present study, senior staff in your child's school have seen and approved the content of the questionnaires.

This research poses no significant health risks.

Are there any benefits?

The results of this investigation will help us to understand how we can increase academic motivation by allowing us to see who the main influencers are in friendship groups and in turn encourage those students to positively impact on their friends.

The wider benefit of taking part in this research is that you will be involved in a new research approach, helping to gain understanding about the way motivation spreads through a social network in school environments.

Will taking part affect my child's grades?

This study is in no way performance related and will not have any link to your child's school studies/grades. They are not marked based on the answers they give, and they will **not** receive a penalty of any kind if you or they decide not to take part.

What if there is a problem?

Any complaint about the way you have been treated during the study or any possible harm you might suffer will be addressed. The detailed information on this is given in Part 3.

Will my taking part in the study be kept confidential?

Yes, all information relating to participation will be kept private and confidential. Further details are given in Part 3.

Part 3

What will happen if we don't want to take part anymore?

You are free to withdraw at any time without giving a reason why and without penalty.

What if I have a problem with the study?

If you have a concern about any aspect of this study, you should ask to speak with the researchers who will do their best to answer your questions (Dr Kou Murayama on 0118 3785558).

If you remain unhappy and wish to complain formally, you can do this through Head of School of Psychology & Clinical Language Sciences, Professor Laurie Butler. If your complaint is not dealt with to your satisfaction you can contact the Chair of the University Research Ethics Committee. Details can be obtained from the School of Psychology and Clinical Language Sciences.

Confidentiality

All information that is collected about you or your child during the course of the research will be kept strictly confidential and records will be given a unique reference number for analysis. For this reason, we are not able to provide individual feedback for students at this time. If we traced your child back from their unique number easily, then the information would not be as confidential.

Paper records will be stored securely in a locked room or cabinet and computer records will be password protected. Personal details will be kept separate from research data once the data collection phase has finished and will be destroyed at the end of the study.

If you join the study, some parts of the data collected for the study may be looked at by authorised and statutory bodies from the University, to check that the study is being carried out correctly. All will have a duty of confidentiality to you as a research participant and nothing that could reveal your identity will be disclosed or taken outside the research site. Consent forms and any identifiable records will be kept for 5 years in line with University guidelines.

Participants and parents have the right to check the accuracy of data held about them and correct any errors. All investigators working on this project have had criminal record checks and have been approved by the School to work with children.

What will happen to the research results?

At the end of the study, once we have analysed the data on all the participants, we will send you a newsletter or email to explain the findings. We will aim to publish the findings in international science journals and meetings, but no identifiable names will be used without your express permission.

Who is organising the research?

Dr Kou Murayama PhD is the Principal Investigator working at the School of Psychology and Clinical Language Sciences at the University of Reading. Professor Patricia Riddell also from the School of Psychology and Clinical Language Sciences will be co-supervising the project. Miss Laura Burgess, BSc (Hons) is a PhD student, and will be using the collected data in her thesis. The research is funded by the South East Doctoral Training Centre (SEDTC) with contribution also from Queen Anne's School, Caversham.

Who has reviewed the study?

This application has been reviewed by the University of Reading Research Ethics Committee and has been given a favourable ethical opinion for conduct.

Thank you very much for reading this sheet and considering taking part in the study.

8.7. Parental consent form for participants aged 11-15 years (survey research)

University of Reading

Study Number:
Identification
Number for this trial: ……..

School of Psychology & Clinical Language Sciences
Harry Pitt Building
Earley Gate,
Reading
RG6 7BE
phone +44 (0)118 378 5558
email k.murayama@reading.ac.uk

PARENTAL CONSENT FORM

Title of Project: Motivation and Peer Relationships

Name of Supervisor/s: Dr Kou Murayama; Prof. Patricia Riddell
Investigators: Laura Burgess

Name of Participant: _____

DOB of Participant:_____

	Please initial box
• I confirm that I have read and understand the information sheet dated ??/??/?? (version 1) for the above study. I have had the opportunity to consider the information and discuss it with _____ (if I chose to) and have had any questions answered satisfactorily.	☐
• The nature of the tests have been explained to me and I understand the requirements for my child to take part in the above study.	☐
• I understand that my, or my child's, participation is voluntary and that I am/we are free to withdraw at any time and do not have to explain the reason for my decision.	☐
• I understand that the project has been subject to ethical review, according to the procedures specified by University of Reading Research Ethics Committees, and has been allowed to proceed.	☐
• I understand that all personal information will remain confidential to the investigators and arrangements for the storage and eventual disposal of any identifiable material has been made clear to me.	☐
• **I agree for my child to take part in the above study.**	☐

University of Reading

School of Psychology & Clinical Language Sciences
Harry Pitt Building
Earley Gate,
Reading
RG6 7BE
phone +44 (0)118 378 5558
email k.murayama@reading.ac.uk

Name of Parent /Guardian:

_____

Signature of Parent/Guardian: Date:

_____ _____

I confirm that I have explained the above-mentioned study, as detailed in the corresponding Information Sheet dated ??/??/?? such that, in my judgment, it is understood by the participant.

Name of Researcher:

_____

Signature of Researcher: Date:

_____ _____

When completed, 1 for participant; 1 for researcher site file

8.8. Information sheet for students aged 11-13 years (survey research)

University of Reading

Motivation Laboratory
School of Psychology & Clinical Language Sciences
Earley Gate, RG6 6AL
Postcode for SatNav RG6 7BE
phone +44 (0) 118 378 5558
email k.murayama@reading.ac.uk

The spread of motivation among peers in schools

Principle Investigator: Kou Murayama PhD
Project entitled **"Motivation and Peer Relationships"**

Information for Participants: L4, 4, U4

The University of Reading are going to do a research study, looking at how the people you hang around with influence the way you work in school and the ideas that you have about the world. You are invited to take part!
BUT, before you decide if you want to join in, you should understand why the research is being done and what will happen. Please read this sheet carefully, and talk to others about the study if you wish.

- *Part 1 tells you why we're doing this research.*
- *Part 2 tells you what will happen in this study if you take part.*
- *Part 3 gives you information about the way the study is managed.*

Contact Details
After reading, if you have any questions please get in touch with a teacher at your school. Otherwise, researchers from the University of Reading will be happy to help:
Principal Investigator Dr Kou Murayama, School of Psychology, University of Reading, RG6 6AL Phone: 0118 378 5558 e-mail: k.murayama@reading.ac.uk.
Researcher Laura Burgess e-mail: l.g.burgess@pgr.reading.ac.uk

Part 1

A bit of background

- Motivation is really important when it comes to learning and succeeding in school and previous research has shown that a students' motivation is better at predicting how good their grades will be, rather than their intelligence level.
- At school you have lots of chances to spend time with others, work in groups, and interact with different students.
- Through these social activities, students can share motivation with each other, sharing this can mean that the motivations become similar in a group.
- The aim of the current research is to investigate the spread of motivation within schools.

Do you have to take part?

No. It is up to you! If you do, you can keep this information sheet and will be asked to sign a form saying that you are happy and agree, before we test you in school. As you are volunteering to take part, you are free to stop at any time without giving a reason. You don't have to take part just because your parents gave permission. The choice is yours.

University of Reading

Part 2

What will happen if I do want to help with the research?

- We test all participants, whatever their age, in the same way.
- We will carry out the testing at your school, at a good time so that your school work isn't interrupted. The research will involve one testing session which will last around 1 hour, 2 at tops. You can have a break during the session if you would like.
- During the session you will be completing questionnaires about your motivation in school and also how much motivation you think your classmates have. We may also ask you to complete a fast and simple computer task.
- Also, we will ask you to mark from a class list all of the students you spend most of your time with, this gives us an idea of the social group/s you are a part of in school.
- You need to answer all questions as honestly as you can, and don't spend too long deciding on your answers.
- The testing does not involve anything unpleasant or uncomfortable, you are free to ask for help at any point.
- The questionnaires have all been designed for school age students.

Are there any risks?

Many of the questions used in this study have been used in past research and some things used are new for this study. Senior staff in your school have agreed to the questions used.

Are there any benefits?

