Teacher beliefs about the aetiology of individual differences in educationally relevant traits, and the relevance of behavioural genetics to education

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Abstract

Background

Despite a large body of research exploring the influence of genetic and environmental factors on educationally relevant traits, few studies have explored teachers' beliefs about, or knowledge of, developments in behavioural genetics related to education.

Aims

The studies presented in this thesis aimed to describe the beliefs and knowledge of UK teachers about behavioural genetics and its relevance to education, and explore group differences. The research also aimed to begin to establish teacher opinions on receiving training in behavioural genetics. Perceptions of the general public regarding the relevance of genetics to education was also explored.

Methods

Data was gathered from a representative sample of UK schools – this included in the mainstream (n=406) and alternative provision (n=103). The general public sample comprised of n=800 online comments on a *Guardian* news article. An online questionnaire was used to gather teacher data. Demographic data and information on participants' beliefs about the relative influence of nature and nurture on cognitive ability/behavioural traits; knowledge of behavioural genetics; openness to genetic research in education; mindset and further training was collected. Data was analysed using a range of quantitative statistical methods. Content analysis was used to analyse data from the general public (online newspaper comments).

Results

Teachers perceived genetic and environmental factors as equally important influences on cognitive ability, although for behaviour problems the AP teachers (mainstream not asked) tended to favour environmental explanations. Teachers in the mainstream tended towards a growth mindset. Knowledge about behavioural genetics was low, but openness to learning more about genetics was high. Some statistically significant differences were observed between groups. The sample of members of the public mainly disagreed with promoting genetics in education and some clear misconceptions and hostilities towards the topic emerged.

Conclusions

Although teachers have a limited knowledge of behavioural genetics, they are open to learning more.

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Declarations

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

To date, two published papers have arisen from the work detailed in this thesis:

Crosswaite, M., & Asbury, K. (2016). 'Mr Cummings clearly does not understand the science of genetics and should maybe go back to school on the subject': an exploratory content analysis of the online comments beneath a controversial news story. *Life Sciences, Society And Policy*, *12*(1). doi: 10.1186/s40504-016-0044-4

Crosswaite, M., & Asbury, K. (2018). Teacher beliefs about the aetiology of individual differences in cognitive ability, and the relevance of behavioural genetics to education. *British Journal Of Educational Psychology*. doi: 10.1111/bjep.12224

1. Background and rationale

1.1 How much do we know about teachers' beliefs about, and knowledge of, genetics?

In a world in which genetic researchers are seeking, with some success, to understand the genetic and environmental aetiology of educational traits including intelligence, academic achievement and motivation, relatively little is known about what teachers know or believe about the encroachment of genetic science into their professional domain. The nature versus nurture debate, in other words whether genes or the environment hold greater sway over human behaviour, is an important topic within education and has been the focus of heated discussion both in and out of the world of education (Tabery, 2015; Ball, 2018). Often, interesting and relevant research is conducted that can, and arguably should, have implications for education but it is largely ignored by the profession. Evidence based practice is a goal that both researchers and educational professionals aspire to; particularly in a political system blighted by anecdotal policy (Nelson and Campbell, 2017). Despite this demand by professionals to be involved in research, too often teachers' voices are not heard. Behavioural genetics and genetics in general have progressed rapidly in the past few years (Heard et al., 2010; Sabatello, 2018) and it may be not too long before we see an increase in the presence of genetic technologies within society (Howard-Jones & Fenton, 2011; Sabatello, 2018).

1.2 Why should teachers understand genetics?

Whatever an individual's personal opinion on the advances in behavioural genetics, it is hard to deny that with the correct consideration and application, behavioural genetics could potentially have something to offer education. From challenging the notion that all children should leave school with the same set of test results to providing evidence for more personalised learning, behavioural genetics offers us a new lens through which to examine our educational system (Asbury and Plomin, 2014). In this sense, it is vital that teachers are part of any conversation about genetics in education, and to be part of the conversation they need to understand genetics. Teachers having knowledge of behavioural genetics empowers them to use the findings as appropriate in their classroom should they wish, but perhaps more importantly it gives them the power to challenge any politicisation or commercialisation of behavioural genetics that may occur in the future. Teachers should be informed so they can make a professional decision and be in a position to contribute an informed view of how they would like the future of genetics in education to look, even if that view is that they want it to play no part at all.

1.3 Research Aims

At the most basic level, due to the overall scarcity of research in the field, the primary aim of this research is to expand our knowledge and understanding of how the education profession perceives the science of genetics.

The overarching aim is to establish teachers' perceptions of the role genetics may play in the educational sector in the UK, and therefore their own professional working lives. The aim is to get a general idea of whether teachers feel positively or negatively towards genetics playing a role in education, and to give them the opportunity to air particular concerns or opinions they may have. To supplement this, and to help build a more substantial picture of the situation, perceptions of members of the general public, are also explored.

Specifically, this research aims to address five key areas related to teachers and their perceptions and opinions of genetics.

The first of these areas of exploration is whether teachers think that individual differences in cognitive ability are better explained by nature or nurture. The aim of asking this is to build a picture of teachers' stance when it comes to how they perceive the role of genes but also to act as a replication of the limited previous studies to have explored this (Walker and Plomin, 2005 and Crosswaite, 2011).

The second aim is to explore whether teachers, and to an extent the general public, are open to behavioural genetics playing a role in education, and to what extent they would like to receive training on the subject. We cannot just assume that teachers actually want to be part of a conversation with genetic researchers so it is important to establish their openness towards the role of behavioural genetics in education.

Thirdly, it is also key to begin to establish how knowledgeable teachers are when it comes to behavioural genetics. With this being such a complex and fast evolving science, it is key that an idea of how teachers might be keeping pace is established.

The fourth aim of the study is to establish how differing teacher demographics, such as gender, might impact their perceptions of the role that advances in genetics and behavioural genetics might have on education. This has included exploring teachers from mainstream and alternative provision settings. This enables us to gain a better insight into how, and potentially why, perceptions might be more positive or negative in different sub-sets of the teaching population.

The final aim is to consider how we might move forward with this information. If teachers are to receive future training on behavioural genetics, what might this look like? How can we tackle misconceptions and hesitations within the teaching and general population? What barriers stand in the way of teachers being able to fully engage with behavioural genetics? It was hoped we could begin to establish some insight into these questions.

1.4 Research questions

This thesis is comprised of broadly four intertwined studies – public perceptions of genetics, mainstream teacher perceptions of genetics, the need for Continuing Professional Development, and perceptions of genetics in Alternative Provision settings. Each study has its own in-depth set of research questions (detailed within individual chapters) but the overarching research question for this body of research is: What perceptions of behavioural genetics are held in education, and what factors affect teacher perceptions?

2. Literature Review: The nature-nurture question, neuroscience and intelligence – teacher's perceptions and understanding.

Within educational and psychological research, the focus of discussion about behavioural genetics tends to be on whether nature or nurture plays a greater role in predicting a child's academic outcomes in school, although the debate has ranged wider than this during the twenty-first century. Behavioural genetic research finds that genes (nature) play an important role in explaining individual differences in academic achievement (Kovas, Haworth, Dale & Plomin, 2007; Shakeshaft et al., 2013; Krapohl et al., 2014; Rimfeld, Ayorech, Dale, Kovas & Plomin, 2016). However, environmental factors, which fall into the nurture category, have also been recognised as influential (Domina, 2005; Walker & Plomin, 2006; Cooper, Crosnoe, Suzzio & Pituch, 2010). On the whole, most genetically-informed research indicates a roughly equal split between the influence of genes (nature) and environment (nurture) across a wide range of educationally-relevant (and other) traits (Polderman et al. 2015). The 'First Law of Behavioral Genetics' is that all human behaviour is heritable to some extent (Turkheimer, 2000) and decades of empirical research bear this out for behaviour, including the types of behaviour with which schools are concerned.

Behavioural genetics is emerging as a factor to consider in education and as the science has progressed rapidly it has increasingly come to the attention of those in politics and education (Heard et al., 2010; Ball, 2018). In this chapter, existing research into teachers' perceptions of the nature-nurture debate will be presented and discussed. The closely related research fields of teachers and neuroscience, intelligence and mindset will also be discussed to provide a wider foundation for this study. The body of literature presented will form the primary evidence-base for research into teachers' knowledge of, and beliefs about, genetics and their role in teaching and learning.

2.1 What do teachers think about the relative influence of nature and nurture on their pupils?

The main study to have focused on teachers' beliefs about the relative influence of genes and experience to date was carried out by Walker and Plomin (2005). They surveyed *n*=556 UK primary school teachers and *n*=1,340 parents to explore their views on the extent to which genetic and environmental factors influence a range of educationally relevant traits (personality, intelligence, behaviour problems, learning difficulties and mental illness). They found that teachers tended to take the middle ground when asked about the relative importance of nature and nurture, placing roughly equal importance on both (except when asked about behaviour problems in which case more emphasis was placed on environmental influences). In this sense, teachers' beliefs reflected extant research findings reasonably accurately (Polderman et al., 2015). Results for parents were very similar (Walker and Plomin, 2005). However, it is important to note that this study was carried out over 10 years ago and the science of genetics has continued to advance rapidly, and to make further in-roads into education since then (Plucker and Shelton, 2015). This raises the question of whether Walker and Plomin's (2005) findings would still hold true today. Furthermore, only primary school teachers were surveyed, leaving a gap in our knowledge of UK secondary school teachers' beliefs about genetics. One particularly useful finding we can take from the Walker and Plomin (2005) study is that 80% of teachers reported having no coverage of genetics during their teacher training (Walker and Plomin, 2005). This suggests that lack of knowledge and misconceptions may prove to be a key area for research. Furthermore, if teacher training in the biological and social aetiology of child behaviour does not exist then this raises questions about whether such training is necessary or important and, if so, how it would be best delivered. The current study aims to address these questions.

The findings of the Walker and Plomin (2005) study provide us with a good overall view of teachers' beliefs about the roles that nature and nurture have to play in educationally relevant behaviours. Their study also begins to paint a picture of how UK primary-school teachers may perceive the nature-nurture question in education – their views are largely in line with the research. In my own previous undergraduate research (Crosswaite, 2011), using a sample of *n*=203 teachers from primary schools across the UK, a similar pattern was found to that observed by Walker and Plomin (2005). Teachers, overall, perceived the role of genes as equal to that of environment in explaining children's academic success in school (Crosswaite, 2011). This was the expected finding in light of previous research and suggests that teachers, on average, do not see pupils as blank slates. On reflection, it makes sense that teachers should be keen to perceive value in their own contribution to a child's success (environment) but also to recognise the role of genes as a result of their experience of working with many children, all different on arrival and all with different potential. In this undergraduate project it was also possible to explore whether any aspects of teacher demographics appeared to affect responses. Noticeably, the study found that those teachers who taught in independent schools were significantly more likely to perceive genes as being more important than environment than those in state schools. Interestingly, teaching at a Free School (a non-profit-making, independent, state-funded school not controlled by a local authority) also came close to being a significant predictor of belief in the greater influence of environmental factors (Crosswaite, 2011). This difference in perceptions between school types offers a potential avenue for further exploration and will be addressed directly in the current research.

However, it should be noted that the findings from this undergraduate research had several limitations. The sample size was modest (*n*=203) compared to that of the Walker and Plomin (2005) study (*n*=556 teachers), making the results more difficult to generalize to a wider UK context. This was exacerbated by the method used, convenience sampling, meaning that the responses were open to volunteer bias (Bryman, 2012). Nevertheless, this initial unpublished study can be seen as a useful pilot for the current research, and provides foundations to build upon in an area that lacks extensive research.

Moving to research outside the UK, a study by Georgiou (2008) explored the Greek Cypriot situation with regard to teacher beliefs. This study varied slightly from Walker and Plomin (2005), and from the current PhD research, in that the main variable to be explored was beliefs about achievement. A comparison was made between the beliefs of experienced and novice teachers. Although Georgiou (2008) did not explicitly put the nature-nurture question to teachers some of the items on the study's questionnaire can reasonably be categorised as nature-nurture questions. For example, one item asked teachers to say how much they agreed with the following statement: 'A child's school achievement is caused by biologically determined characteristics' (Georgiou, 2008, p.

122). This is clearly a question that was designed to probe teacher opinions' regarding the role of genes in achievement – nature. As such, this study can offer us a comparable set of findings in a different European context. Although the effect sizes of the differences between novice and experienced teachers were small (below $\eta^2 = .20$ in most comparisons) Georgiou (2008) found that experienced teachers were significantly more likely to attribute achievement to factors such as intelligence and gender than student teachers were. In comparison, novice (student) teachers were more likely to attribute academic success to environmental factors such as teacher effort (although the two groups did not differ significantly in their beliefs about the importance of child effort).

There are some limitations in our capacity to interpret these results in relation to the current project. Primarily, the difficulty is that items that asked about genes were not combined in a single scale so we do not have an understanding of teachers' overall beliefs. They may have favoured the environment in relation to one trait or behaviour and genes in relation to another. They do, however, offer useful insight by supporting the idea that beliefs within the teaching population are not homogenous and may change over the course of a career. This has also been found in studies in other geographical contexts. For example, one US-based study found that teachers of different ages were motivated by different factors (Hilderbrandt & Eom, 2011). It could be theorised that as teachers progress through their career they encounter more and more children who, despite their best efforts, fail to make progress, or conversely, children who they may not be able to afford their full attention but who thrive regardless. Perhaps this difference in emphasis is merely down to classroom experience although it could be argued, more pessimistically, that teachers increasingly understand their own limitations as their careers progress and lose the enthusiastic belief that they can make a substantial difference.

Because Georgiou (2008)'s study was carried out in the Greek-Cypriot context we cannot generalise the findings to the UK. However, Georgiou's (2008) study does reiterate what has been found in other related studies (Walker & Plomin, 2005; Hilderbrandt & Eom, 2011) – teachers' perceptions of the nature-nurture question vary across teacher demographics and characteristics. This once again strengthens the case for including teacher demographic variables in the proposed study, levels of teaching experience included.