The results of this investigation will help us to understand how we can increase school motivation by allowing us to see who the main influencers are in friendship groups and in turn encourage those students to positively impact on their groups.

This is an exciting new research approach, not been used before. It will help us to learn about the way motivation spreads in schools.

We will be offering chocolate and amazon voucher prize draws on the day as thanks for taking part.

Will taking part affect my grades?

This study is **NOT** linked to your school studies/grades. You are **NOT** marked based on the answers you give, and you will **NOT** receive a penalty of any kind if you decide not to take part.

Will my taking part in the study be kept confidential?

Yes, all information regarding participation will be kept private and confidential, meaning no one will see your answers and only the researchers will be able to trace your unique participant number back to your name. More details are given in Part 3.

University of Reading

Part 3

What will happen if we don't want to take part anymore?

You are free to leave at any time without giving a reason why.

What if I have a problem with the study?

If you have a worry about anything this study, you should speak to your teachers, or ask to speak with the researchers who will do their best to answer your question. They can pass you on to the right people if your worry is serious.

Confidentiality

All information that is collected about you during the research will be kept confidential and details are given a unique number for analysis. For this reason we aren't able to give you individual feedback, if we traced you back from your unique number easily, then the information isn't as confidential.

Paper records will be stored securely in a locked room or cabinet and computer records will be password protected. Personal details will be kept separate from data, once the data collection has finished. They will be destroyed at the end of the study.

If you join the study, some parts of the data collected for the study may be looked at by authorised professionals from the University, just to check that the study is being carried out correctly. All will have a duty of confidentiality to you and nothing that could show your identity will be disclosed or taken outside the school or university. Consent forms and anything with your name on will be kept for 5 years, to follow the University guidelines.

All investigators working on this project have had criminal record checks and have been approved by the School to work with children.

What will happen to the research results?

At the end of the study, once we have analysed the data from everyone, we will send you a newsletter to explain the findings. We will aim to publish the findings in international science journals but no identifiable names will be used without your permission.

Who is organising the research?

Dr Kou Murayama PhD is the Principal Investigator working at the School of Psychology and Clinical Language Sciences at the University of Reading. Professor Patricia Riddell also from the School of Psychology and Clinical Language Sciences will be co-supervising the project. Miss Laura Burgess MSc, is a PhD student, and will be using the collected data in her thesis. The research is funded by the South East Doctoral Training Centre (SEDTC) with contribution also from Queen Anne's School, Caversham.

Who has reviewed the study?

This application has been reviewed by the University of Reading Research Ethics Committee and has been given a favourable ethical opinion for conduct.

Thank you very much for reading this sheet and considering taking part in the study.

8.9. Assent form for participants aged 11-15 years (survey research)

University of Reading

School of Psychology & Clinical Language Sciences
Harry Pitt Building
Earley Gate,
Reading
RG6 7BE
phone +44 (0)118 378 5558
email k.murayama@reading.ac.uk

Study Number:
ID Number for this trial: ……..

STUDENT ASSENT FORM

Title of Project: Motivation and Peer Relationships

Name of Supervisor/s: Dr Kou Murayama; Prof. Patricia Riddell
Investigators: Laura Burgess

Name of Participant: _____

DOB of Participant: _____

Please initial box

- I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information and discuss it with _____ (if I chose to) and have had any questions answered. ☐
- The study has been explained to me and I understand the requirements to take part. ☐
- I understand that I am volunteering and that I am free to withdraw at any time and do not have to explain the reason for my decision. ☐
- I understand that the project has been through an ethical review as set out by University of Reading Research Ethics Committees, and has been allowed to continue. ☐
- I understand that all personal information will remain confidential to the investigators and arrangements for the storage and eventual disposal of any named material have been made clear to me. ☐
- I am willing for my results from the measures carried out as part of this study to be shared with my class teacher/s as part of an anonymous average. ☐
- I agree for some or all of the data I provide to be preserved over the long term, and to make the data available, in anonymised form if required, either openly or subject to appropriate safeguards, so that they can be consulted and re-used by others, in accordance with the University's Research Data Management Policy. ☐
- **I agree to take part in the above study.** ☐

University of Reading

School of Psychology & Clinical Language Sciences
Harry Pitt Building
Earley Gate,
Reading
RG6 7BE
phone +44 (0)118 378 5558
email k.murayama@reading.ac.uk

Name of Student:

_____

Signature of Student: Date:

_____ _____

I confirm that I have explained the above mentioned study, as detailed in the corresponding Information Sheet such that, in my judgment, it is understood by the participant.

Name of Researcher:

_____

Signature of Researcher: Date:

_____ _____

When completed, 1 for participant; 1 for researcher site file

8.10. Additional figures – Chapter 3 histograms

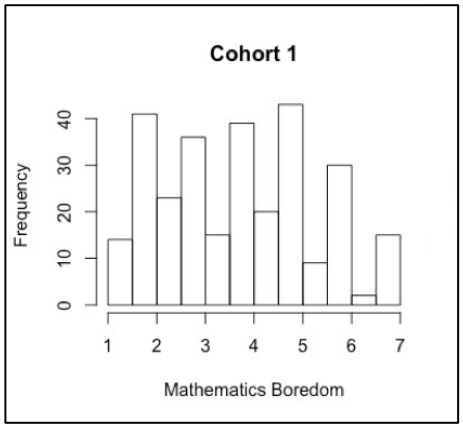


Figure 12. Mathematics Interest score distributions.

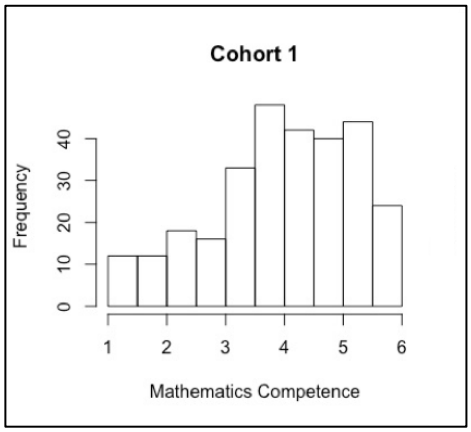


Figure 13. Mathematics Boredom score distributions.

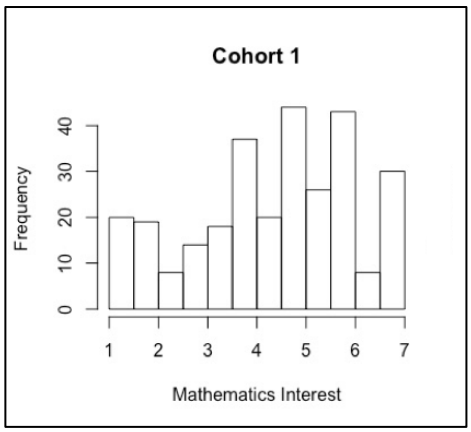


Figure 14. Mathematics Competence (academic self-concept) score distributions.

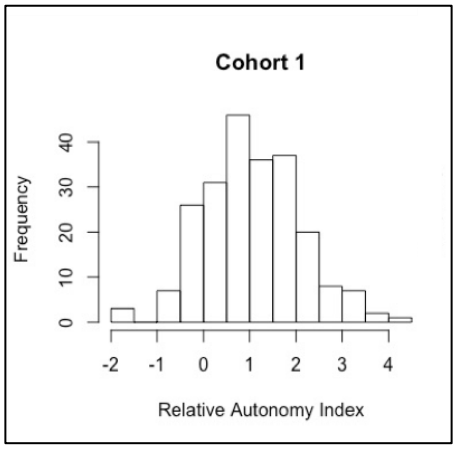


Figure 15. Relative Autonomy Index (measure of autonomous regulation) score distributions.

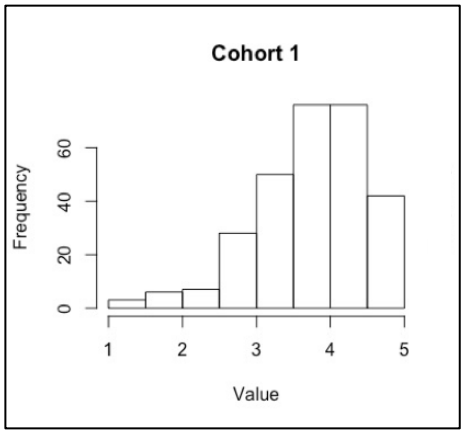


Figure 16. Value score distributions.