Continuing to look at the picture of teacher perceptions beyond the UK, Castéra and Clément (2012) carried out a comprehensive international study looking at teachers' perceptions of genetic determinism and biological influences on human behaviour generally. Although this study did not focus solely on teachers' perceptions of genetics in education it still provides a valuable contribution to this small field. Castéra and Clément (2012) surveyed *n*=8,285 teachers across 23 countries. The UK was included, but only provided *n*=154 of the responses, therefore comprising a small part of the overall sample. A number of the questions in the comprehensive questionnaire focused on genetic determinism with regard to behaviour and intelligence and are therefore of direct relevance to the current study. However, many items were not focused solely on children and education. For example: 'Women are less intelligent than men because their brains are smaller than men's brains' (Castéra and Clément, 2012). This is a noticeably different methodological approach to gathering teachers' perceptions than the other studies discussed, as the focus was more on a general perception teachers have of genetics across the spectrum and in response to a loaded statement. However, the findings are of interest in helping to build a picture of how teachers view the role of biology in human behaviour.

Castéra and Clément (2012) found that significant differences existed between countries. For example, teacher perceptions in African countries and Lebanon were more heavily inclined towards 'innatism' or a deterministic view than teacher perceptions in European countries, Brazil and Australia. When examined independently of the country in which the teacher resided, religion did not explain a significant amount of variance in how likely teachers were to lean towards a genetically deterministic view. Perhaps surprisingly, nor did the level of knowledge a teacher had about biology (Castéra and Clément, 2014). However, the study found that the years a teacher had spent in Higher Education was a significant influence; teachers who had spent less time in Higher Education were more likely to report genetically deterministic views (Castéra and Clément, 2012).

Clément and Castéra (2014) followed up this study by conducting a very similar, but European-specific study into teachers' ideas of biological determinism across Denmark, Estonia, Finland, France and Italy (Clément and Castéra, 2014). In this study they focused specifically on human performance, with 24 questions being asked. They can roughly be grouped as follows: Genetic determinism of personal or individual features, genetic predisposition of children's' performance, genetic/biological differences related to gender, genetic differences among ethnic groups or among social behaviour and questions exploring more general knowledge of genetics (Clément and Castéra, 2014). Key to this study is how teachers viewed biological determinism on children's performance. Clément and Castéra (2014) found that biology teachers from Denmark, Finland and Estonia were most likely to agree that genetics were at play when it came to a child's performance in school. The authors suggest that due to historical and social reasons, teachers from France and Italy were less likely to hold this view. Although the questions asked were not specifically related to cognitive ability, they do offer us a more general insight into how on the continent the role of genetics is perceived in education. Overall, it seems that the country a teacher resides in makes a noticeable difference to their opinion. It would be hard to historically or socially link the UK to one of these five countries. Indeed the UK has its own unique background and culture that likely influences opinions on genetics just like in these other European countries.

These findings from Clément and Castéra (2012, 2014) overall suggest that it is likely we will see a more balanced attitude to the nature-nurture question from teachers in the UK, as other more specific studies have shown, but also sets an interesting precedent for the possibility of exploring teacher perceptions of the nature-nurture question in education specifically in a cross-country and cross-cultural context. Findings also suggest that there may be a need to incorporate material about the biological bases of learning in teacher training courses to help improve understanding. The current study aims to begin to lay some foundations for this to occur.

In terms of teacher perceptions of the aetiology of behaviour problems, there has been only a small amount of exploration to date. The first study has been previously explored in depth due to being the only other study to explore teacher perceptions of genetics in relation to cognitive ability (Walker and Plomin, 2005). In Walker & Plomin's (2005) study, behaviour problems was one of five phenotypes (personality, intelligence, behaviour problems, learning difficulties, and mental illness) that teachers and parents were asked to comment on with regards to how much they felt individual differences were explained by nature (genes) or nurture (environment). For behaviour problems (treated as a homogeneous group in this study), it emerged that teachers favoured environmental explanations for individual differences to a greater extent than for the other four traits. Only 43% of participants saw genes as being at least as important as environment (by contrast, for the other traits the vast majority of teachers – at least 87% - saw genes as playing at least as important a role as the environment). This study offers some insight into what we may expect but the sample was not made up of AP teachers, who are the focus of behaviour questions in the current study. Also, as mentioned, it asked about ‘behaviour problems’ as a group without addressing whether perceptions may differ for, say, internalising and externalising behaviour problems.

In conclusion, although we are making some headway in establishing a clearer picture of the role that genes and environment have to play in a child’s academic success, progress and behaviour (Asbury, 2015), both through the twin method and molecular techniques such as Genome-Wide Association Studies (GWAS), there is still a large element of uncertainty and a lack of consensus around whether genetic information is relevant for educationalists. This is not a negative issue but rather one that paves the way for continued research and study in what is still a relatively controversial aspect of science that holds great scope for further research (Tabery, 2015). However, if the study of the actual nature-nurture question is still incomplete; then research into how educational professionals on the ground perceive such research is positively lacking. Very few studies seek to explore how the public and, in particular, education professionals, not only perceive the nature-nurture question in education but also how they are likely to be affected by progress in the development of genetic technology, and how they perceive the advancement of such science. The studies that do exist show us that teachers overall place themselves somewhere in the middle regarding the nature-nurture question. On average, they think that genes and experiences are roughly equally influential (a relatively accurate perception in fact). In this sense we have a picture, but a limited picture, of teacher perceptions and how they might vary based on individual teacher characteristics and contexts, so there is little material for comparison; either in the UK or globally. Up to this point, we have only collected a snapshot of how the UK teaching population may respond to the nature-nurture question and to behavioural genetics in general. The study by Walker and Plomin (2005) was comprehensive and has laid valuable foundations but is now thirteen years old. During those thirteen years the science of behavioural genetics has moved on rapidly and it is possible that the perceptions and opinions of teachers may also have altered. What is also clear from this research is that teachers should not be seen as a homogenous group and that their perceptions can vary for a multitude of reasons. Based on this, the current study looks to provide some data on different teacher demographics and how they may influence perceptions of the nature-nurture question. Overall, the current study hopes to begin to shed some light on teachers' perceptions and understanding of behavioural genetics as well as beginning to explore potential avenues for further training and professional development.

2.2 Teachers' factual understanding of neuroscience and the brain

Neuroscience is a fast moving, innovative and wide-reaching science, meaning its findings can have repercussions throughout society, including education (Devonshire and Dommett, 2010; Howard-Jones, 2014). As with behavioural genetics, it is a relatively young science (Goswami, 2006) and it is therefore yet to become firmly established within the knowledge and understanding of the general population (Pasquinelli, 2012), which of course includes teachers and other stakeholders in education. Findings and research from neuroscience can help us gain a better insight into what the future may hold for behavioural genetics. Neuroscience is much better known to teachers than behavioural genetics, as it has already filtered down into education in a variety of ways including the Wellcome Trust's I'm A Scientist project ("Understanding learning: education and neuroscience | Wellcome", 2018). We therefore have some insight into the effects it has had on teachers and education. Exploration of neuroscience in education gives us the opportunity to see in advance potential difficulties behaviour genetics may encounter if and when behavioural genetics research begins to permeate education practice or policy.

Much of the research within the field of neuroscience, when linked to education, has been focused on four key areas which can be loosely defined as: teachers' factual understanding of the brain; 'neuromyths' (misconceptions among teachers); applications of neuroscience in education; and finally, teachers' views and opinions of neuroscience.

Focusing first on the research that has explored teachers' factual understanding of the brain and the discipline of neuroscience, the research on the whole suggests that teachers and educators show a desire to engage with neuroscience and the study of the brain but tend to lack a strong grasp of the topic, which can have a number of knock on consequences which have been explored in the research (Devonshire and Dommett, 2010; Hook and Farah, 2013; Howard-Jones, 2014). For example, Pasquinelli (2012) explored factual understanding of neuroscience amongst the general population. It was found that understanding was low and it was concluded that it was unlikely we would be able to do much to address this. Pasquinelli (2012) claimed low knowledge and understanding is most likely due to a lack of scientific literacy in the general population that might help them sort fact from fiction, but also the challenge of varying myths across countries and cultures. Indeed, this may well also be the case for behavioural genetics. However, perhaps it is arguably more imperative that teachers, who are ostensibly helping to mould and influence young people's brains every day, have a stronger foundation in the science to aid them in their profession.

On a theoretical level this suggests that the dissemination of scientific information to teachers and indeed the general public comes with a number of hurdles and caveats. It would seem that simply being interested in or knowing more about a scientific topic does not guard against misconceptions. Perhaps this highlights a missing link, we often share research findings as researchers but tend to neglect offering sound and understandable ways for the public and teachers to utilise them in their professional practice. If this isn't remedied we risk repeating the mistake of allowing scientific information to fall into the control of companies or politicians who tend to exacerbate misconceptions and misunderstandings. These issues extend beyond neuroscience and need to be considered carefully by behavioural geneticists.

Studies exploring teachers' factual understanding are relatively global, with research covering the UK, Netherlands, Portugal, Brazil, China and Turkey to name a few (Karakus, Howard-Jones and Jay, 2015). In a study conducted by Dekker, Lee, Howard-Jones and Jolles (2012) a number of external factors were identified that helped determine the level of understanding and knowledge a teacher had. This included whether or not teachers regularly read science magazines, with those who did scoring better on questions exploring their general knowledge of the brain. The study, whose sample consisted of teachers from the United Kingdom and from the Netherlands, also found that Dutch teachers had a greater understanding of the brain that their English counterparts. The researchers offer no explanation as to why there may be a cultural difference but highlight that although Dutch teachers had a greater understanding of the brain, they were no less likely to believe in 'neuromyths' than UK teachers. In fact, teachers who had better knowledge about the brain were more likely to believe in 'neuromyths' (Dekker, Lee, Howard-Jones and Jolles, 2012). This highlights the concern that those particularly interested in an element of educational research/science may be more susceptible to its related myths. This must be considered when looking to start the conversation with teachers about behavioural genetics – how to inform without inadvertently leading to misinformation.

However, the ability to draw information regarding teachers' factual understanding was limited by this study's specific focus on teacher misconceptions of neuroscience. This led the researchers to choose a sample who had expressed that they were already interested in neuroscience as a discipline, and in how they could use it in the classroom (Dekker, Lee, Howard-Jones and Jolles, 2012). This allows possible bias in that this particular sample's knowledge and understanding may be greater than that of teachers in general. The main insight we can gain from this study regarding understanding and knowledge was that the researchers found teacher knowledge and understanding, even among this biased sub-group, to be insufficient to allow the teachers to accurately and correctly identify and avoid misconceptions and 'neuromyths'.

2.3 'Neuromyths'

To look more closely at 'neuromyths' numerous studies have explored common misconceptions or 'neuromyths' teachers hold about neuroscience and its application in education, it is here that the greatest body of research lies. The fact that ' neuromyths' have been found to be widespread in education suggests that a key marker of teachers' understanding of educationally-relevant science is not just the facts they can recall but also their ability to put the knowledge to use in deciphering whether an assertion is scientifically accurate or not. This will be a key consideration when exploring similar concepts in behavioural genetics. It is worth noting, however, that it is not just educators who hold misconceptions about the brain. In a study by Macdonald et al. (2017), researchers explored whether 'neuromyths' were also pervasive amongst the general population. They found that the general public were actually more likely to believe in 'neuromyths' compared to educators – particularly those related to dyslexia and learning styles. As would be expected, those with a higher exposure to education or training in neuroscience were less likely than both the general public and teachers to accept 'neuromyths' as fact (Macdonald et al., 2017). This shows that the issue of these 'neuromyths', is widespread and not unique to educators. In fact, although 'neuromyths' are widespread in education, teachers are actually in a slightly more knowledgeable and informed position than the general public.

One particular study by Karakus, Howard-Jones and Jay (2015) explored the prevalence of 'neuromyths' across a sample of primary and secondary school teachers in Turkey and found that the situation in Turkey was much the same as in other parts of Europe. The highest incidence of misconceptions surrounded learning styles and brain side preferences (Karakus, Howard-Jones and Jay, 2015).

Although Turkey shared the same issues with misconceptions and 'neuromyths' as other European countries, due to teachers' lack of understanding and knowledge, there were some differences mainly in the areas of second language learning (more Turkish teachers believed neuromyths about acquisition of language) and brain plasticity. It was concluded by the researchers that cultural differences, especially in the case of second language learning misconceptions, was the most likely explanation for the differences observed between countries (Karakus, Howard-Jones and Jay, 2015). This highlights the issue of how even when presented with potentially the same scientific evidence, many teachers are still heavily influenced by other factors that shape and mould their opinions and beliefs, this will also likely be true in the area of interest – behavioural genetics. In another study looking at the international context, Rato, Abreu and Castro-Caldas (2013) found that again teachers showed an interest in engaging with neuroscience but were also drawn in by 'neuromyths.' This study showed that the most prevalent 'neuromyths' arising in the sample of Portuguese teachers also surrounded the ideas of learning styles, left and right brain preference and multiple intelligences (Rato, Abreu and Castro-Caldas, 2013).

However, the study also picked up on a 'neuromyth' somewhat unique to the Portuguese context – that a boost in vitamin supplement intake will stimulate the brain – highlighting how cultural and social context cannot be removed from the equation. In other words, it is not just a lack of access to the sound, widely recognised science that can lead to teachers holding misconceptions and 'neuromyths' globally but also the context in which they are teaching can have a specific impact on which myths they believe to be correct and which they believe to be incorrect. Interestingly, this vitamin 'neuromyth' unique to the Portugese context was one of the tested myths that fewest teachers believed (Rato, Abreu and Castro-Caldas, 2013). Unfortunately, this result is not explored further by the researchers and we are left to speculate as to why Portuguese teachers were more likely to believe it.

Although overall countries were broadly similar in believing in multiple intelligence and brain side preferences there were some 'neuromyths' unique to some countries. Therefore, there is the need to consider any key genetic misconceptions unique to the British context. It also highlights the potential to consider a cross-cultural perspective in future research on behavioural genetics, as here too there may be some cultural variance or anomalies.