Figure 17. Grit subscale for consistency of interest score distributions.

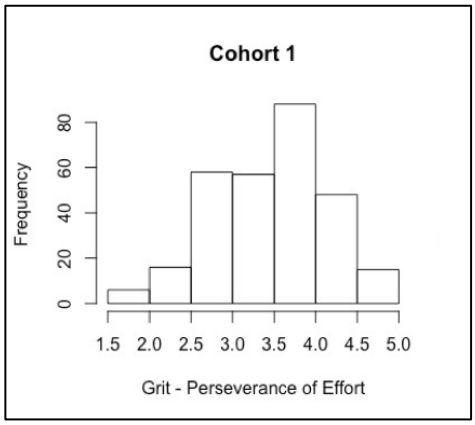


Figure 18. Grit subscale for perseverance of effort score distributions.

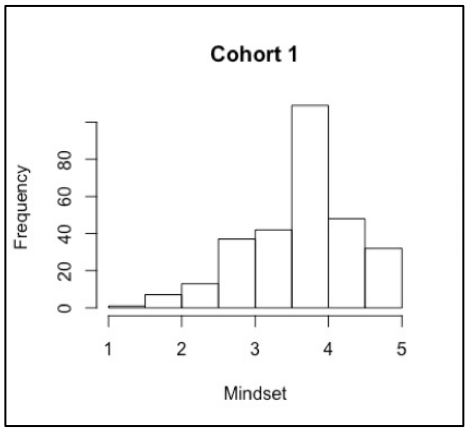


Figure 19. Mindset score distributions.

8.11. Additional figures – Chapter 3 forest plots

The following are examples of overall trends where sixth form year groups (Year 12 and 13) look similar in comparison to their younger cohorts.

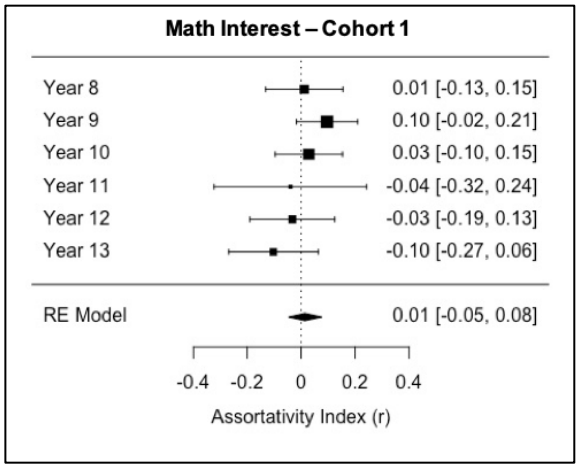
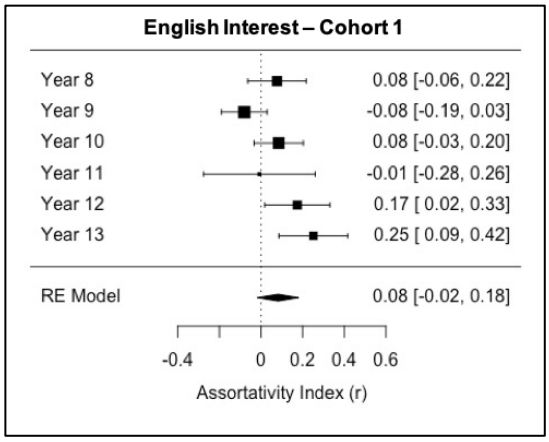


Figure 20. Forest plots depicting the Math Interest estimates across the six year groups included in the random-effects meta-analysis.



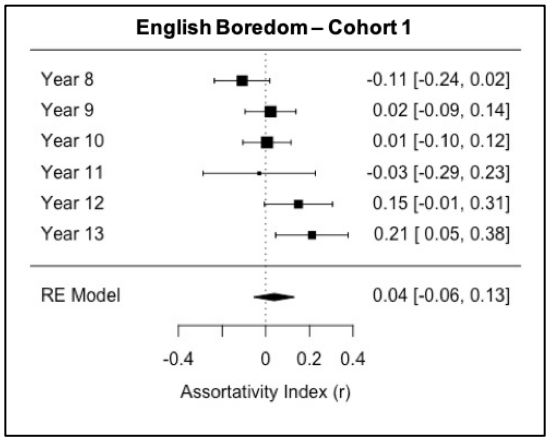


Figure 21 and 22. Forest plots depicting English Interest and English Boredom estimates from cohort 1 across the six year groups included in the random-effects meta-analysis.

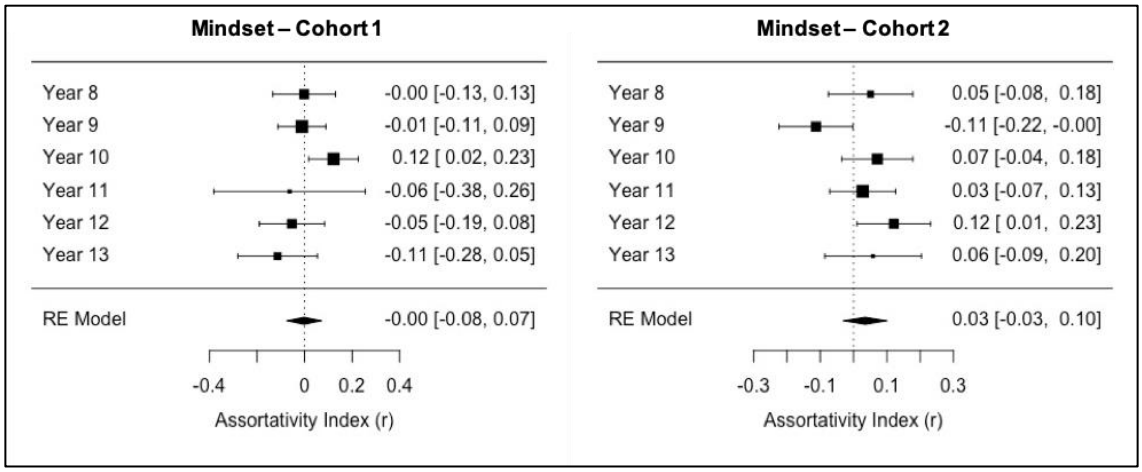


Figure 23. Forest plots depicting the Mindset estimates across the six year groups included in the random-effects meta-analysis.

8.12. University of Reading Ethics Committee (UREC) study approval – Motivation and peer relationships

University of Reading

Coordinator for Quality Assurance in Research
Dr Mike Proven, BSc(Hons), PhD

Academic and Governance Services
Whiteknights House
Whiteknights, PO Box 217
Reading RG6 6AH

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fax +44 (0)118 378 8979
email m.j.proven@reading.ac.uk

Dr Kou Murayama
School of Psychology and Clinical Language Sciences
University of Reading
RG6 6AL

20 January 2017

Dear Kou

UREC 16/60: Motivation and Peer Relationships *Favourable opinion*

Thank you for the response (email, dated 16 January 2017 and including attachments, refers) addressing the issues raised by the UREC Sub-committee at its December 2016 meeting. On the basis of this response and the revised documentation, I can confirm that the Chair is pleased to confirm a favourable ethical opinion.

Please note that the Committee will monitor the progress of projects to which it has given favourable ethical opinion approximately one year after such agreement, and then on a regular basis until its completion.

Please also find attached Safety Note 59: Incident Reporting in Human Interventional Studies at the University of Reading, to be followed should there be an incident arising from the conduct of this research.

The University Board for Research and Innovation has also asked that recipients of favourable ethical opinions from UREC be reminded of the provisions of the University Code of Good Practice in Research. A copy is attached and further information may be obtained here:

http://www.reading.ac.uk/internal/res/QualityAssuranceInResearch/reas-RSqar.aspx.