Looking more specifically at studies done in the UK context, as this holds the greatest relevance for the intended research, we can build a more detailed picture of exactly what this research means. A study by Dekker et al. (2012) explored 'neuromyths' amongst UK teachers (Dutch teachers were also used as a comparison group). Teachers were asked to say whether they felt a range of statements such as ‘We only use 10% of our brain’ were incorrect, correct or could chose to assert that they were unsure. The study also explored differences amongst teachers based on demographics such as sex, age, school type (primary/secondary) but also, as mentioned earlier on indicators of potential knowledge level such as reading of popular science magazines and whether they had attended any specific training in educational neuroscience. The findings concluded that overall teachers believed about 50% of the myths presented to them with the most prevalent belief in myths being those relating to learning styles and left/right brain learners (Dekker et al., 2012). In terms of relevant findings to the proposed area of study the fact that those teachers who had a greater level of knowledge and engagement in neuroscience in fact had a greater chance of believing in the ‘neuromyths’ is key. As mentioned, it suggests that misconceptions pervade all levels of understanding and this could easily apply to misconceptions about genetic science too. Therefore, it is worth being aware that misconceptions can come hand in hand with interest and knowledge in a topic. It may be worth using the identification of misunderstandings and misconceptions amongst teachers as a way of better understanding their attitudes and views which may stem from false assumptions. Another key element of this study for the proposed research area is the finding that demographics (age, sex, and primary/secondary) made no difference to the holding of these misconceptions, this was also the case in the Turkish study (Karakus, Howard-Jones and Jay, 2015) and again this is an element of behavioural genetics understanding that may be worth considering.

It may at first seem that teachers holding misconceptions or believing ‘neuromyths’ may not be of particular relevance or importance. After all, most individuals hold onto ideas that may not have complete scientific backing, in fact we are surely all vulnerable to cultural and societal misconceptions (Howard-Jones, 2014). It could be seen as somewhat unfair and over-optimistic to expect teachers to be able to have the time and inclination above their professional duties to learn about the intricate details of neuroscience.

However, as highlighted in a study by Geake (2008) the additional concern comes when external agencies take neuroscience and translate it into educational programmes, often based on pseudoscience (Goswami, 2006; Geake, 2008; Howard-Jones, 2014). In Geake’s (2008) study four key areas were identified as having been translated into popular educational programmes or perpetrated as myths within schools: multiple intelligences, 10% of brain usage, left and right brain thinkers and VAK (visual, auditory and kinaesthetic) learning styles. What Geake's (2008) study highlights is the vulnerability of teachers to misinformation, highlighting the importance of ensuring they have ready access to proper scientific education and are not drawn into often costly (Goswami, 2006; Rato, Abreu, and Castro-Caldas, 2013) time-consuming and scientifically unfounded schemes and programmes that could undermine their classroom practice (Goswami, 2006; Geake, 2008). In this sense, it seems of paramount importance that research strives not only to make steps in science and in education but that it also offers professionals with the tools and knowledge needed to ensure they can decipher myths and pseudoscience from sound evidence based findings (Howard-Jones, 2014). Although Geake's study focused upon neuroscience as a discipline, there is also a need to be aware of the vulnerability of teaching professionals to misinformation in the context of genetic technological advancements, as will be the focus of the proposed study.

A number of researchers have emphasised the need for a communicator to bridge the gap between the scientific community and the teaching community (Goswami, 2006; Pasquinelli, 2012; Hook and Farah, 2013), with suggestions that, ex-scientists for example, could fulfil this role (Goswami, 2006). However, others have suggested that such communication would be ineffective and counter-productive if teachers were simply told 'what to do' by the experts (Pickering and Howard-Jones, 2007) and it has been highlighted that until neuroscience gets some recognition in teacher training the myths are likely to remain (Howard-Jones, 2014). Again this is a key area of consideration for the scientific community making strides in genetic technology and potentially hoping to see their findings used in the educational sector, whether this is in the training of teachers or in actual classroom application.

The main studies that explored the prevalence and most common 'neuromyths' in various geographical contexts (Dekker et al. 2012; Rato, Abreu and Castro-Caldas, 2013; Karakus, Howard-Jones and Jay, 2015) all shared a similar methodological approach. Owing to the fact that all three studies found similar results it would not be unreasonable to suggest that their method delivered a relatively valid approach (Bryman, 2012). In turn, this insight has helped to guide the methodology used in this study focusing on behavioural genetics. The method deployed similarly by all three studies involved moderate (over 100) to large (*n*=583) samples for this type of work across teachers from both primary and secondary schools. All three studies then asked their sample to respond to pre-set statements (very similar across all three studies) that were 'neuromyths', the teachers then answered whether they felt the statements were true, false or not sure. This allowed the researchers to quantify data that was based on beliefs, feelings, attitudes and perceptions of teachers across different age ranges, as the current study will, making it easier to analyse and interpret in a more generalizable manner (Bryman, 2012).

2.4 Applications of neuroscience in education/ teachers' perceptions of neuroscience

Aside from just establishing the 'neuromyths' prevalent in the teaching population, a small number of researchers have also sought to explore the application of neuroscience in the classroom and to consider the opinion of professionals from both the scientific and teaching communities. Devonshire and Dommett (2010) raise some important considerations in the relationship between neuroscientists and teachers. From many of the previous studies explored, there emerged a clear picture that teachers and educators were keen to engage in finding out more about neuroscience (Dekker et al. 2012; Rato, Abreu & Castro-Caldas, 2013; Hook and Farah, 2013; Karakus, Howard-Jones & Jay, 2015).

However, Devonshire and Dommett (2010) remind us that there are also the needs of the scientific community to bear in mind. They suggest that there may be some reluctance from neuroscientists to enter a partnership with educators due to fears surrounding their findings and research being misinterpreted or commercialised for the education sector. This could be seen as a risk to their credibility and professional image (Devonshire & Dommett, 2010) and, as we have seen from the prevalence of 'neuromyths', this is a very real problem (Dekker et al. 2012; Rato, Abreu & Castro-Caldas, 2013; Karakus, Howard-Jones & Jay, 2015). There are two main points to pull from the Devonshire and Dommett (2010) study that could be relevant for genetic science. The first is that they found the most effective partnerships arose when the findings made in neuroscience did not create educational theories but rather either helped support or falsify them (Devonshire and Dommett, 2010). It is likely that this partnership would potentially prove to be more effective as it puts the neuroscientists in a supporting rather than invasive and dominating role, still allowing educators (who of course have the most experience of classroom reality) to develop and trial theories. With the progression in genetic technologies (Selzam et al., 2016) it may also be worth bearing in mind how teachers may feel threatened or invaded by advances in genetic technology, if not delivered in a collaborative and supportive manner.

The other key finding related to the practicality of the marriage between education and science, which of course is also relevant to the field of genetic science. Devonshire and Dommett (2012) highlighted the basic logistical barriers to allowing scientists to have the ability to ensure educators are correctly informed of their latest advances. Of course, as it a well-known issue for teachers, time caused by an already heavy workload (Courtney, 2014) and space in which the two sides can meet pose major barriers for an effective relationship, as do communication differences arising from the differing disciplines the two sides come from (Howard-Jones, 2014). It is not unlikely that such issues would also prevail between the genetic science and teaching communities.

In a study by Hook and Farah (2013), that helped to further build the picture from the teachers' perspective as to what they want from the scientific community we also see some level of reluctance not seen in many of the studies focusing on 'neuromyths'. The teachers in the Hook and Farah study (2013) conceded that despite an interest in neuroscience they felt that at the moment the application of neuroscience in the classroom was limited and that instead their interest lay in more helping them gain some understanding into the brains of the children they taught (Hook and Farah, 2013). This again suggests that both sides in the partnership – neuroscientists and teachers – although open to each other's ideas, have reservations about the practicalities and realities. However, from Hook and Farah's (2013) study it is not possible to generalise the opinions reported as their sample consisted of only 13 educators who were already attending Learning and Brain conferences (Hook & Farah, 2013). This very niche sample makes it difficult to know if such attitudes and opinions are held by all teachers. Therefore, it is important to ensure that when collecting attitudes and opinions relating to genetic technology it is done with a larger more diverse sample size, which in turn could improve the generalisability of the findings to the UK context at least (Bryman, 2012).

Not all researchers have been so quick to suggest that neuroscience necessarily should hold a prominent place in education. Billington (2017) has questioned whether neuroscience is a ‘friend or foe’ to education and suggested that it would be a serious error for scientists and researchers to forget that scientific findings and results are not easily translated to individual children (Billington, 2017). The need to remain critical towards neuroscience is emphasised by Billington and others, it’s not so much that neuroscience has no place, but rather we must be careful when and where it is applied to education (Joldersman, 2016; Billington, 2017). This seems a sensible opinion, and it is unlikely neuroscientists themselves believe that everything they do is completely relevant to education. Billington (2017) highlights the need for critical discourse at an academic level, and challenges some assumptions in neuroscience such as the notion that by understanding the brain we can understand what it is to be human. From this, we need to remember that neuroscience and indeed behavioural genetics are but individual tools in the toolbox of education and that we must remain mindful as to the potential unforeseen impact of research. Careful consideration must be taken before rushing into applying psychological and neurological research to education.

Moreover, in a study by Howard-Jones & Fenton (2011) the researchers argue that the complex ethical issues involved in neuroscience research and the subsequent considerations for education cannot be viewed alone but instead must be seen as part of a wider interdisciplinary public dialogue (Howard-Jones & Fenton, 2011). In this original study, Howard-Jones & Fenton (2011) asked educational practitioners (trainee teachers, teachers and head teachers) for their perspective on a range of educationally relevant areas including genetic profiling (Howard-Jones & Fenton, 2011). They noted that ‘neuromyths’ has likely prompted increased dialogue between scientists and educators, yet caution that there is a fine line between bombarding teachers with hard to apply information and oversimplifying results in ways that foster misconceptions (Howard-Jones & Fenton, 2011). In terms of genetic profiling, when the educators were asked 42% thought the use of genetic information in education should be prevented. Also, 61% felt it was unlikely that the use of genetic information in education could be controlled sufficiently to make it desirable (Howard-Jones & Fenton, 2011). These findings are of noticeable significance to this study, demonstrating the difficulties and hesitations of both teachers and the scientific community across a range of relevant psychological fields. It is likely that any dialogue with teachers will not be simple and will require a great deal of forethought and consideration if we are to avoid ethical dilemmas or alienation of the teaching community.

To conclude, there are a number of key findings from research exploring the discipline of neuroscience in the context of education that hold relevance and importance when considering the discipline of genetic science in education. Most research has focused on the prevalence of misunderstandings and misconceptions of neuroscience amongst the teaching population, termed 'neuromyths'. On the whole the studies found that across Europe; teachers and educators were interested in neuroscience and the same 'neuromyths' were prevalent across different geographical contexts (Howard-Jones, 2014). These 'neuromyths' also helped to build a picture of the level of knowledge and understanding amongst teachers. From this, it is not unreasonable to assume that without the proper training and information, as other studies explored in the neuroscience context, teachers could easily fall into holding misconceptions and misunderstandings about advances in genetic technology. Yet, as highlighted in the neuroscience research, gleaning teachers' and scientists' opinions and attitudes is of great importance in helping to solve some of the issues identified in the literature. We must also be mindful of how and if the findings from research are always beneficial to education. The geographical and cultural context in which the research took place also proved to be of importance and is worth considering this when making generalisations from findings from this study

With regards to the applicability of the methods and research designs used in the neuroscience literature, there are a few key points to take away. Firstly, it is worth using methods that allow us to quantify opinions and attitudes but then it is also important, and a common practice, to enrich this data either with background variables, open comments or interviews. Secondly, if results are to be made more generalisable to the wider teaching population then the sample size needs to be sufficiently large and representative. Questionnaire methods have been successfully used across a number of studies exploring teachers' beliefs and attitudes towards neuroscience and could easily be translated to an appropriate form for use in studies exploring genetics. On the whole the information gained from the literature exploring neuroscience holds many key points of consideration (due to the similarly contentious and complex nature of the two sciences) for anyone planning to embark on research exploring the relationship between teachers/ educators and genetic science/technology.

2.5 Intelligence: Challenges when defining intelligence

Despite strong scientific evidence that IQ plays an extremely important role in predicting academic success and how well people do beyond school into adult life, even serving as a predictor of longevity (Plomin and von Stumm, 2018), it is often viewed with an element of fear, caution and disagreement not just by teachers but the public as a whole (Asbury and Plomin, 2014; King, 2015). Although we have now largely moved on from some socially divisive uses of IQ testing, such as the 11+, of the 20th century (Ormrod, 2008), some debate remains about the validity, and even the morality, of intelligence testing. Given the evidence suggesting the reliability and validity of IQ it is important to understand teachers' views of intelligence, as well as the nature-nurture questions, and how those views might influence pupils' educational experiences and outcomes.

Before this research field is explored, it is first worth trying to define what we mean by intelligence. As an abstract concept there is unlikely to be a single agreed definition, and this remains a challenge for education, as the term is often used to refer to everything from social skills to results on IQ tests (Bahman & Maffini, 2008; Rockstuhl, Seiler, Ang, Van Dyne & Annen, 2011, Plomin and Von Stumm, 2018). This means that when teachers are asked to comment on, or act upon, the intelligence (rather than the achievement) of the children they teach they may be unclear as to what is actually being referred to (Nettlebeck and Wilson, 2005; Duckworth, Quinn and Tsukayama, 2012). For this reason, a widely accepted definition of intelligence may prove useful not only in terms of improving the validity of research into teachers and intelligence (without a clear definition we risk muddled responses to questions relating to intelligence), but also in ensuring the concept is clear, helping to reduce misconceptions and misunderstandings amongst professionals.

Therefore, it is worth exploring some suggestions. Within the literature many general definitions for intelligence exist. Nettlebeck and Wilson (2005) propose the following working definition:

‘[the] ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, and to engage in various forms of reasoning to overcome obstacles by taking thought’ (as cited in Neisser et al., 1996, p.77).