Yours sincerely

[redacted]

Dr M J Proven
Coordinator for Quality Assurance in Research (UREC Secretary)
cc: Dr John Wright (Chair); Dr Laurie Butler (Head of School);

8.13. Opt-out correspondence to parents/legal guardians of participants ages 11-15 years (survey research)

Dear Parents of **<<YEAR>>**,

We are writing to you about the ongoing BrainCanDo motivation research project with the University of Reading.
As a reminder, the project is focussed on looking at patterns of motivation in students' social networks, to see if motivation becomes similar between socially connected individuals over time. As an addition to this, we are periodically collecting brain imaging data from a smaller sample of students, extending our research question by asking 'Do students' brains become more similar over time, based on their positive social interactions?'
The next phase of data collection involves researchers from the university returning to QAS to carry out motivation and social network surveys, in a similar manner to the school visits we did earlier last year (academic year 2016/17).
We are now doing our year follow up from the previous surveys that we carried out last year, and the process is much the same as before.
We will ask each student to complete an online survey where they will provide information about their motivation at school, and then provide us with their anonymous social network information.

Attached to this email is the detailed information sheet for the survey element of the research.

If after reading the information sheet you DO NOT want your child to be involved in the survey, please contact the school office to make them aware.
We are planning to come into school to collect social network information on <<DATE>>, so please be sure to contact the school office ahead of this date if you do not want to be involved.

You are also able to withdraw your daughter's data from the research project following the data collection, should you wish to do so.

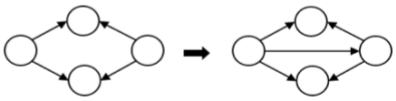
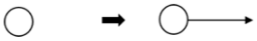
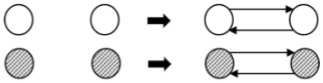
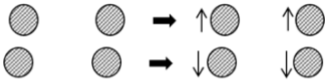
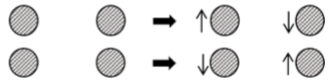
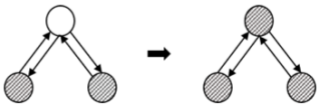
If you require any additional information before reaching a decision about your child's participation, or at any point during this project, please contact:
Laura Burgess email: **l.g.burgess@pgr.reading.ac.uk**, or;
Kou Murayama email: **k.murayama@reading.ac.uk**, phone: **0118 3785558**.

Sincerely,

Miss Laura Burgess (PhD student) & Dr Kou Murayama (Associate Professor)

8.14. Additional figures – Chapter 4 specified model effects

Table 1. Description of SIENA effects modelled, separated by structure, selection and influence effects.

Effect	Description	Graphical representation
Structure effects		
Density	Preference for ties to arbitrary others, reflects the denseness of a network	
Reciprocity	Preference for mutual ties.	
Transitivity	Preference for ties with the friends of your friends. Provides a measure for network closure.	
Balance	Tendency to have ties to structurally simlar others (i.e. having the same pattern of ties as others with whom you are connected)	
Selection effects		
Alter	Actors with higher scores on a certain individual-level covariate receive more nominations	
Ego	Actors with higher scores on a certain individual-level covariate give more nominations	
Similarity x Reciprocity	Demonstrating a preference for mutual ties with similar others (i.e., actors that have similar values on a certain individual-level covariate)	
Influence effects		
Linear Shape	Overall tendency to have higher or lower values in a certain variable.	
Quadratic Shape	Positive values indicate that high scores lead to an increase in the variable over time, whereas low scores lead to a decrease in the variable over time. Negative values indicate that high scores lead to decreases in the variable over time, whereas low scores lead to increases in the variable over time.	
Similarity x Reciprocity	The degree to which individual-level covariate scores are increased or decreased based on mutual relationship ties (i.e., whether influence can be attributed to reciprocated relationships).	

Note. Table derived from Ojanen, Sijtsema, Hawley & Little (2010) and Gremmen et al. (2019).

8.15. Centre for Integrative Neuroscience and Neurodynamics (CINN); Initial screening form for persons entering the MR environment

INITIAL SCREENING FORM

CINN Centre for Integrative Neuroscience and Neurodynamics

Scanning Session Code: (YYMMDDhhmm)

School of Psychology and Clinical Language

NAME OF PARTICIPANT ..... Sex: M / F

Height..... cm Approximate weight in kg..... (one stone is about 6.3 kg)

Date of birth.....

Please read the following questions CAREFULLY and provide answers on behalf of your child. For a very small number of individuals, being scanned can endanger comfort, health or even life. The purpose of these questions is to make sure that your child is not one of these people.

You have the right to withdraw your child from the screening and subsequent scanning if you find the questions unacceptably intrusive. The information you provide will be treated as strictly confidential and will be held in secure conditions.

Delete as appropriate

1.	**Has your child been fitted with a pacemaker or artificial heart valve?**	**YES/NO**
2.	**Does your child have any active implants, such as cochlear, ocular, penile implant?**	**YES/NO**
3.	**Has your child ever had any metal fragments in their eyes?**	**YES/NO**
4.	**Has your child ever had any metal fragments, e.g. shrapnel in any other part of their body?**	**YES/NO**
5.	**Does your child wear a hearing aid?**	**YES/NO**
6.	**Has your child ever suffered from any heart disease?**	**YES/NO**
7.	**Does your child have any body piercings that they cannot, or is unwilling to, remove?**	**YES/NO**
8.	**Does your child have any drug infusion pump installed?**	**YES/NO**
9.	**Does your child have any stimulators for nerves, brain or bone installed?**	**YES/NO**
10.	**Has your child been sterilised using clips?**	**YES/NO**
11.	**Is there any possibility that your child might be pregnant?**	**YES/NO**

12. **Does your child have any surgically implanted metal in any part of your body, other than dental fillings and crowns (e.g. joint replacement or bone reconstruction)** **YES/NO**

13. **Has your child ever had any surgery that might have involved metal implants of which you are not aware?** **YES/NO**

14. **Does your child wear a filling, crown, dental post (entirely within the tooth) associated with root canal treatment, retainer, bridge, or braces?** **YES/NO**

15. **Does your child wear transdermal patches that contain metal?** **YES/NO**

16. **Does your child have any tattoos or permanent make-up?** **YES/NO**

17. **Has your child ever suffered from epilepsy or thermoregulatory problems?** **YES/NO**

18. **Does your child have an intrauterine contraceptive device (IUD) installed?** **YES/NO**

19. **Is your child using coloured contact lenses?** **YES/NO**

Please enter below the name and address of the child's doctor (general practitioner).

(Not required for persons entering the MRI Controlled Area but not being scanned.)

Name of GP (surgery):

Address of GP (surgery):

I understand that I my child is about to undergo an MRI scan. I have read and understood the questions above and have answered them correctly.

SIGNED..... DATE.....

In the presence of ..... (name) .....(signature)

8.16. Centre for Integrative Neuroscience and Neurodynamics (CINN); Second screening form for persons entering the MR environment

Form completed if parent is in attendance:

SECOND SCREENING FORM

CINN Centre for Integrative Neuroscience and Neurodynamics

Scanning Session Code: (YYMMDDhhmm)

School of Psychology and Clinical Language Sciences

This form should be completed and signed immediately before your child's scan, after removal of any jewellery or other metal objects and (if required by the MRI Operating Person) changing your child's clothes.

Name of Participant: ..... Name of Parent.....

Birth Date(Participant) ..... Sex (Participant): M / F

Please read the following questions CAREFULLY and provide answers on behalf of your child. For a very small number of individuals, being scanned can endanger comfort, health or even life. The purpose of these questions is to make sure that your child is not one of these people.

You have the right to withdraw your child from the screening and subsequent scanning if you find the questions unacceptably intrusive. The information you provide will be treated as strictly confidential and will be held in secure conditions.

BEFORE YOUR CHILD IS TAKEN THROUGH FOR THEIR SCAN IT IS ESSENTIAL THAT THEY REMOVE **ALL METAL OBJECTS** INCLUDING: WATCHES, PENS, LOOSE CHANGE, KEYS, HAIR CLIPS, METAL UNDERWIRE BRA, ALL JEWELLERY, METALLIC COSMETICS, TRANSDERMAL PATCHES, CHEQUE/CASH POINT CARDS.