Plucker and Shelton (2015) in the context of behavioural genetics; share a longstanding model of intelligence used in education and psychology developed by Raymond Cattell, which builds upon the basic definition by Neisser (1996) (Cattell, 1943). It proposes two strands of intelligence (crystallized and fluid) with the former representing accumulated knowledge such as cultural knowledge and use of this in everyday life. The latter (fluid intelligence) is said to refer to the strength of the short-term memory, rapidity of thought and novel problem solving abilities (Petruccelli, Fiorello and Thurman, 2010; Nisbett, 2013; Plucker and Shelton, 2015).

Gottfredson (1994) also offers us an overall definition of intelligence.

‘Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience. It is not merely book-learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings, ‘catching on’, ‘making sense’ of things, or ‘figuring out’ what to do.’ (Gottfredson, 1994, p. 13)

Used more simply Gottfredson’s definition has been summarised to

‘the ability to learn, reason and solve problems’ (Plomin and Von Stumm, 2018)

and in this form it offers a simpler, perhaps more accessible definition. Of course, the three definitions offered are merely scraping the surface of the discussion and debate over what intelligence is, and many more models and definitions have been offered. Such controversy and lack of clarity has led some to suggest that there is no way to define the concept, yet we know that intelligence matters in education and beyond (Ritchie, 2015; Plucker and Shelton, 2015).

To explore another take on 'intelligence', we also have the concept of general cognitive ability (often referred to as g). This is the concept most commonly used in psychology, including behavioural genetics, which has studied the heritability of g (Haworth et al., 2009). In more detail, g represents the general factor that emerges from a factor analysis of a battery of cognitive tests (Ritchie, 2015) and, in line with Gottfredson's (1994) definition, can be defined as 'the ability to learn, reason and solve problems' (Plomin & von Stumm, 2018). In many ways this type of cognitive ability is what many people might first think of when they hear the word 'intelligence'. However, the very fact that general cognitive ability is not called intelligence was a purposeful move to help avoid some of the lexical and semantic issues already discussed (Plomin & Spinath, 2004; Haworth et. al., 2009). The existence of g, a statistical construct that emerges from a battery of cognitive tests, is one of the most replicated findings in psychology (Deary, 2001; Deary, Spinath & Bates, 2006). G offers us an overarching measure of the multifaceted nature of human cognitive ability.

To explore g in more detail, general cognitive ability (g) has been consistently shown to be a robust, reliable construct showing good stability and predictive validity over time. Interestingly, the heritability of g has been found to increase as people grow older (Haworth et. al., 2009; Plomin and Von Stumm, 2018). Overall, g is substantially heritable and has been the focus of many twin, adoption and family studies. Heritability estimates tend to average 40% but, in fact are lower in the preschool years and can reach 80% in adult life (Bouchard & McGue, 2002; Plomin and Spinath, 2004; Haworth et. al., 2009). Moreover, g has also been shown to be associated with a myriad of life outcomes beyond education such as better health, longer life expectancy and income (Sternberg, Grigorenko & Bundy, 2001; Batty, Kivimäki & Deary, 2010).

Within this review, three key research areas related to intelligence will be explored: measuring and using IQ and g in education, teachers' implicit theories of intelligence and their estimates/judgements of students' intelligence and finally differences in teacher estimates/judgements of the intelligence of students with additional needs.

2.6 Measuring and using IQ and g in Education

Defining intelligence and determining the role of IQ tests in education has always been controversial, and there is still little consensus as to what should be the correct practice in schools (Nettlebeck and Wilson, 2005; Nisbett, 2013).

Over a decade ago, Nettlebeck and Wilson (2005) explored the relevance of IQ testing in schools, and whether it can go beyond the merely descriptive to actually furthering our understanding of how intelligence plays out in schools. Having conducted a thorough review of the use and misuse of IQ tests over the years, and exploring possible avenues for growth, Nettlebeck and Wilson concluded that IQ tests represent a useful tool in educational settings (Nettlebeck and Wilson, 2005). They established a number of key ways in which IQ testing could contribute to educational settings. IQ scores, they argued, can help teachers to verify a suspected level of academic ability in a child. In a way, the authors were suggesting that rather than being used as a predictor IQ scores should be used for the purposes of confirming pre-existing teacher judgements. By this, they meant that a teacher could use an IQ type test to confirm a suspected special need – be it giftedness or learning difficulties. They acknowledged that such confirmation wouldn't lead to identification of the correct course of action for the child, but it would help act as the first step to help inform teachers if a child is going off track and maybe help them steer said child towards interventions or challenges as appropriate (Nettlebeck and Wilson, 2005). Secondly, they proposed that IQ tests could be used to identify a particular difficulty an individual may be experiencing, allowing teachers to respond appropriately through tailored interventions and resources (Nettlebeck and Wilson, 2005). The authors stressed that IQ test results can act only really as a guide of a child's capability in a culture that is the same as where the IQ test is developed, to avoid any cultural bias. They also warned against the use of IQ tests to assess teacher effectiveness and outcomes and to determine content in the classroom. This is because IQ tends to remain stable over the life course as well as the fact that IQ tests and the curriculum are not necessarily interlinked so we cannot expect teaching of the curriculum to necessarily impact IQ (Nettlebeck and Wilson, 2005).

Nettlebeck and Wilson (2005) also argued that IQ tests should not be used in isolation and should only form part of a wider assessment. It could be said that by promoting IQ tests as only a small part of the picture they devalue the very tool they are trying to promote. However, IQ tests do offer us the opportunity to get a measure of cognitive ability, which can offer valuable insight for teachers as to which children may need the most support (i.e. which children are likely to find learning hardest). IQ tests can also offer some future projection for teachers and schools by allowing them to have a clearer idea of where their individual children are at which could help them better plan interventions and support (Nettlebeck and Wilson, 2005). Of course, IQ should form only part of the picture that informs a teacher's practice but it seems unreasonable, in the face of a strong body of evidence, to dismiss it as a meaningless tool.

More recently, Nisbett (2013) carried out a similar review examining the place of IQ and IQ testing in today's education system in the US. Nisbett (2013) suggests that modern versions of the IQ test, such as the Stanford-Binet and Wechsler batteries should not be ruled out as useful contributors to education as they have been shown to be highly correlated with children's later school outcomes. But again, as with Nettlebeck and Wilson (2005), Nisbett (2013) emphasises caution when using the results from IQ tests in isolation and how they are interpreted, suggesting instead that they form part of a bigger holistic picture. Moreover, although promoted as only being used as part of a wider assessment process we must always remember that teachers could be subjective and such a quantifiable score of 'intelligence' as can be gleaned from an IQ test could influence a teacher's perception of a child's intelligence consciously or subconsciously (teacher expectancy effects). Of course, this may well still happen regardless of teacher knowledge of IQ. Most teachers make relatively accurate predictions of IQ regardless of any kind of large scale testing (Pretzlik, Olsson, Nabuco and Cruz, 2003; Chamorro-Premuzic, Arteche, Furnham & Trickot, 2009). Moreover, common practices in schools such as setting or streaming could equally, consciously or sub-consciously, influence teachers' perceptions of IQ.

Once again, we arrive at the notion that IQ tests must be approached with a level of caution but can be part of the holistic package a teacher uses to best educate the children in their care. Yet, we are left with little guidance as to exactly how and when teachers should use them, and indeed which IQ test to use… if any. After some surface exploration, it was found that there are some instances of schools using the CAT (cognitive ability test) to test children for their own purposes (specifically to help them decide setting and streaming in the first year of secondary school) but there is no official government line on the topic ("Year 7 CATs: Everything Parents Need to Know", 2018). Overall, there seems to be a potential for IQ tests to offer schools an accurate measure of a trait that is clearly linked to a range of later school outcomes. However, due to historic and social reasons, IQ tests still remain on the fringes of education with their use being sporadic and the potential benefits they have to offer untapped by teachers.

Measuring and using g in education has not been tried on any kind of significant scale, like IQ tests with which they are highly correlated albeit statistically different, yet the academic research on general cognitive ability and education is moving rapidly. In behavioural genetics, the heritability of g has been found to be changeable over time but in a clear and consistent pattern (Haworth et al., 2009). Although only 20-30% of individual differences in g in pre-school children are explained by genetic factors, by the time we reach adulthood, the heritability of g increases to around 60% (Plomin and Spinath, 2002; Haworth et. al., 2009). But what does this all mean for education and teachers? Studies have found that g is related to all kinds of educationally relevant outcomes such as maths ability and reading fluency (Hart, Petrill, Thompson & Plomin, 2009). Therefore, it's potentially important that teachers have at least some grasp of this concept in order for them to understand this key trait amongst the children they teach, how it likely varies from child to child and how it may change across the school years. However, it is worth noting that g does not equal achievement in school - moderate correlations have been found between general cognitive ability and academic achievement (ranging from 0.4-0.7) (Krapohl et al., 2014; Čavojová & Mikušková, 2015). So g is important and can be used to help predict a range of educationally relevant traits, but it is not the only factor at play in terms of educational outcomes.

2.7 Mindset and teacher's implicit theories of intelligence

The second area of research has explored teachers' perceptions of whether intelligence is a fixed or a malleable construct. These terms represent the entity (fixed and unchangeable) theory of intelligence, and the incremental (malleable and unfixed) theory of intelligence as described by Dweck and Leggett (1998). The concept is known as 'mindset' and refers to beliefs surrounding human attributes although primarily intelligence and academic abilities. The idea is that if a growth mindset (incremental theory) it promoted rather than a fixed mindset (entity theory) then basic abilities an individual has can be improved through effort and application (Dweck, 2014). Mindset has become increasingly popular in UK schools with the promotion of pupils' growth mindset arguably seen as a new panacea in education (Rustin, 2016). Educational charities in the UK have also started to invest in mindset interventions as they begin to spread across UK schools (Education Endowment Foundation, 2015). Yet despite this rush to invest in mindset and mindset interventions, research into the impact of mindset interventions on academic achievement have cast doubt on a strong effect in terms of growth mindset equalling better academic achievement (Sisk, Burgoyne, Sun, & Macnamara, 2018).

Mindset is of particular interest to the current study because self-reported mindset gives an insight into how individuals see their ability to alter their own, or others' intelligence. By this reckoning, a genetic determinist should have an extreme fixed mindset (there's no point in trying too hard if your destiny is in your genes) and an environmental determinist should have an extreme growth mindset (there are no limits to what you can achieve). It is likely, however, that most people will fall between these two extremes. It is therefore possible that if the individual's mindset is closely associated with their perceptions of the relative roles of nature and nurture then this could offer important insights to researchers. This is because a number of studies have looked at the effect of mindset in the classroom, on teachers and on pupils and it is possible that beliefs about genetics may have similar effects or associations (Pretzlik, Olssonn, Nabuco and Cruz, 2003; Georgiou, 2008;

Jonsson, Beach, Korp and Erlandson, 2012; Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013). Therefore, mindset offers a useful perspective on whether a teacher's beliefs about genetics are likely to help or hinder their classroom practice, or to make no difference at all.

Studies in this area have mainly explored how teachers' theories of intelligence and mindset vary, and what effect their belief has on teaching and learning in their classrooms. One study to explore teachers' implicit theories of intelligence was a Swedish study that looked into high school teachers' implicit theories of intelligence, with a particular focus on whether teachers from different subjects differed in their mindset (Jonsson et al., 2012). The researchers found that high school teachers of languages, social sciences and practical disciplines were significantly more likely to prefer the incremental theory of intelligence whilst those who taught mathematics were more likely to lean towards an entity theory. Differences were also found based on teacher age (youngest/ most inexperienced and oldest/most experienced both favoured entity) (Jonsson et al., 2012). From this, it would not seem unreasonable to suggest that teachers from different subjects may also differ in their perceptions of the role they might see genetics playing in cognitive ability. Teachers from the arts and social sciences may lean towards a greater role for the environment (incremental favouring a more growth mindset which is malleable based on the environment) and teachers from mathematics and science might lean towards a greater role for genes (entity theory seeing intelligence in a more fixed mindset). It is not difficult to hypothesise that those teachers who favour an entity theory of intelligence may value genetic information more, as this is seen as the more fixed component of cognitive ability that isn't easily edited (Tabery, 2015; Panofsky, 2015). This potential difference based on subject taught will form part of the investigation into teacher beliefs about the heritability of intelligence in the current study.

Importantly, Jonsson et al. (2012) discuss the relevance of these findings when applied to the classroom context. Drawing on past research, they highlight that a teacher's entity theory can impact pupils detrimentally. Studies have suggested that teacher beliefs surrounding a child's intelligence can impact how a child is treated as well as how a child responds to tasks set to them by a teacher (Butler, 2000; Chamorro-Premuzic, Arteche, Furnham & Trickot, 2009). They suggest that for teachers in mathematics there may need to be greater teacher education to help them understand the learning process in mathematics. They also make the suggestion that such specialisation right at the beginning of a teacher's career may also contribute towards distinct views of intelligence. However, this assumes that it is the subject that the teachers teach that is determining their theory of intelligence, they have only observed a correlation here and we cannot be sure that it is the subject, rather than say, for example the personality, of maths teachers that is driving their mindset beliefs and, for that matter, their interest in teaching maths. This insight into what determines a teacher's mindset matters as if mindset is linked to the nature-nurture questions, then these findings provide us with an insight into why teachers may perceive the nature-nurture question a certain way.

A few studies have explored teachers' perceptions of mindset and theories of intelligence with a particular focus on the comparable groups of pre-service (student) and in-service teachers (currently teaching) (Jones, Bryant, Snyder and Malone, 2012; Gutshall, 2014). Jones et al., (2012) compared experienced and pre-service teachers on their theories of intelligence. In contrast to some previous findings (Georgiou, 2008), they found that more experienced teachers were not more likely than less experienced teachers to have an entity or fixed view of intelligence. However, a quarter of the sample did hold an entity or fixed view of intelligence (Jones et al., 2012). That said, the generalisability of their findings was very limited, as highlighted by the researchers themselves. They chose to deploy convenience sampling which resulted in a very small sample of n=33 in-service teachers and n=237 pre-service teachers from a limited geographical pool in the US who were primarily female (Jones et al., 2012). However, it does add to the broader picture of the teaching population and where they stand in terms of theories of intelligence and mindset. Once again this research suggests that teachers should not be seen as a homogenous group. However, for the purpose of the current study the findings are of limited applicability being based in only a very small sub-section of the US.

A related study conducted with a similarly limited sample (n=113) found that 73% of trainee teachers favoured an incremental/growth view of intelligence and that this was fairly stable throughout their training (Gutshall, 2014). This study did not however have a comparison group of experienced teachers but did deliver similar results to those of Jones et al., (2012), finding that roughly three quarters of teachers held an incremental/growth view of intelligence. In many ways, these results are not surprising and are somewhat intuitive. Teaching is a profession that aims to equip and empower children to learn and succeed. As such it would be hard to imagine that the majority of teachers would perceive an individual as unable to work hard and persevere to improve their outcomes – if they did feel students' intelligence was fixed; arguably many teachers might feel they were wasting their time. However, there is still a substantial proportion of the sample in these studies that did not have an incremental/growth view of intelligence and as such we cannot declare teachers to be homogenous in their mindset.

A recent study took a slightly different approach and explored not only the difference between pre-service and in-service teachers' mindset but also how this view affected their view of the factors influencing their students' academic performance (Patterson, Kravchenko, Chen-Bouck and Kelley, 2016). Data from *n*=73 pre-service teachers and *n*=53 in-service teachers suggested that, in contrast to Georgiou (2008) but in-line with Jones et al., (2012), pre-service and in-service teachers did not differ in their theories of intelligence. Overall, participants tended to report an incremental view of intelligence. However, perhaps most interestingly, they found that those teachers with a stronger entity theory were also more likely to view teachers as less responsible for students' academic performance (Patterson, Kravchenko, Chen-Bouck and Kelley, 2016). The study has limitations, primarily a small and non-representative sample, but it prompts interesting questions (Patterson, Kravchenko, Chen-Bouck and Kelley, 2016). If an entity theory of intelligence is associated with placing more emphasis on genes, and vice-versa for an incremental theory - something the current study tests - then teacher's views of the nature-nurture question may conceivably impact how they see their role in the classroom and how they perceive the factors that affect a student's academic outcomes. Therefore, it is important for the current study to include a measure of mindset in order to allow this comparison to be explored. If perceptions of genetics affect teachers' behaviour and their attitudes to teaching, then the implications of this must be considered. If perceptions are false and harmful, then there may be implications for intervention.

One study explored international differences in trainee-teacher mindset (Asbury et al., 2015).

This study explored differences between the mindset of student teachers in the UK and East Asia, with a total sample of n=255. Although all of the trainee teachers were receiving their training in the UK, significant differences were found in their mindset. Overall, all students tended towards a growth mindset. However, UK citizens (n=111) were more growth minded than their East Asian (primarily Chinese) counterparts (n=144), and the difference was statistically significant. Although the study was limited to a comparison of two countries, as well as having a limited male sample, it does add to this emerging picture, also found in the Castéra and Clément (2014) study, that there are differences amongst teachers that are most likely impacted by the context, culture and educational climate in which they teach. As there have been some findings that teacher mindset does matter in the classroom, and can affect classroom practice (Pretzlik, Olssonn, Nabuco and Cruz, 2003; Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013; Gutshall, 2013; Patterson, Kravchenko, Chen-Bouck and Kelley, 2016), then this point is of note to the current study. It once again highlights the lack of homogeneity amongst the teaching population and illustrates the point that is not necessarily the professional background of an individual that drives their mindset and, potentially, their perceptions of the relative influence of nature and nurture.

To explore more in depth how a teacher's mindset can influence their practice, researchers in an Israeli study looked at the beliefs of n=42 secondary school teachers (Butler, 2000); although the sample here was small it begins to offer us some insight. Implicit theories of intelligence were found to influence teacher behaviour in the classroom. Teachers who held an entity theory were found to be more likely to make judgements on overall pupil cognitive ability based only on initial achievement. Furthermore, the research suggested that children were limited by these expectations as teacher tended not revise their assumptions of children even in the face of contradictory evidence (Butler, 2000). Here the researchers are implicating that the Pygmalion effect may be at play. This is the concept that individuals tend to end up living up to whatever expectations are made of them; so in this case, the suggestion would be that teacher expectations of their students would impact their actual academic progress (Rosenthal & Jacobson, 1992; Friedrich, Flunger, Nagengast, Jonkmann & Trautwein, 2015). Yet research into the phenomenon isn't conclusive. A longitudinal study exploring the Pygmalion effect with a focus on maths achievement found that the relationship between teacher and student was more complex (Friedrich, Flunger, Nagengast, Jonkmann & Trautwein, 2015). Here they found that although the Pygmalion effect was found at an individual level, teacher expectations were positively associated with maths outcomes at the end of the study; however, this was not significant when a student's prior attainment was controlled for and a student's self –concept also partially mediated the impact of teacher expectations (Friedrich, Flunger, Nagengast, Jonkmann & Trautwein, 2015). In relation to this review, this tells us that the assumption, that seems commonplace in studies exploring teachers' theories of intelligence, that teacher expectations drive student outcomes may not be clear cut. Yes, they can help in terms of motivation and self-belief; but there is little evidence to suggest that an incremental theory held by a teacher will necessarily improve a child's outcomes, with some research emerging already backing this up (Sisk, Burgoyne, Sun, Butler & Macnamara, 2018). It is likely that many teachers feel they should hold an incremental belief for the very reason that they likely believe it to be more closely linked to higher student attainment – yet this is not a unanimous finding in the literature and teachers risk over investing in an intervention without the backing of strong evidence to suggest mindset interventions are in fact the way to boost academic achievement (Sisk, Burgoyne, Sun, Butler & Macnamara, 2018). This idea may also reflect in teachers' responses to the nature-nurture questions, teachers may be hesitant in suggesting genes play a bigger role as it may be perceived as deterministic and detrimental to student outcomes.

Pretzlik, Olsson, Nabuco and Cruz (2003) aimed to explore the nature of teachers' judgements of intelligence and how these judgements impacted children's own perceptions of their and their peers' intelligence. Overall the researchers found that teachers' perceptions of their pupils' intelligence reflected the level of intelligence assigned to them from an IQ test. Moreover, pupils' own views of their intelligence mirrored those that the teachers held for them (Pretzlik et al., 2003). The fact that, unsurprisingly, teachers' realistic predictions of a child's ability reflected the IQ of the child under their supervision has been demonstrated in other studies as well (Chamorro-Premuzic et al., 2009). In a related study, Chamorro-Premuzic, Arteche, Furnham and Trickot (2009) compared teacher intelligence estimate accuracy in comparison to that of the pupils themselves and their parents.

The researchers found that, as might be expected, teachers were significantly more accurate than parents at estimating intelligence. However, there was no difference in accuracy when teacher predictions were compared to those of pupils (Chamorro-Premuzic et al., 2009). However, the findings were somewhat limited and would be difficult to make any generalisation from due the limitations of the teacher sample. Only six teachers were involved in the study and although in the UK context, so relevant for the proposed study, they were limited to secondary schools in London alone (Chamorro-Premuzic et al., 2009). Although the sample size was small (*n*=58 children from the UK and *n*=47 children from Portugal), the finding from Chamorro-Premuzic et al. (2009) suggest that teachers' predictions of intelligence are not hugely impactful in terms of how they influence a pupils performance and self-belief. If pupils are likely to accurately predict their own level of intelligence, then once again this casts doubt on the Pygmalion effect in terms of the fact that regardless of the teacher's expectations, pupils have their own expectations of themselves.

To conclude, the idea that a growth mindset both amongst teachers and pupils could boost academic achievement may not be a given. However, given the strong focus on mindset in UK schools, and the links between thinking about how fixed intelligence is, and thinking about genetic factors as influences on intelligence, the current study will gather data on teachers' self-reported mindset.

2.8 Teachers theories of intelligence for children with additional learning needs

A small number of studies have begun to look at whether teacher's mindset and theories of intelligence change based on whether or not the children they teach have additional learning needs (Gutshall, 2013). Gutshall (2013) explored whether teacher mindset across four scenarios remained the same. A sample of *n*=238 teachers (although it is worth noting here that the majority of teachers (87%) involved did not identify themselves as special educators) were presented with scenarios that focused on situations they may encounter in their everyday practice relating to children struggling in class. They were then asked to answers questions based on Dweck's mindset scale with relation to the child they had just read about. Teachers were randomly assigned a scenario focused on a child with additional learning needs or without. Findings showed that, like for IQ predictions, a teacher's mindset belief tended to mirror their mindset towards the student presented in the scenario. In other words, the teacher's pre held mindset beliefs tended to be reflected in how they reacted towards the different scenarios (Gutshall, 2013). It seems potentially that any Pygmalion effect present could in fact be a two-way effect with expectations feeding back and forth between teacher and pupil. When responses to scenarios including children with additional learning needs were compared to those of children without, there was little change in mindset responses from the teachers (Gutshall, 2013). This is interesting in light of the current study as some early exploration will also be made regarding whether teachers perceive the role of genetics differently when they teach children with additional learning needs. With the likelihood that teachers with a growth mindset/incremental theory are more inclined to promote the role of the environment, this provides us with a comparative set of findings to explore to see whether the same neutrality towards mindset for children with additional learning needs is mirrored for perceptions of behavioural genetics, this is something that is hoped will be able to be explored in the current research.

Taking a slightly different angle, a study by Woolfson, Grant & Campbell (2007) aimed to explore whether teachers from mainstream, mainstream learning support teachers and special school teachers differed in their perceptions of how much stability and control learners had when experiencing difficulties. Now it is worth mentioning here that this study was not looking specifically at mindset, but on rating children in different scenarios based on Weiner's (1985) attribution theory. By this we mean attributions of stability and controllability in learning scenarios. In other words, is a child's difficulty something that will continue unchanged (stability) or is it something they can change themselves (controllability). Although not the same as mindset, both are theories which seek to explain motivations to learn and drivers for academic success and both are potentially relevant to beliefs about heritability (Cook & Artino, 2016); therefore a reasonable comparison can be made. Woolfson, Grant & Campbell (2007), found that the teachers, who worked in mainstream settings, including those who worked as support teachers, viewed those children with additional learning needs as having less control over their performance than those children without additional needs. In contrast, teachers in special schools saw the controllability for both types of children as fairly similar. In terms of stability, special school teachers saw all children, regardless of additional needs, as more likely to change than both groups of mainstream teachers. This contrasts with the findings from Gutshall (2013) who saw no change between the perceptions of mainstream teachers when presented with questions regarding children with and without additional leaning needs. However, perhaps the bigger picture here is that teachers in special schools, although not overall significantly different to mainstream teachers in their attributions of controllability and stability; differed because unlike mainstream teachers, there was not a significant difference between the attributes they assigned to children without additional needs and to the attributes they assigned to children with additional learning needs. This significant difference was however present for mainstream teachers (Woolfson, Grant and Campbell, 2007). This once again begins to build the picture that teachers may not be homogenous particularly when attributing motivations for learning and control over learning to children with and without additional needs. The sample size in this study was reasonable at n=99 although it was geographically limited to one Scottish local education authority which somewhat limits generalisability. Moreover, it is worth noting that the study by Woolfson, Grant & Campbell (2007) is now over 10 years old, therefore, it would be reasonable to say that more work is needed now looking into Alternative Provision teachers' perceptions of cognitive ability.

However, this finding that children with additional needs are perceived on at least an equal level with mainstream children by teachers (when focusing on how much a child can progress intellectually) is not a unanimous finding. In a study focusing specifically on theories of intelligence (mindset) in relation to children with Down Syndrome, a different finding emerged (Drapeau, Carlier and Huguet, 2017) compared to that from Woolfson, Grant & Campbell (2007) and Gutshall (2013). It was found that, once again comparing professionals who worked with children with Down syndrome (special education teachers, speech therapists, nurses, social workers, etc.) and another group who did not (adults from the community), that both groups of adults reported theories of intelligence that were less incremental (growth mindset) when thinking about individuals with Down syndrome in comparison to typically developing children. However, although all the adults overall held a more fixed mindset regarding the children with Down syndrome; professionals who worked with children with Down Syndrome were statistically significantly more likely than adults who didn't work with children with Down syndrome to perceive the intelligence of children with Down Syndrome as malleable, a more growth-minded approach (Drapeau, Carlier and Huguet, 2017). The authors note that the reasoning for this different finding may be because Down Syndrome is recognised as a fixed disability, owing to the well-known fact it is caused by a particular chromosomal abnormality, Trisomy 21, i.e. it is clearly biological in origin (Drapeau, Carlier and Huguet, 2017). This highlights the possibility that teachers working with children with additional needs may not see all additional needs in the same way. It seems likely that certain disabilities elicit certain perceptions among professionals with regards to how fixed or malleable they feel a child's intelligence is. This could potentially mean that because teachers who work with children with additional needs may have more insight into some of the driving forces – potentially genetic – behind a child's disability or additional need, they may perceive them differently to teachers in the mainstream. Although these theories are not the same as perceptions of the role of genetics in cognitive ability and behaviour, they do provide us with some insight into how teachers perceive ability and whether they see it as something the children they teach, with or without additional needs, have control over and whether it is something changeable or more fixed. However, overall there is a real lack of homogeneity in the findings to date, making the need to explore this issue further even more pertinent.

Although these theories are not the same as perceptions of the role of genetics, they do provide us with an insight as to how teachers perceive intelligence and whether they see it as something the children they teach, with or without additional needs; have control over and whether it is something changeable or more fixed. This once again feeds into the findings that suggest how mindset may influence a teacher's perceptions of cognitive ability, as will be explored in this study.

2.9 The theoretical relationship between mindset and nature-nurture

How an individual perceives their own and others' mindset is said to reveal a lot about their underlying beliefs, attitudes and assumptions about people and everyday life. Theories of intelligence researchers such as Carol Dweck have argued that those with a fixed mindset tend to perceive intelligence as a fixed trait. They believe that knowledge can be acquired, but the ease with which it is learned remains largely fixed. Conversely, those with a growth mindset believe that basic human qualities are developed through effort and practice. If you work hard you can improve upon the behavioural traits you were born with.