Delete as appropriate

1. Is your child wearing or carrying any metal items such as those listed above? **YES/NO**

2. Have your answers to any of the questions in the initial screening form changed? **YES/NO**
(The initial screening form must be shown to you before you answer this question.)

More specifically, please confirm:

3. Has your child been fitted with a pacemaker, artificial heart valve or cochlear ocular, penile or other bodily implant? **YES/NO**

4. Is there any possibility that your child is pregnant? **YES/NO**

I have read and understood the questions above and have answered them correctly.

SIGNATURE..... DATE.....

FOR STAFF USE:

I certify that the initial screening form and the consent form have been completed by the parent/guardian of the person named above and I have attached them to this form. The volunteer and their parent/guardian have been given the standard information sheet about MRI experiments, together with any necessary study-specific information, and has been given an opportunity to ask questions. I am satisfied that the parent/guardian is adequately informed and understands the content of the consent form. I have taken adequate steps to ensure that the volunteer has no ferro-magnetic metal in or on his/her person and I am satisfied that the scan can proceed.

SIGNATURE..... NAME (PRINT) .....

DATE.....

SIGNATURE..... NAME (PRINT) .....

DATE.....

Form completed if parent not in attendance:

SECOND SCREENING FORM

CINN Centre for Integrative Neuroscience and Neurodynamics

Scanning Session Code: (YYMMDDhhmm)

School of Psychology and Clinical Language Sciences

This form should be completed and signed immediately before your child's scan, after removal of any jewellery or other metal objects and (if required by the MRI Operating Person) changing your child's clothes.

Name of Participant: ..... Name of Parent.....

Birth Date(Participant) ..... Sex (Participant): M / F

Please read the following questions CAREFULLY and provide answers on behalf of your child. For a very small number of individuals, being scanned can endanger comfort, health or even life. The purpose of these questions is to make sure that your child is not one of these people.

You have the right to withdraw your child from the screening and subsequent scanning if you find the questions unacceptably intrusive. The information you provide will be treated as strictly confidential and will be held in secure conditions.

BEFORE YOUR CHILD IS TAKEN THROUGH FOR THEIR SCAN IT IS ESSENTIAL THAT THEY REMOVE **ALL METAL OBJECTS** INCLUDING: WATCHES, PENS, LOOSE CHANGE, KEYS, HAIR CLIPS, METAL UNDERWIRE BRA, ALL JEWELLERY, METALLIC COSMETICS, TRANSDERMAL PATCHES, CHEQUE/CASH POINT CARDS.

Delete as appropriate

1. Is the child wearing or carrying any metal items such as those listed above? **YES/NO**

2. Have the parent's answers to any of the questions in the initial screening form changed? **YES/NO**
(The initial screening form must be shown to the parent before you answer this question.)

More specifically, record here how the parent has responded to the following questions:

3. Has the child been fitted with a pacemaker, artificial heart valve or cochlear ocular, penile or other bodily implant? **YES/NO**

4. Is there any possibility that the child is pregnant? **YES/NO**

I have read and understood the questions above. I confirm I have recorded the answers as provided by the parents.

NAME (witness)..... DATE.....

SIGNATURE (witness)..... DATE.....

FOR STAFF USE:

I certify that the initial screening form and the consent form have been completed by the parent/guardian of the person named above and I have attached them to this form. The volunteer and their parent/guardian have been given the standard information sheet about MRI experiments, together with any necessary study-specific information, and has been given an opportunity to ask questions. I am satisfied that the parent/guardian is adequately informed and understands the content of the consent form. I have taken adequate steps to ensure that the volunteer has no ferro-magnetic metal in or on his/her person and I am satisfied that the scan can proceed.

SIGNATURE…… NAME (PRINT) ……..

DATE……

SIGNATURE…… NAME (PRINT) ……..

DATE……

8.17. Information sheet/booklet for parents/legal guardians of participants (MRI research)

University of Reading

BrainCanDo

www.braincando.com

INFORMATION FOR PARENTS

Motivation contagion project

Information for Parents

We would be grateful if you could assist us by participating in our study.

In this next stage of data collection, we are interested in fully understanding how motivation changes across time, measured using magnetic resonance imaging (MRI).

Your child is being invited to participate in this study because they are a healthy student aged between 11 and 18.

The research sessions will take around 1 hour and your child will visit the University of Reading along with another student and accompanying parents/teachers for a 2 hour visit. In brief, the scanning element would involve completing various simple cognitive tasks during a brain imaging session.

CONTACT DETAILS

If after reading the information below you have any queries, please contact a member of staff at your school.

Alternatively, researchers from the University of Reading will be happy to help:

Principal Investigator Dr Kou Murayama k.murayama@reading.ac.uk

Researcher Laura Burgess l.g.burgess@pgr.reading.ac.uk

The following notes give information about the study and what it would be like for your child to take part:

PART 1 tells you about the purpose of the study;

PART 2 tells you general information about the MRI technique;

PART 3 tells you information about what will happen if you decide to take part;

PART 4 tells you more detailed information about how the study is managed.

The MRI study takes place at the University of Reading, Psychology Department and at the Centre for Integrative Neuroscience and Neurodynamics, adjacent to the Psychology Department. We shall recompense your child £10 (in the form of an online voucher) as a token of our appreciation for the time and effort involved in participation. If you choose to attend the university to accompany your child for the data collection, you are able to claim expenses for any travel.

PART 1

The purpose

Why do we need to do the research?
Motivation is a main factor that drives students' learning and achievement in school. In fact, previous research has shown that students' motivational engagement is a better predictor of their marks in school than intelligence test scores.

In recent years there has been growing interest on how factors like learning environment, teaching styles and parenting styles impact on students' motivation in school. Even though there is more focus on this area, only a small amount of work has been carried out on the influences coming from the students' friendships.

Schools provide lots of chances for students to make friends, work as groups, and interact with each other. Through social activities, students share their motivational experiences with their friends, causing the students' motivation to influence those of their friends (and vice versa).

The aim of the current research is **to investigate the spread of motivation within a school environment.**

We will collect brain activity of students to see if brain activity becomes more similar over time.

PART 2

General Information

What is functional magnetic resonance imaging (fMRI)?
MRI is a method for producing images of the brain. It involves placing a participant inside a large, powerful magnet, which forms part of the brain scanner. We use MRI to image the structure of different parts of the brain. We can also image which parts of the brain are more or less active.

When particular regions of the brain are active, they require more oxygen, which comes from the blood. As a result, the flow of blood to the area increases. These changes can be detected and then be converted by a computer into 3D images. This enables us to determine which parts of the brain are active during different tasks.

What are the safety precautions taken?
As far as we know, this procedure poses no direct health risks. No health risks have been associated with the magnetic field or radio waves, since the low-energy radio waves use no radiation. The process can be repeated without side effects. However, the Department of Health advises that certain people should NOT be scanned. Because the scanner magnet is very powerful, it can interfere with heart pacemakers and clips or other metal items which have been inserted into the body by a surgeon, or with body-piercing items.

If your child has had surgery which may have involved the use of metal items they should

NOT take part. Note that only magnetic materials (e.g. steel) are likely to cause problems. Normal dental fillings do not prohibit people from being scanned, though a dental plate which contained metal would do so, and they would be asked to remove it.

Your child will be asked to remove metal from their pockets (coins, keys), remove articles of clothing which have metal fasteners (belts, etc.), as well as most jewellery. Alternative clothing will be provided as necessary. Additionally, watches and credit cards should not be taken into the scanner since it can interfere with the way they work.

You will be asked to complete a questionnaire (the Initial Screening Form), which asks about these and other matters to decide whether it is safe for your child to be scanned. You will also be asked to complete a second, shorter, screening form by telephone right before the scan (Second Screening Form).

There is no intended clinical benefit to you from taking part in this study. The scans are not able to provide a medical diagnosis or a clean 'bill of health' and the person conducting the scans will not be able to comment on any results.