Compare this with the simple, dichotomous (now widely accepted as unrealistic) approach to the nature-nurture debate: those firmly on the side of nature believe that human traits are determined by genetic factors, present from the moment of conception; in other words, they are fixed or predetermined to a certain extent. Those on the nurture side of the debate, conversely, believe that human traits, including cognitive ability, are largely shaped by the environment such as childhood experiences and the people who bring you up. It is therefore reasonable to hypothesise a relationship between a fixed mindset and an acceptance of genetic determinism.

Obviously, these are brief and simplified definitions that don't take into account the complex interplay between the two sides and the fact that most people do not sit at the extremes of the spectrums. Most genetic researchers now prefer to talk about nature via nurture rather than nature versus nurture. This more nuanced understanding does not map so neatly onto the fixed vs growth mindset dichotomy, possibly suggesting that theories of intelligence lack sufficient nuance. However, there are clear theoretical links between preferring genetic explanations for behaviour and a fixed mindset and preferring environmental explanations and a growth mindset. However, the mechanism for such associations is unclear as determinism, the most obvious candidate, could represent an over-focus on either genetic or environmental explanations while that distinction is less clear for fixed and growth mindsets.

There are good reasons for hypothesising a link between mindset and perceptions of the relative influence of genes and experience. However, after testing this hypothesis empirically, and based on the findings, it may be useful to explore behavioural, genetic and environmental mechanisms that might explain such a link.

Conclusions

In conclusion, we have only limited and possibly out-dated research into teachers' perceptions of cognitive ability and the role of genes overall. From the limited research we can see that teachers are realtively accurate in their perceptions of the nature-nurture question but various demographic factors may play a role in these perceptions (Walker and Plomin, 2005; Georgiou, 2008; Clément and Castéra, 2012, 2014). In terms of intelligence, we see that as a concept it remains a source of contention in the educational world. It seems like no one wants to come to one definition and testing surrounding intelligence has had a tarnished past (Ritchie, 2015). Yet throughout the history of education, IQ tests as a measure have been used on and off and are still present in some schools for in-school purposes. Yet we see the promotion of grammar schools by the government, which rely on IQ tests for admissions (Stone, 2017), although this has not been welcomed by the education profession (Walker, 2016). Perhaps there is a lot more IQ tests have to offer education if they could only shake their chequered history. In terms of this study, and in light of the growing awareness of behavioural genetics in the public sphere, it will be interesting to see if teachers hold the same hesitation towards general cognitive ability as a concept worth measuring and potentially using as an education tool. Although not called intelligence specifically, cognitive ability is closely linked and has been linked to a host of outcomes (Hart, Petrill, Thompson & Plomin, 2009). It is hoped teachers may be more open to the potential role behavioural genetics could play in education.

The research on mindset has given us a glimpse into how the perceptions and attitudes teachers have towards the nature-nurture question and behavioural genetics may affect and play a role in their classroom practice and attitude towards teaching. Mindset has been found in some studies to matter and, due to likely similarities between mindset and the nature-nurture question, it is not unfeasible to suggest that a teacher's perception of genetic influence on learning and behaviour may also influence how they teach. This makes it important to establish how teachers feel about the topic and to begin to explore how training and CPD could educate teachers in findings of behavioural genetics, and help them to accurately understand their relevance to education.

As the concept of mindset continues to grow in popularity in schools; we see that teachers are not homogenous in their theories of intelligence – fixed or growth. These differences have emerged based on subject specialisms as well as whether or not the children they teach have additional needs. Yet the picture is mixed as to what extent a teacher's theory of a child's intelligence affects them. Some research shows that it can hamper a child's ability to tackle a task; yet when we dig a little deeper we can see that this assumed Pygmalion effect may not be as strong as many assume. Often a child's own estimate of their intelligence is quite accurate, similarly to a teacher's estimate. Moreover, mindset interventions do not necessarily lead to improved academic outcomes when translated into educational settings (Sisk et al., 2018).

There is also an emerging picture that there may be a difference in teacher's theories of intelligence in mainstream schools and alternative provision settings. In seems that particularly when thinking about children with additional needs, teachers in the mainstream tend to see their intelligence as more fixed when compared to typically developing mainstream children and that special school teachers may differ in this. It has also emerged that different disabilities may elicit different perceptions of intelligence; here the difference isn't just as simple as mainstream vs. additional needs.

In terms of what this means for this study, the findings on intelligence offer an insight into the consensus among teachers at the moment with regards to intelligence. Most favour the idea that intelligence is something malleable and tend to report a growth mindset. Yet what has also been found is that intelligence is hard to define and as such comes with the addition of misunderstanding and misconceptions when it comes to applying findings surrounding intelligence, cognitive ability and mindset in the classroom. Findings also show us that when it comes to intelligence, teachers are not homogenous in their views, with subject specialty and additional needs status revealing differing views. In terms of behavioural genetics, the link seems likely that those with a growth mindset will favour environmental explanations of individual differences, and those with a fixed mindset will favour genes as the principal drivers of cognitive ability. This provides us with some context for teachers' perceptions when there is such little to go on in the field of behavioural genetics specifically

3. Literature Review: Relevant findings from behavioral genetics

The question of whether genetic or environmental factors explain more variance in human behaviour, the nature versus nurture debate, has become an important topic within education and has been the focus of much recent debate. It is worth noting though, that this debate is not limited to education and discussions of the influence of genetics on human behaviour cause controversy within society (Garner, 2013; Tabery, 2015). Key to the current study are findings from behavioural genetic research regarding the heritability of cognitive ability and other educationally relevant traits such as reading and maths ability, educational attainment and behaviour.

Before the above areas are explored, it is worth noting that the majority of the studies that will be cited in this chapter have used the twin study method. By studying the differences between identical and non-identical twins researchers are able to identify the extent to which genetic and environmental effects explain individual differences in behaviour. Identical twins raised together share both their genes and shared environment whereas non-identical twins only share 50% of their genes but also a shared environment. Shared environmental effects are those experiences and environments that make two children growing up in the same family more similar to each other, whereas non-shared environmental effects are those that do not contribute to making them alike. It is from twins, that researchers are able to establish the heritability (degree to which individual differences are influenced by genetic effects) of a trait. Then allowing the remainder of variance, which must be explained by non-genetic factors, to also be explored and broken down into shared environmental effects (c^2) and non-shared environmental effects, which include measurement error (e^2) (Knopik, Neiderhiser, DeFries & Plomin, 2016).

3.1 Current findings regarding nature-nurture and cognitive ability

The heritability of cognitive ability has been established through a large number of twin and adoption studies (Plomin, Fulker, Corley & DeFries, 1997; Petrill & Deater-Deckard, 2004; Haworth et al., 2009; Panizzon et al., 2014). They have shown us that cognitive ability is substantially heritable but that the proportion of variance explained by genetic factors changes over time (Haworth et al., 2009). For example, Petrill & Deater-Deckard (2004) used a within-family adoption design to establish genetic and environmental influences on cognitive ability. Using a US adoption sample the researchers aimed to establish whether parents' cognitive ability correlated with that of their biological and their non-biological children. Overall, the researchers found there was a modest but significant correlation (r=.23) between parents and their biological children but not between the same parents and their adoptive children (r=-.03). This suggests a heritability estimate of roughly 50%. Non-shared environmental effects explained the remaining 50%, with shared environmental effects explaining none of the variance (Petrill & Deater-Deckard, 2004). Similar findings have also been found in earlier studies (Plomin, Fulker, Corley & DeFries, 1997).

Twin studies have also been used to measure the heritability of cognitive ability. Haworth et al., (2009) used a sample of n=11,000 pairs of twins from across four countries. They examined the heritability of cognitive ability across the life span. They found that overall it was highly heritable, with the heritability of general cognitive ability (*g*) increasing with age (Haworth et al., 2009). More specifically, the heritability of general cognitive ability increases significantly and linearly from 41% in childhood (9 years) to 55% in adolescence (12 years) and to 66% in young adulthood (17 years). The authors proposed that this increase in the heritability of *g* might be explained by genotype-environment correlation, whereby a child increasingly selects their environment based on their genes as they grow and develop (Haworth et al., 2009). Bergen, Gardner, and Kendler (2007), through a meta-analysis of six studies, also concluded that heritability increased from approximately 55% (13 years) to 70% (25 years) (Bergen, Gardner & Kendler, 2007). In terms of this study, what this tells us is that there is not a 'right answer' for all teachers. Indeed if teachers are to be most accurate with their beliefs about the relative role of genes and environment on cognitive ability, we should see a difference based on the age of the children they teach. Those who teach younger children, if they are accurate, would see a greater role for the environment and those teaching at a secondary level should see roughly equal roles for genetic and environmental factors.

Briley and Tucker-Drob, (2013) aimed to further explore the heritability of general cognitive ability across the lifespan in an attempt to better explain the phenomenon of increasing heritability. Using a meta-analysis of other longitudinal twin/adoption studies, they suggested a more complex explanation:

> 'Our results indicate that longitudinal changes in heritability can be understood in terms of both innovative variance explained by genes not previously active and carryover (amplification and decay) of previously active genetic influences, with the relative contributions of each of these mechanisms differing across development' (pg. 1711-1712).

In other words, in the early years of a child's life novel genetic influences occur with gene being 'activated' and previous genetic influences deteriorate. This process continues until around the age of 8 by which time genetic innovation recedes and the child's existing influences begin to continually amplify, resulting in increasing heritability with age (Briley and Tucker-Drob, 2013).

They found that this was the rule rather than the exception, providing a valuable explanation for the increasing heritability of cognitive ability. In terms of this study, we would not expect teachers to know or understand this, but it is possible that the growing importance of genetic factors in secondary school will be reflected in their responses.

3.2 Current findings regarding genetic and environmental influences on educational attainment and behaviour

Having briefly presented an overview of what is known about balance of genetic and environmental influences on cognitive ability, it is also important to explore the balance of nature and nurture's effects on academic achievement, and to emphasise that ability (or intelligence) and achievement, while correlated, are not the same thing. It is known that genes (nature) do play a role in explaining individual differences in success in school (Garner, 2013; Trzaskowski, Shakeshaft & Plomin, 2013; Asbury, 2015). However, environmental factors have also been recognised by behavioural geneticists as having an impact on a child's academic outcomes (Domina, 2005; Walker & Plomin, 2006; Cooper, Crosnoe, Suzzio & Pituch, 2010).

One twin study aimed to explore whether teacher assessments of Mathematics and English achievement early in school (5-7 year olds) were influenced by genes (Walker et. al, 2004). Their findings, when identical twins were compared to fraternal twins, supported the notion that academic achievement in the early school years is substantially influenced by genes (with heritability estimates lying between .42 and .64). This was the case whether a twins' achievement was measured by the same or a different teacher (Walker et. al, 2004). This study drew on the Twins Early Development Study (TEDS) sample, giving the researchers access to a large and representative sample of both UK teachers and twin pairs (*n*=2,978 and *n*=1,189 respectively). This means that the findings have a good likelihood of being generalisable to the wider UK population (Bryman, 2012). Overall, this study provides a strong set of UK findings that support the significant influence of nature (genes) on teacher-assessed academic achievement. The researchers themselves, however, highlight, that this does not mean environment plays no part. This study can help build up a picture and contribute to our understanding of the role genes play in academic outcomes.

A further study supported the earlier findings (Walker et. al, 2004) that genes had a significant role to play in educational outcomes but at a later stage of education, when the twins were aged 16 (Krapohl et. al., 2014). The researchers analysed the GCSE results of *n*=13,306 twins, once again using the extensive TEDS sample. Their findings concluded that intelligence (influenced by genes) accounted for more of the heritability of educational achievement (75%) at GCSE than any other single variable (they used a mixture of environmental and genetic variables) (Krapohl et. al, 2014). This is a noteworthy finding, using a large sample, suggesting a dominant role for genes in educational outcomes. It reiterates the importance for the proposed study that teachers' views are sought on how they feel a potentially increased emphasis on genetics in education may affect them and their pupils (Howard-Jones & Fenton, 2011). However, intelligence was not the only correlate of GCSE achievement. When all of the other variables measured (self-efficacy, school environment, home environment, personality, well-being, parent-reported behaviour problems, child-reported behaviour problems and health) were combined it was found that together they accounted for as much of the heritability of GCSE as intelligence. Therefore, although intelligence, influenced by genes, plays a large role in educational outcomes, it only does so in tandem with a range of other genetic and environmentally influenced factors, which are also at play (Krapohl et. al, 2014). This study represents a good example of how such studies are presented by the media (Rousewell, 2014). At the time, headlines with the phrases 'genes dictate' emerged and other articles claimed you should 'blame your parents' for bad exam results (Ambridge, 2014; Macrae, 2014). Behavioural genetics studies are often presented in an over-simplified, deterministic and sensationalist manner, potentially leaving the public and teachers open to misunderstanding.

Having discussed and used the word 'educational outcomes' as a general term to cover attainment, achievement, test results and scores it is worth nothing that they all mean something different and research in the field has also acknowledged this (again these subtleties in terminology will need to be considered for the proposed study). One study by Haworth, Asbury, Dale and Plomin (2011) focused specifically on achievement independent of and controlling for prior ability (*g*) and previous attainment (based on school achievement measures). They did this in the hope of better establishing a purer measure of the added value of school ('the contribution of a school environment to students' achievement') for children's achievement (Haworth, Asbury, Dale & Plomin, 2011). This twin study used a sample of n=4000 pairs of TEDS twins and found a strong influence of genes (around 50% heritability) on achievement, even when previous attainment and ability (*g)* had been controlled for (Haworth, Asbury, Dale & Plomin, 2011). Yet, as shown, genes only accounted for 50% of the variance, the remainder was found to be explained by shared (30%) and non-shared (21%) environmental factors. Overall, this study once again adds to the bank of literature that supports the notion of genetic effects playing a strong and significant part in explaining individual differences in educational outcomes. Moreover, when *g* (cognitive ability) was controlled for, genes were still found to be a significance influence – in fact just as significant as before. This suggests that there is more than just the genetic influence of *g* driving academic achievement and it suggests a need for more research, like that of Krapohl et al. (2014) into what other genetically-influenced behaviours or mechanisms are at play.