The researchers involved are not experts in MRI diagnosis, as they are psychologists or allied scientists and are **not medical doctors,** meaning they cannot look at the scans from a medical point of view. We ask you to give the name and address of your child's GP. This is because occasionally, when we image healthy participants, the researchers may be concerned that something does not look 100% normal on the scan. In such cases, we will send a copy of the image to your child's GP, so that they can decide what course of action is best. By signing the consent form, you allow us to do this. If you are not willing to authorise this, please do not volunteer for the study.

It is important that you realise that these research scans are **not a medical procedure,** and will not provide any information that may help in the diagnosis of any medical condition. If you do have any health concerns, you should contact a qualified medical practitioner in the normal way.

What is it like in the scanner?
To be scanned, you would lie on your back on a narrow bed on runners, on which you would be moved until your head was inside the magnet. The scanner itself looks like a very large ring donut, and you would slide through until your head is in the centre!

The scanning process itself creates irregular loud noises, and you would wear ear-plugs or noise reducing headphones. We would be able to talk to you while you are in the scanner through an intercom. This is what your child will experience during the session.

If they are likely to become very uneasy in this relatively confined space (suffer from claustrophobia), they should NOT take part in the study. If they do take part and this happens, they will be able to alert the researchers and will then be removed from the scanner quickly.

It is important that your child keeps their

head as still as possible during the scan, and to help them with this, their head will be supported by padded headrests. We would ask them to relax their head and keep it still for no longer than one hour at a time (they will not be continuously scanned for this period), which may require some effort on their part. If this becomes too difficult or uncomfortable, they may call to be removed from the scanner.

Your child may be asked to look at a screen through a small mirror (or other optical device) placed just above their eyes. They may be asked to make judgements about what they see or asked to perform some other kind of task in their head. Details of the specific study that your child is invited to participate in are given in Part 4 of this sheet. Detailed instructions will be given just before the scan, and from time to time during it.

Your child will be able to say that they wish to stop the testing and leave at any time, without giving a reason. This would not affect their relationship with the researchers or teachers in any way.

If you agree to participate you will be asked to complete and sign an initial screening form. It is perfectly in order for you to take time to consider whether to participate, or discuss the study with other people, before completing this process.

Remember, you will still have the right to withdraw at any time before or during the study, without giving a reason.

The brain images will be held securely and neither you nor your child will be identified by name in any publications that might be made from the study. The information in the two screening forms will also be treated as strictly confidential and the forms will be held securely until eventually destroyed. Further information about the specific study in which you are invited to participate has been included in the next section. Please feel free to ask any questions about any aspect of the study or the scanning procedure.

PART 3

Specific information about this study

Brief outline of tasks and procedure
The research session as a whole will take in total approximately 1 hour. The total amount of time your child could be in the MRI scanner may be up to 1 hours (up to 35 mins scan time). This will include introducing them to the scanner room, making sure they're comfortable on the bed, tuning and calibration of the MR machine, taking structural images of their brain (i.e. to image what the brain looks like) as well as taking images of the brain activity while working on a task in which they will be presented with visual images.

During the session, your child will be asked to perform the following (or a subset of the following) tasks.

1 Prescreening & scanning preparation
You will be asked questions, based around a pre-determined list, to check that your child does not have any conditions, medications, or recent experiences that put them at risk during the neuroimaging procedures. These will include questions about potential sources of metal in their body and about previous head trauma. You may need complete some of these forms more than once during the study, this will preferably be done in person, but may be done over the phone.

2 Questionnaires
Your child will complete several questionnaires. One will gather information on their characteristics: date of birth, school year, first language, ethnicity, and medications. Another around their general feelings about themselves, and finally a questionnaire on their current motivational status.

3 Cognitive task
When in the scanner your child will be asked to perform a simple cognitive task where they will be presented with a series of stimuli which they will view whilst in the scanner by looking at a mirror reflecting the contents of a screen. They will be asked to make a response based on what they view using a button press box. Before the session they will receive a detailed explanation of the procedures and a chance to practice the task. Before they leave, we will debrief them about the aim and details of the study, and discuss how they experienced the study.

PART 4

Information relevant to both elements of the study

Are there any risks?
Risks and discomfort related to the MRI process have been detailed above. For this specific task, there are very few risks. If the study becomes too difficult or uncomfortable, your child may demand to quit at any time.

Are there any benefits?
The results of the MRI will help us to understand how academic motivation changes in the brain over time and how this is related to the patterns seen in the social network groups, from the data collected in the questionnaires that your child will have previously completed in class. If the motivation becomes similar, does the brain activity also become similar between friends? It is also a unique opportunity for your child to see a picture of their brain!

The wider benefit of taking part in this research is that you will be involved in a new research approach, helping to gain understanding about the way motivation spreads through a social network in school environments. This is will feed back into your child's school and impact on teaching and classroom set ups.

Will taking part affect my child's grades?
This study is in no way performance related and will not have any link to your child's school studies/grades. They are not marked based on the answers they give, and they will not receive a penalty of any kind.

What will happen if we don't want to take part anymore?
You/Your child are free to withdraw at any time without giving a reason why.

What if there is a problem?
Any complaint about the way you have been treated during the study or any possible distress you might have experienced will be addressed. If you have a concern about any aspect of this study, you should ask to speak to the principle researchers who will do their best to answer your questions.

If you remain unhappy and wish to complain formally, you can do this through Head of School of Psychology & Clinical Language Sciences, Professor Laurie Butler. If your complaint is not dealt with to your satisfaction you can contact the Chair of the University Research Ethics Committee. Details can be obtained from the School of Psychology and Clinical Language Sciences or from the school's Head Teacher.

Data confidentiality, storage and disposal of personal information
All information collected about you or your child during the course of the research will be kept strictly confidential and records will be given a unique reference number for analysis. Paper records will be stored securely in a locked room or cabinet and computer records will be password protected. Personal details will be kept separate from research data once the data collection phase has finished and will be destroyed at the end of the study.

If you join the study, some parts of the data collected for the study may be looked at by authorised and statutory bodies from the University, to check that the study is being carried out correctly. All will have a duty of confidentiality to you as a research participant and nothing that could reveal your identity will be disclosed or taken outside the research site. Consent forms and any identifiable records will be kept for 5 years in line with University guidelines.

Participants and parents have the right to check the accuracy of data held about them and correct any errors. All investigators working on this project have had criminal record checks and have been approved by the School to work with children.

Taking part in this study is completely voluntary; you may withdraw your child at any time without having to give any reason. Please feel free to ask any questions that you may have about this study at any point.

What will happen to the research results?
At the end of the study, once we have analysed the data from all the participants, we will send you a newsletter or email to explain the findings. We will aim to publish the findings in international science journals and meetings but no identifiable names will be used without your express permission.

Who is organising the research?
Dr Kou Murayama PhD is the Principal Investigator working at the School of Psychology and Clinical Language Sciences at the University of Reading. Professor Patricia Riddell also from the School of Psychology and Clinical Language Sciences will be co-supervising the project.

Miss Laura Burgess MSc, is a PhD student, and will be using the collected data in her thesis. The research is funded by the South East Doctoral Training Centre (SEDTC) with contribution also from Queen Anne's School, Caversham.

Who has reviewed the study?
This application has been reviewed by the University of Reading Research Ethics Committee and has been given a favourable ethical opinion for conduct.

For more information, please contact one of the researchers using the details at the beginning of this information sheet.

Thank you very much for reading this sheet and considering taking part in the study.

University of Reading

BrainCanDo
www.braincando.com

8.18. Consent form for parents/legal guardian of participants (MRI research)

University of Reading

Dr.Kou Murayama, room 2S23
Department of Psychology
Earley Gate, Whiteknights
Reading RG6 6AL, UK

Tel: (0)118 378 5558
Email: k.murayama@reading.ac.uk

CONSENT FORM for Parents/Guardians

Study title: Motivation and Peer Relationships: Investigating Behaviour and Brain.

Name of Supervisor/s: Dr Kou Murayama; Prof. Patricia Riddell
Investigators: Laura Burgess

Name of Participant: _____

DOB of Participant: _____

When you have read each statement below, please put your initials in the box next to it to show that you understand and agree with the statement

- I have read and had explained to me the accompanying information sheet about this study, and had the opportunity to ask questions ☐
- I understand the purposes of the project and what will be required of me/my child. I agree to the arrangements described in the information form, in so far as they relate to my participation ☐
- I understand that I have the right to withdraw at any time ☐
- I authorise the Investigators to inform my child's GP that I am taking part in the study. ☐
- I understand that I will need to fill in an initial screening form which will decide whether it is safe for my child to have an MRI scan. ☐
- I understand that the scans will be done solely for research purposes, and that the investigators are not experts in MRI diagnosis, and cannot provide a 'clean bill of health. ☐
- I authorise the Investigators to inform a radiologist and, if required, my child's GP if anything is noticed in the brain images which may require further investigation. ☐
- I have received a copy of this consent form and the accompanying information form ☐
- I agree to participate in the study ☐

GP details

Name: _____

Address: _____

University of Reading

Dr.Kou Murayama, room 2S23
Department of Psychology
Earley Gate, Whiteknights
Reading RG6 6AL, UK

Tel: (0)118 378 5558
Email: k.murayama@reading.ac.uk

In accordance with recent advice from the University of Reading Ethics Committee, we now ask permission for some or all of your data to be preserved for the long term, and to be made available, in anonymised form if required, either openly or subject to appropriate safeguards. This is so that the data can be consulted and re-used by others, in accordance with the University's Data Management Policy.

If you are happy to agree to this please initial this box before signing below ☐

Name of Parent /Guardian:

_____

Signature of Parent/Guardian: Date:

_____ _____

I confirm that I have explained the above mentioned study, as detailed in the corresponding Information Sheet, such that, in my judgment, it is understood by the participant.

Name of Researcher:

_____

Signature of Researcher: Date:

_____ _____

[FORM TO BE PRESENTED IN AN ONLINE FORMAT]

When completed, 1 for participant; 1 for researcher site file

8.19. Information sheet/booklet for participants (MRI research)

University of Reading

BrainCanDo

www.braincando.com

INFORMATION FOR STUDENTS

Motivation contagion project

Information for Participants

This is a booklet about the next stage of our Motivation Contagion project.

This time, we are interested in understanding how motivation changes across time, measured using functional magnetic resonance imaging (fMRI).

You are invited to participate in this study because you are a healthy student aged between 11 and 18. The research session will take no longer than 1 hour, and you will be asked to complete various simple cognitive tasks inside the MRI scanner, plus some simple questionnaires outside of the scanner.

These notes give information about the study and what it would be like to take part:

PART 1 tells you why we are doing the research;

PART 2 tells you general information about the MRI technique;

PART 3 you information about what will happen if you decide to take part;

PART 4 you more detailed information about how the study is managed.

The study takes place at the University of Reading, Psychology Department and at the Centre for Integrative Neuroscience and Neurodynamics and you would take 2 hours out of your school day to come and visit and take part. After the scan, you get to look around and see what other types of information we can get from the brain. We will also give you a £10 voucher as a thank you for your time.

CONTACT DETAILS

If after reading the information below you have any questions, please contact a member of staff at your school.

Otherwise, the researchers from the University of Reading will be happy to help:

Principal Investigator Dr Kou Murayama k.murayama@reading.ac.uk

Researcher Laura Burgess l.g.burgess@pgr.reading.ac.uk

PART 1

Why we are doing this research

Why do we need to do the research?
Motivation is a main factor that drives your learning and achievement in school. In fact, previous research has shown that students' motivation is a better predictor of their marks in school than intelligence test scores.

In recent years, there has been growing interest on how factors like learning environment, teaching styles and parenting styles impact on students' motivation in school. Even though there is more focus on motivation, only a small amount of work has been carried out on the influences coming from students' friendships.

Schools provide lots of chances for you to make friends, work as groups, and interact with each other. Through social activities, you share motivational experiences with your friends, causing your motivation to influence your friends (and vice versa).

The aim of the current research is to investigate the spread of motivation within a school environment.

We will do this by collecting brain activity of students to see if it becomes more similar over time.

PART 2

General Information on fMRI

What is functional magnetic resonance imaging (fMRI)?
MRI is a method for producing images of the brain. It involves placing the participant inside a large, powerful magnet, which forms part of the brain scanner. We use MRI to image the structure of different parts of your brain. We can also image which parts of your brain are more or less active.

When regions of the brain are active, they require more oxygen, which comes from your blood. As a result, the flow of blood to the area increases. These changes can be detected and then be converted by a computer into 3D images. This enables us to determine which parts of the brain are active during different tasks.

Are there any risks?
As far as we know, this procedure poses no direct health risks. No health risks have been associated with the magnetic field or radio waves, since the low-energy radio waves use no radiation, meaning it won't 'fry your brain'! The process can be repeated without side effects.

However, the Department of Health advises that certain people should NOT be scanned. Because the scanner magnet is very powerful, it can interfere with heart pacemakers and clips or other metal items which have been inserted into the body by a surgeon, or with body-piercing items.

If you have had surgery which may have involved the use of metal items you should **not take part**. Though, only magnetic materials (e.g. steel) are likely to cause problems. Normal dental fillings do not stop you from being scanned, but a dental plate which contained metal would do so, and you would be asked to remove it.

You will be asked to remove metal from your pockets (coins, keys), remove articles of clothing which have metal fasteners (belts, etc.), as well as most jewellery. Alternative clothing will be provided if necessary.

Watches and credit cards should not be taken into the scanner since it can interfere with the way they work. Your parent/s will have been asked to complete an initial screening form, which asks about these and other matters to decide whether it is safe for you to be scanned. They will also be asked to complete a second, shorter, screening form right before the scan.

Because this is a University research project and not a visit to a hospital, the scans are not able to provide a medical diagnosis or a clean 'bill of health' and the person conducting your scans will not be able to comment on the results of your scans.

The researchers involved are not experts in MRI diagnosis, as they are psychologists or allied scientists and are **not medical doctors**, meaning they cannot look at the scans from a medical point of view. We ask your parent/s to give the name and address of your GP. This is because occasionally, when we image healthy participants, the researchers may be concerned that something does not look 100% normal on the scan. In such cases, we will send a copy of the image to your GP, so that they can decide what course of action is best. By signing the consent form, you agree to this. If you are not willing to allow this, please do not volunteer for the study.

It is important that you realise that these research scans are **not a medical procedure**, and will not provide any information that may help in the diagnosis of any medical condition. If you do have any health concerns, you should contact a qualified medical practitioner in the normal way.

What is it like in the scanner?

To be scanned, you would lie on your back on a narrow bed on runners, on which you would be moved until your head was inside the magnet. The scanner itself looks like a very large ring donut, and you would slide through until your head is in the centre!

The scanning process itself creates intermittent loud noises, and you would wear earplugs or sound-attenuating headphones. We would be able to talk to you while you are in the scanner through an intercom. If you are likely to become very uneasy in this relatively confined space (suffer from claustrophobia), you should **not take part** in the study. If you do take part and this happens, you will be able to alert the researchers by activating an alarm and will then be removed from the scanner quickly.

It is important that you keep your head as still as possible during the scan, and to help you with this, your head will be supported by padded headrests. We would ask you to

relax your head and keep it still for no longer than one hour at a time (you will not be continuously scanned for this period and for this study it should be half an hour), which may require some effort on your part. If this becomes too difficult or uncomfortable, you may call to be removed from the scanner.

You may be asked to look at a screen through a small mirror (or other optical device) placed just above your eyes and/or be asked to listen to sounds through headphones. You may be asked to make judgements about what you see or asked to perform some other kind of task in your head. Details of the specific study in which you are invited to participate will either be attached to this sheet or given to you verbally by the researcher. Detailed instructions will be given just before the scan, and from time to time during it.

You will be able to say that you wish to stop the testing and leave at any time, without giving a reason. This would not affect your relationship with the researchers or your teachers in any way. The study will not benefit you directly, and does not form part of any medical diagnosis or treatment. If you agree to participate you will be asked to sign an assent form, with the researcher there with you. It is perfectly in order for you to take time to consider whether to participate, or discuss the study with other people, before signing. After signing, you will still have the right to withdraw at any time before or during the study, without giving a reason.