Additionally, as discussed by the researchers in considering possible directions for future study, there remains an opportunity for variance not explained by genes to be broken into an 'index of schools' added value' (Haworth, Asbury, Dale & Plomin, 2011). They argue that this would be a purer measure of school effectiveness than school-level achievement, which reflects child factors at least as much as school factors. If an index of schools' added value were to be created then educators may increasingly channel focus and resources into those school environmental factors that have the biggest impact allowing their environmental influence to be as meaningful as possible in light of a strong genetic influence.

Although twin studies provide evidence of moderate to strong influence of genes, biological studies looking at particular genetic influences have proved, until recently, less compelling. For example, Jerrim, Vignoles, Lingam and Friend (2014) found that three candidate genes for reading ability had a negligible effect on reading skills and no socio-economic group were more likely to have a genetic risk associated with three candidate genes (Jerrim et. al, 2014). However, the field has moved on from candidate gene studies to Genomewide Association Studies (GWAS) and the picture is beginning to change.

Recently, Selzam et al. (2017) looked to explore the association between genetic effects on education achievement and reading ability using a polygenic risk score (polygenic risk scores combine many genetic loci found to be associated with a trait, to create a composite that predicts genetic propensities for individuals) and identified a much more compelling finding. They explored a range of different aspects of reading such as efficiency and comprehension. They looked across the school age spectrum at ages 7, 12 and 14 using a UK based sample of n=5,825 participants. Selzam et al. (2017) found that this polygenic risk score could predict 5.1% of the variance in reading performance at age 14 (2.1% at age 7 and 3.5% at age 12) (Selzam et al., 2017). The authors suggest their results show that predicting specific individual learning abilities using DNA is becoming possible and, although at the moment there is no real world application, the prediction is that the 5%

of variance explained will only increase from now with more and more studies and more powerful polygenic risk scores (Selzam et al., 2017).

When we look at reading in the context of twin studies, Plomin, Shakeshaft, McMillan and Trzaskowski (2014) further demonstrate the heritability of reading ability. They looked at reading by comparing expert readers with normal-level readers, and found that genetic factors accounted for more than half of the differences in reading performance between those children classed as expert readers (top 5%) and those classed as normal level readers (Plomin, Shakeshaft, McMillan & Trzaskowski, 2014). Moreover, the same genetic factors explained variance among normal readers, as for those as the extreme, which could have been an anomaly for reasons outside of potential genetic influence, for example extremely keen readers (Plomin, Shakeshaft, McMillan &Trzaskowski, 2014). However, caution must be exercised when directly comparing studies of a particular phenotype that use different methods. Plomin, Shakeshaft, McMillan and Trzaskowski (2014) used the twin method whereas Jerrim et. al (2014) and Selzam et al. (2017) used candidate genes. Therefore, it could be that the difference in their findings was due not to either finding 'the answer' to the nature-nurture question in the context of reading but rather the results of two very different methodological approaches. With such complexities in the research and so many contrasting findings it is clear that a study aiming to explore teachers' perceptions of genetic science is going to need to address how misconceptions can be avoided and how teachers can be helped to understand the complexities of this body of research.

Another aspect of education explored in this study to some extent is behaviour problems. This has also been the focus of behavioural genetic research. A number of different measures are used to measure behaviour problems, including the Strengths and Difficulties Questionnaire (SDQ) (the measure of behaviour problems focused on in the current study (Goodman, 1997)). The SDQ is a short but widely used and well-validated measure of anxiety, hyperactivity, conduct problems, peer problems and prosocial behaviour in childhood and adolescence. When it comes to what we know about the heritability of these SDQ traits evidence suggests moderate to substantial heritability (35%-77%) that remains stable throughout development (Scourfield, Van den Bree, Martin & McGuffin, 2004; Saudino, Ronald & Plomin, 2005; Lewis, Haworth & Plomin, 2014; Lewis & Plomin, 2015). In terms of environmental influences, shared environmental influence has consistently been found to be low for SDQ traits – with non-aggressive conduct disorder being the exception (Saudino, Ronald & Plomin, 2005; Knopik, Neiderhiser, DeFries & Plomin, 2016).

In one comprehensive study of the aetiology of behaviour problems, both teacher and parent estimates of behaviour were used (Saudino, Ronald & Plomin, 2005). It was found that when twins' behaviour was rated by different teachers rather than by the same teacher, teacher estimates of heritability were lower and estimates of non-shared environmental variance were higher. The authors attributed this to the likelihood that different classroom environments and peer groups may have contributed to these behaviour differences (Saudino, Ronald & Plomin, 2005). Hyperactivity showed the highest genetic influence (.66-.77) and emotional problems (anxiety) the lowest (.35-.55). Prosocial behaviour ranged from (.40-.76), peer problems (.56-.83) and conduct problems (.62-.81) (Saudino, Ronald & Plomin, 2005). It is worth noting here that this instantly highlights misconceptions among the teachers in the Walker and Plomin (2005) study who perceived there to be less genetic influence on behaviour problems compared to other traits – despite most behavioural traits showing moderate to substantial heritability.

The finding that hyperactivity is one of the most heritable traits on the SDQ questionnaire is interesting in light of some research with teachers. Russell, Moore & Ford (2016) reported an in-depth qualitative study exploring the beliefs of n=41 teachers from England working with children with ADHD (of which hyperactivity is one of the main elements). They worked across the age ranges with some teachers coming from mainstream schools and some coming from Pupil Referral Units (PRUs). Focus groups were conducted to gather data about the teachers' beliefs about the causes of ADHD. Results showed that teachers expressed belief in both biological (genetic) and environmental influences on ADHD. When it came to the biological causes, teachers accepted a biological cause for ADHD. However, when they were discussing environmental causes, the researchers found that teachers tended to talk about these factors for longer and in more depth. Discussion around environmental causes tended to focus on home life, parenting, diet and school (Russell, Moore &

Ford, 2016). It is also worth noting that teachers tended to accept both sides of the discussion and, rightly, did not see genetic and environmental factors as mutually exclusive. In terms of the relevance for this study, teachers noted that genetics could be a contributing factor, highlighting that when it comes to specific behavioural conditions, some teachers may be more willing to cite genetic causes. However, the authors highlighted the clear lack of knowledge from teachers surrounding the biological influences, and their higher level of confidence in discussing the environment. This may be explained by the lack of knowledge and training currently present in teaching, an issue explored in depth in Chapter 8. It is however worth noting that this study was a relatively small qualitative study with participants from a limited geographical area, so findings cannot be generalised across the UK.

Overall, we know from twin studies that behaviour problems show moderate to substantial genetic influence. Internalising disorders such as anxiety and depression show moderate heritability around 40% (e.g. Cheeseman et al., 2017) while hyperactivity shows more substantial heritability (Saudino, Ronald & Plomin, 2005). It will be interesting to explore, in the current study, how teachers in Alternative Provision (AP) settings perceive the aetiology of SDQ traits.

3.3 What has behavioural genetics research learned about shared and non-shared environmental influences on achievement, intelligence and educationally relevant traits?

Once the heritability of a trait has been estimated; then the remaining variance must be explained by environmental factors, including measurement error (Knopik, Neiderhiser, DeFries & Plomin, 2016). Before an exploration of the literature, it is worth establishing what is meant exactly by shared environment (c^2) and non-shared environment (e^2). When discussing shared environment what we are talking about are non-genetic influences that affect children who grow up in the same family setting in the same way, any non-genetic factor that makes family members similar to one another. This might include, for example, parenting style, neighbourhood, family income or reading material available in the home (Knopik, Neiderhiser, DeFries & Plomin, 2016; Asbury & Plomin, 2014). However, it is worth noting that these shared environmental influences only explain the c^2 component of variance if they are experienced in the same way by the children in the family. For example, although both children share the same parents, parenting style would only be classed as a c^2 factor if there was no discrepancy (perceived or actual) in the way the parents treat their children. Moreover, c^2 factors tend to explain less influence in most traits as children get older (Knopik, Neiderhiser, DeFries & Plomin, 2016).

As discussed, as well as shared environment (c^2) there is also non-shared environment (e^2) that can help us explain some of the variance in achievement, intelligence and educationally relevant behaviour. Non-shared environmental effects are those that are not correlated between family members. In other words, e^2 encompasses anything which one family member experiences but the other does not, such as a particular friendship group, traumatic accident or a different teacher at school (Plomin, 2011). It also includes objectively shared experiences if they affect the two children or young people differently. As identical twins raised in the same house share both their genes and shared environment influences, non-shared environment factors are key in explaining any variance between them in terms of educational traits and outcomes (Knopik, Neiderhiser, DeFries & Plomin, 2016; Asbury, Moran & Plomin, 2016).

Research into the influence of shared and non-shared environment on educationally relevant characteristics have, on the whole, presented findings that show e^2 (non-shared) factors are the most influential (Asbury, Dunn & Plomin, 2006; Plomin, 2011; Daw, Guo & Harris, 2015). Mostly, findings in behavioral genetics have placed little emphasis on the role of c^2 (shared) in explaining variance between individuals after the pre-school years; however, this is not completely clear cut, as will be explored later on (Daw, Guo & Harris, 2015).

Exploring findings relating to c^2 and e^2 in terms of educationally relevant traits, a number of studies have explored the influence of shared and non-shared environmental effects on reading skills (Samuelson et al., 2006: Olson et al., 2011). For example, Samuelsson et al. (2006) explored genetic and environmental influences on reading and spelling skills in the early years. Their cross-cultural study (U.S, Australia and Scandinavia) found broadly similar patterns across all countries, although it is worth nothing here this study was not UK focused (Samuelsson et al., 2006). Print knowledge and vocabulary showed moderate heritability varying dependent on country (.18-.26) and strong shared environment influences again varying dependent on country (.50-.74). In comparison, varying by country, phonological awareness, verbal memory and rapid naming showed substantial heritability (.46-.87) and lower influences from shared environment (.00-.41). Overall non-shared environment estimates were low to moderate across all traits ranging from .05 to .32. However, Samuelsson et al. (2006) found that when a child was of pre-kindergarten age (i.e. before they had started school) differences in their reading (print knowledge) and vocabulary in particular were much more open to influence from shared environmental factors. Further comparative analysis was carried out to explore differences between the US and Australia (Scandinavia was excluded as the sample size was too small and many of the children had not started reading or writing). It was found that stronger, but not significantly, genetic influences were present in the Australian sample compared to the US sample in terms of non-word reading efficiency, word reading efficiency, and spelling (Samuelsson et al., 2006). The researchers suggest that such differences, although not significant, were mainly down to various literacy approaches in the two countries. What this study tells us is that for reading and spelling heritability is substantial, but the shared and non-shared environment influence varies by country and by the child's stage of development. The education system and approaches to reading and spelling in a country likely have an impact on the genetic and environmental influences on the trait. It is likely that UK, with a different education system, may also differ slightly so it worth bearing that in mind in the context of these study findings.

Reading and spelling are just some of many educationally relevant traits that teachers interact with on a daily basis. Therefore looking at another study that focused particularly at children at the very early stages of their education but looking at a different educational trait, Lemelin et al., (2007) found that differences in school readiness could be best explained by a combination of genes, e^2 and c^2. In particular, they found that c^2 provided a strong contribution to explaining differences in cognitive school readiness (Lemelin et al., 2007). This study had a substantial sample (n=840), and although set in the Canadian context, their findings mirror those of similar research in other contexts in terms of young children being influenced more heavily by c^2 factors (Samuelsson et al., 2006;

Lemelin et al., 2007; Olson et al., 2011). This once again highlights the likelihood that teacher demographics, in this case being the age they teach in particular, may influence the role they feel genetics has to play. Theoretically, it could be likely that early years practitioners will be less likely to be proponents of the role of genetics and the importance of genetic science in their classroom, due to the emerging picture that SE has a greater role to play amongst younger children.

So far, the focus has been on research findings relating to the role of shared and non-shared environment on intelligence, achievements and school related behaviours but primarily in terms of literacy skills. Therefore, it is worth exploring the findings also in the context of numerical and mathematical skills as this has been the focus of specific research within behavioural genetics (Kovas et al., 2009; Luo et al., 2011). Reviewing the research, a similar pattern of c^2 and e^2 influences as found in other academic areas. Kovas et al., (2009) found that once heritability of maths ability had been accounted for (found to be around two-thirds of explanation of variance) then the remainder could be explained by primarily e^2 (24%) followed by c^2, explaining only 12% of the variance in maths ability in a UK sample of 10-year-old twins (Kovas et al., 2009). For mathematics achievement) a picture is emerging to suggest that variance is largely explained by genetic and non-shared environmental factors (Luo et al., 2011). In terms of this study, what these findings show is that for the two subjects (mathematics and literacy) that receive so much focus from teachers and education the picture is similar. Most of the variance can be explained by genetic factors, with a lesser but still important proportion explained by non-shared environment (which can include schooling effects but also measurement error), with shared environment influences explaining much less variance.

This pattern of findings continues to translate to end of school tests, suggesting that throughout schooling this balance of heritability, c^2 and e^2 remains broadly similar (Krapohl et al., 2014). However, it is worth noting a shift in the role of shared environment from GCSE (end of school exams at 16) to optional A-levels (end of school exams at 18). When it comes to GCSE results for UK teenagers, shared environment accounted for around a quarter (.26) or the variance with non-shared environment accounting for just .12 of the variance (Krapohl et al., 2014). In comparison, overall mean A-level performance across a range of subjects was also highly heritable (.59) but in comparison, non-shared environment (.34) explained more of the variance than shared environment (.7) at A-level (Rimfeld, Ayorech, Dale, Kovas & Plomin, 2016). Perhaps this suggests that with growing independence non-shared environmental influences become more important (Rimfeld, Ayorech, Dale, Kovas & Plomin, 2016). What these exams results tell us, it that for the most pivotal of academic outcomes, heritability is high but environmental factors, which include teaching and teachers, are also important in explaining individual differences. It is interesting to consider whether teachers who may have experience across different age groups pick up slight changes in terms of the balance in c^2 and e^2 at different schooling stages.