The images of your brain will be held securely and you will not be identified by name in any publications that might be made from the study. The information in the two screening forms will also be treated as strictly confidential and the forms will be held securely until eventually destroyed. Further information about the specific study in which you are invited to participate follows in the next section. Please feel free to ask any questions about any aspect of the study or the scanning procedure before completing the initial screening form.

PART 3

Specific information about this study

Brief outline of tasks and procedure
The research session will take in total approximately 1 hour. The total amount of time you are in the MRI scanner may be up to 1 hour (35 mins scan time). This will include introducing you to the scanner room, making sure you're comfortable on the bed, tuning and calibration of the goggle system and the MR machine, taking structural images of your brain (i.e. to image what your brain looks like) as well as taking images of your brain activity while working on a task in which you will be presented with visual images.

During the session, you will be asked to perform the following tasks.

1 Prescreening & scanning preparation
Your parents will be asked questions to determine that you do not have any conditions, medications, or recent experiences that would put you at risk while during the neuroimaging procedures. These will include questions about potential sources of metal in your body and about any previous head trauma. They may complete some of these forms more than once during the study.

2 Questionnaires
You will complete several questionnaires such as questionnaire on your characteristics: date of birth, years of education, first language, ethnicity, medications. Another about about your general feelings about yourself, and a final questionnaire on your current motivational status.

3 Cognitive task
In the scanner, you will be asked to perform a simple cognitive task where you will be presented with a series of stimuli which you will view by looking at a mirror reflecting the contents of a screen. You will be asked to make a response based on what you view using a button press box. Before the session you will receive a detailed explanation of the procedures and a chance to practice the task. Before you leave, we will debrief you about the aim and details of the study, and talk about how you experienced the study.

PART 4

Detailed information on running the study

Are there any risks?
Risks and discomfort related to the MRI process have been detailed above. For this specific task, there are very few risks. If the study becomes too difficult or uncomfortable, you may quit at any time.

Are there any benefits?
The results of this investigation will help us to understand how academic motivation changes in the brain over time and how this is related to the patterns seen school groups, from the data collected in the questionnaires that you have previously completed in class.

It is also a great opportunity to get a picture of your brain!

The wider benefit of taking part in this research is that you will be involved in a new research approach, helping to gain understanding about the way motivation spreads through a social network in school environments. This will have a positive impact on education everywhere!

Will taking part affect my grades?
This study is in no way performance related and will not have any link to your school studies/grades. You are not marked based on the answers you give, and you will not receive a penalty of any kind if you decide not to take part.

What will happen if we don't want to take part anymore?
You are free to withdraw at any time without giving a reason why.

What if there is a problem?
Any complaint about the way you have been treated during the study or any possible distress you might have experienced will be addressed. If you have a concern about any aspect of this study, you should ask to speak to the researchers or teachers who will do their best to answer your questions.

If you remain unhappy and wish to complain formally, you can do this through Head of School of Psychology & Clinical Language Sciences, Professor Laurie Butler. If your complaint is not dealt with to your satisfaction you can contact the Chair of the University Research Ethics Committee. Details can be obtained from the School of Psychology and Clinical Language Sciences.

Data confidentiality, storage and disposal of personal information
All information collected about you during the course of the research will be kept strictly confidential and records will be given a unique reference number for analysis. Paper records will be stored securely in a locked room or cabinet and computer records will be password protected. Personal details will be kept separate from research data once the data collection phase has finished and will be destroyed at the end of the study.

If you join the study, some parts of the data collected for the study may be looked at by authorised and statutory bodies from the University, to check that the study is being carried out correctly. All will have a duty of confidentiality to you as a research participant and nothing that could reveal your identity will be disclosed or taken outside the research site. Consent forms and any identifiable records will be kept for 5 years in line with University guidelines.

Participants and parents have the right to check the accuracy of data held about them and correct any errors. All investigators working on this project have had criminal record checks and have been approved by the School to work with children.

Taking part in this study is completely voluntary; you may withdraw at any time without having to give any reason. Please feel free to ask any questions that you may have about this study at any point.

What will happen to the research results?
At the end of the study, once we have analysed the data from all the participants, we will send you a newsletter or email to explain the findings. We will aim to publish the findings in international science journals and meetings but no identifiable names will be used without your express permission.

Who is organising the research?
Dr Kou Murayama PhD is the Principal Investigator working at the School of Psychology and Clinical Language Sciences at the University of Reading. Professor Patricia Riddell also from the School of Psychology and Clinical Language Sciences will be co-supervising the project.

Miss Laura Burgess, MSc is a PhD student, and will be using the collected data in her thesis. The research is funded by the South East Doctoral Training Centre (SEDTC) with contribution also from Queen Anne's School, Caversham.

Who has reviewed the study?
This application has been reviewed by the University of Reading Research Ethics Committee and has been given a favourable ethical opinion for conduct.

For more information, please contact one of the researchers using the details at the beginning of this information sheet.

Thank you very much for reading this sheet and considering taking part in the study.

University of Reading

BrainCanDo
www.braincando.com

8.20. Assent form for participants (MRI research)

University of Reading

Dr.Kou Murayama, room 2S23
Department of Psychology
Earley Gate, Whiteknights
Reading RG6 6AL, UK

Tel: (0)118 378 5558
Email: k.murayama@reading.ac.uk

ASSENT FORM for participants

Study title: Motivation and Peer Relationships: Investigating Behaviour and Brain.

When you have read each statement below, please put your initials in the box next to it to show that you understand and agree with the statement

- I have read and had explained to me by _____the accompanying information sheet about this study, and had the opportunity to ask questions ☐
- I understand the purposes of the project and what will be required of me. I agree to the arrangements described in the information form, in so far as they relate to my participation ☐
- I understand that I have the right to withdraw at any time ☐
- I authorise the Investigators to inform my GP that I am taking part in the study ☐
- I understand that I will need to fill in a short screening forms which will decide whether it is safe for me to have an MRI scan. ☐
- **I understand that the scans will be done solely for research purposes, and that the investigators are not experts in MRI diagnosis, and cannot provide a 'clean bill of health.** ☐
- **I authorise the Investigators to inform a radiologist and, if required, my GP if anything is noticed in the brain images which may require further investigation.** ☐
- I have received a copy of this consent form and the accompanying information form ☐
- I agree to participate in the study ☐

Participant's name:
Date:
Signature

Investigator's name:
Date:
Signature

Witness' name:
Date:
Signature:

GP details
Name:

Address:

8.21. University of Reading Ethics Committee (UREC) study approval – Motivation and peer relationships: Investigating behaviour and brain

University of Reading

Coordinator for Quality Assurance in Research
Dr Mike Proven, BSc(Hons), PhD

Academic and Governance Services
Whiteknights House
Whiteknights, PO Box 217
Reading RG6 6AH

phone +44 (0)118 378 7119
fax +44 (0)118 378 8979
email m.j.proven@reading.ac.uk

Dr Kou Murayama
School of Psychology and Clinical Language Sciences
University of Reading
RG6 6AL

7 February 2017

Dear Kou

UREC 17/07: Motivation and Peer Relationships: Investigating behaviour and brain *Favourable opinion*

Thank you for the response (email dated 3 February, and including attachments, refers) addressing the issues raised by the UREC Sub-committee at its January 2017 meeting. On the basis of these responses and the revised documentation, I can confirm that the Chair is pleased to confirm a favourable ethical opinion.

Please note that the Committee will monitor the progress of projects to which it has given favourable ethical opinion approximately one year after such agreement, and then on a regular basis until its completion.

Please also find attached Safety Note 59: Incident Reporting in Human Interventional Studies at the University of Reading, to be followed should there be an incident arising from the conduct of this research.

The University Board for Research and Innovation has also asked that recipients of favourable ethical opinions from UREC be reminded of the provisions of the University Code of Good Practice in Research. A copy is attached and further information may be obtained here:

http://www.reading.ac.uk/internal/res/QualityAssuranceInResearch/reas-RSqar.aspx .

Yours sincerely

[redacted]

Dr M J Proven
Coordinator for Quality Assurance in Research (UREC Secretary)
cc: Dr John Wright (Chair); Dr Laurie Butler (Head of School); Laura Burgess (PhD student)