Overall, the balance between genes, shared and non-shared environment on education is complex. Primarily using the twin study method, variation in traits is explained by heritability shared and non-shared environment. The research suggests that, in terms of the environment, non-shared environmental factors have a bigger role to play in explaining variation between children than shared environmental factors. However, c^2 and e^2 interplay is not fixed or linear and we all experience the environment differently, therefore one environmental influence will be potentially more influential for one person, whereas it might have little effect upon another (Asbury, Almeida, Hibel, Harlaar & Plomin, 2008). It is important to remember that behavioural genetics tells us about populations, not about individuals. Moreover, the c^2 and e^2 interplay likely changes in balance throughout our lifespan, with c^2 factors playing a smaller role as we move out of the preschool years (Plomin, DeFries, Knopik & Neiderhiser, 2013). What can be concluded is that researchers are making steps towards being able to more confidently establish the role of c^2 and e^2 in terms of achievement, intelligence and educationally relevant behaviour. However, there is still much research yet to be done and it must always be remembered that the each child presents a unique case; perhaps at best we can hope for accurate estimates that can help inform and guide us in educational practice.

3.4 Historical legacy of behavioural genetics, IQ and the eugenics movements

Genetics, not unjustifiably, is conflated by many with eugenics and with that dark period in history, from the Industrial Revolution to the end of the Second World War, when eugenic ideas were widely accepted and caused widespread harm. Therefore, it is important to acknowledge and understand the historical links between genetics, cognitive ability and eugenics when considering perceptions of 21st century genetic research. Establishing where reasonable feelings of trepidation about genetics stem from can enhance our understanding of public perceptions of the science, and also suggest ways to avoid the misuse of genetics in the future. This is particularly important when considering how best to share behavioural genetic findings with the public and educators.

For many members of the general public, which of course includes teachers, mentioning behavioural genetics in the context of cognitive ability and IQ conjures up instant associations with right-wing, racist, fascist and eugenic beliefs and preferences (Berryessa & Cho, 2013). In its heyday eugenic policies led to discrimination, sterilisation and even death for those deemed not to be ‘well born’. Even though eugenic ideas have not been mainstream since the late 1940s in most societies, many fear that the growth of research in behavioural genetics may lead us back down that path and that genetically-informed policy-making can only lead to eugenic policies (Berryessa & Cho, 2013). Progress is dependent on us accepting, acknowledging, understanding and addressing these fears (Sofair & Kaldjian, 2000).

The term ‘eugenics’ was first coined by Francis Galton in the 1880s and means ‘well born’ (Chitty & Benn, 2009). Tensions between the classes in society at the time meant the idea proved popular, particularly amongst the middle and upper classes who feared the rapid population growth of what they saw as the lower classes (Chitty & Benn, 2009). A follower of Francis Galton was a man named Cyril Burt, who was arguably the first to start applying intelligence selection in education and whose impact has arguably had the longest lasting impact in UK society (Chitty & Benn, 2009). It is important to note that these ideas – to do with genetics and cognitive ability – were being developed alongside each other.

Repercussions of IQ testing and the 11 plus system in the UK; which saw a period following World War 2 in which IQ tests were used to divide children into streamed education – grammar schools for those who passed and technical schools or secondary moderns for everyone else. This system is now largely viewed as having failed those children not selected to attend the academic grammar schools as in many cases the technical school options never materialised and the secondary moderns came to be seen as a 'dumping ground' (Chitty & Benn, 2009). In spite of this some grammar schools remained in areas of the UK such as Kent, and recently the debate was reignited when the Conservative party tried to pursue a policy of grammar school reintroduction and funding (Rayner, 2017). In spite of ample evidence that this is not a beneficial way to educate young people there remains an appetite for selection on the basis of cognitive ability. A 2016 poll, for example, found that 38% of the general public support the idea of selective education and it clearly still has the support of many politicians (Kettle, 2016; Kentish, 2017). Selection on the basis of intelligence is bound up in the public imagination with eugenics, albeit as a somewhat less brutal form of discrimination. Bringing genetics into the equation – over and above IQ test scores – makes a clear link between selection and eugenics.

Debates like the grammar school debate have clear potential to reignite eugenic fears, particularly when such debates are combined with discussions of the heritability of intelligence. By confronting such issues, informed with the knowledge of what can happen if genetic technology is abused and misconstrued, we can become better able try to guard against the potential negative consequences of behavioural genetics – this is crucial as DNA data becomes increasingly available – allowing us to focus on the positive impact the research could have.

Understanding of the history of the eugenics movement is essential if we are to take a sensitive approach to the dissemination, discussion and regulation of issues ranging from direct-to-consumer genetic testing to the potential incorporation of DNA data into education. We need to consider issues related to discrimination on the basis of genes driven by outside agencies but also by parents and potential parents. Such testing could, for example, lead to parents seeking out children with specific complex behavioural traits – namely avoiding low intelligence and selecting for intellectual talent (Berryessa and Cho, 2013). Moreover, should teachers ever be given access to their pupils' DNA data (probably in the form of polygenic scores) it may be hard for them to see beyond this information and teach the child objectively. Yet, as has been clearly laid out by researchers in behavioural genetics, although all this is possible, it must come with a conversation about the legal and ethical boundaries rather than us simply objecting and hoping the ideas will be forgotten (Ball, 2018). If we don't take centre stage as researchers and lead the way in addressing concerns, challenging misuse and setting boundaries – sensitively and in the context of an undoubtedly troubled history - we leave it open to become a political or ideological cause.

Worryingly, such possibilities have already begun to creep in. For example, Toby Young, a political commentator in the UK, recently advocated what he coined 'progressive eugenics', a choice of terminology that was obviously inflammatory and led to reactions that demonstrated just how sensitive this topic still is (Ball, 2018).

In conclusion, we cannot erase the abhorrent historical use of eugenics to justify racial, social and ethnic segregation, and ultimately, the Holocaust and nor should we try. This history serves as a potent reminder that we must guard against the misuse of any science and research – not just behavioural genetics. In order for the positive contribution behavioural genetics could make to our education system to be possible we need to be sensitive to the negatives in the science's past. We need an open discourse around hesitations and apprehensions towards the science to ensure that, as a society, we guard against any potential misuse as well as embracing positive contributions.

Conclusion

What this chapter contributes to the thesis research focus is an insight into the most accurate estimates we have to date about the balance between heritability, shared and non-shared environmental influences on behaviour. This allows us to compare the perceptions of teachers with what we know, and to explore whether slight changes in the balance are reflected in differing teacher perceptions based on demographics. More specifically based on the findings from this and the cognitive ability studies, the fact that infant children appear to be more influenced by c^2 factors must be kept in mind when exploring differences between teachers of infant children and teachers who teach older children. Teachers may well see evidence of this different interplay on their practice, therefore affecting their perceptions of the role of genes and environment in education. For behaviour problems (appearing on the SDQ scale), often considered to be more driven by environment – despite most showing considerable heritability, there is a need to further explore how different behavioural traits are perceived in terms of nature-nurture. Using a sample of alternative provision teachers who are likely to have experienced myriad behaviour problems, the question will be whether their beliefs about the aetiology of behaviour problems reflect the scientific findings. Moreover, with such a complex research picture being presented, it is also worth considering how this might act as a barrier for the teachers – the focus of the proposed study – potentially leading to misconceptions or lack of knowledge stemming from difficulties in interpreting the research findings.

The chapter also reflects on the often tarnished past that behavioural genetics and IQ has. We must ensure that the lessons learnt from the abhorrence of the eugenics movements in Nazi Germany and elsewhere are not forgotten and remain at the forefront of the minds of those engaged in any future ethical debates about the use of genetics. Yet, mistakes and misuse from the past shouldn't lead us to ignore the benefits behavioural genetics could bring and as society modernises and becomes more progressive we must look carefully into how best to move forward with the findings we now have emerging from behavioural genetics.

4. What does the general public think about the role of genetics in education?

4.1 Introduction and research questions

The primary focus of this PhD research is a study of teachers' beliefs about, and knowledge of, genetics, as presented in Chapter 7. As a precursor to this research a study of the beliefs of a section of the general public about the role of genes in education was undertaken. This study is available in published form (Crosswaite & Asbury, 2016). Knowledge of how the public view the role of genes in education provides a useful baseline against which teacher-specific views can be compared.

For reasons both historical and conceptual, genetic science is often misunderstood by the general public (Tabery 2015). There is a false but widespread belief that traits that show genetic influence are in some way pre-determined and not malleable. This misconception can generate hostility and a fear that opening the door to genetic research will open a door to discrimination (Tabery 2015; Munafo 2016). When this controversial topic is combined with education, something most people have personal experience of and opinions about, then it is highly likely to evoke conflicting views and attitudes. At a time when scientists are calling for more account to be taken of genetic research in education (Asbury and Plomin 2013; Thomas et al. 2015) we have only a limited understanding of how the general public feels about this and how they might react to genetically informed educational policies or practices, should they become a realistic proposition.

On 11th October 2013 an article was published in the UK *Guardian* with the headline 'Genetics outweighs teaching, Gove advisor tells his boss'. The article reported a leaked essay written by special advisor Dominic Cummings to the then UK Secretary of State for Education, Michael Gove. It reported Cummings' views on the influence of genes on academic achievement and his view of teacher quality in the UK. It also focused on his opinion that government initiatives such as Sure Start had failed and that UK Higher Education lacked credibility (Wintour 2013). This specific article was chosen due to the title 'Genetics outweighs teaching…' succinctly drawing attention to the nature-nurture debate in education around which this whole thesis is based. This element of the study acted as a broad umbrella study with a large sample to provide a good overview, before then focusing primarily on teachers. The different methodology used, also allowed the whole doctoral study to use a strong mixed methods approach to further broaden the validity and reliability of findings (Bryman, 2012).

The article was based on a 237-page essay written by Cummings entitled 'Some thoughts on education and political priorities'. It is notable, for our purposes, that only five of the 237 pages of this wide-ranging document discussed genes. This was not, primarily, an essay about genetics. In the short section on genetic influence Cummings' main argument was that the science of genetics is largely ignored in education. Few could deny that this was the case at the time of writing. He briefly discussed historical misconceptions surrounding genetics and presented findings from recent studies. His short account focused primarily on the research of UK-based behavioural geneticist, Professor Robert Plomin, and argued that the single largest factor influencing the performance of children is their genes. Cummings presented heritability estimates from Plomin's Twin's Early Development Study (TEDS) citing a heritability estimate of 70% for phonics at ages 7 and 12 (Harlaar et al. 2014); 60–70% for reading and mathematics ability at ages 7, 9 and 12 (Kovas et al. 2013); and 60% for English, Maths and Science GCSE achievement (Shakeshaft et al. 2013). Cummings also reported the finding that educational achievement is more heritable than IQ (Kovas et al. 2013). However, he failed to cite the relevant sources in his essay, referring to this body of work generically as 'Plomin's'. That said, the heritability estimates presented genuinely reflected the research, although for GCSE achievement heritability estimates were between 50 and 60%, depending on the subject.

Cummings went beyond heritability estimates, speculating that good teachers can improve reading standards for all but that they cannot narrow the gap between individuals. This assertion is likely to have been based on the finding that individual differences in reading are primarily explained by genetic differences between individuals. Therefore, an intervention targeted at a whole country can improve average achievement but is unlikely to narrow the gap between the highest and lowest achievers as it is not in fact designed to address the gap. In this sense Cummings' speculation was reasonable and rooted in evidence. He concluded his essay by discussing what should happen in the future when genome wide association studies (GWAS) identify particular genes associated with general cognitive ability (g), something that is beginning to happen now but is still very much in its infancy (Davies et al. 2016). He argued that this development should lead to 'truly personalised education' (Cummings 2013, p.73). In sum, Cummings' essay offered a short description of some existing behavioural genetic evidence and some personal speculation based on that evidence. The information he presented was, on the whole, factually correct but its portrayal in the *Guardian* article arguably introduced some distortion.

That said, a case could be made that in his brief discussion Cummings himself painted a rather narrow picture of behavioural genetic findings relevant to learning and education that was somewhat lacking in nuance. For example, teachers or parents could interpret his account as meaning that the aetiology of heritability is simple, stable and not open to influence. This is not the case. Heritability estimates are not fixed because they are dependent on the environment in which children learn. If children grow up in a society in which not everybody has the right to go to school, then heritability is likely to be low and school attendance will explain a lot of variance. In a society in which all children have precisely the same experiences and opportunities then heritability will be 100% as genes will be all that differentiates between them. Heritability does not imply a lack of malleability and teachers and parents are likely to be influential via genotype-environment correlations as well as more directly, as features of a child's learning environment (Plomin et al. 2016). This message was not apparent in either the article or the essay on which it was based. To illustrate this point, recent research shows that the genetic contribution to GCSE achievement can be explained by factors including general cognitive ability, self-efficacy, behaviour problems, personality, well-being and perceptions of the school environment (Krapohl et al. 2014). Furthermore, a meta-analysis of all findings from behavioural genetics, i.e. not just for educationally-relevant traits, also suggests a complex picture with heritability, shared environment and non-shared environmental factors all playing an important role in explaining human behaviour (Haworth et al. 2011; Branigan et al. 2013; Polderman et al. 2015). On average, in Polderman et al.'s (2015) meta-analysis, genes appear to explain roughly half of the variance in behaviour, and environment (including measurement error) the other half.

The *Guardian* article reported Cummings as saying that achievement was 'mainly based on genetics'. This does reflect the heritability estimates presented in the essay, and the research they came from. However, this description and the statement that 'genetics outweighs teaching' implied a determinism that the evidence does not support and that, in fact, Cummings did not claim. In the research cited, genes explained somewhat more variance than environmental factors in most cases. The effects of all relevant genes combined do indeed appear to outweigh the effects of any single environmental factor (e.g. teachers). However, this does not mean that achievement is genetically determined, or that teachers don't matter, both of which the article implied: 'Cummings maintains that individual child performance is mainly based on genetics and a child's IQ rather than the quality of teaching' (Wintour 2013). Cummings did not in fact say this and the research does not support it other than to the extent that it is unreasonable to pit the effects of a single environmental factor (i.e. teaching) against all genetic effects (i.e. not a single genetic variant).

The article was widely discussed (Jones 2013; Toynbee 2013) and generated n=3008 on- line reader comments from members of the public. Compared to other education articles published in the *Guardian* at the same time this article received a particularly large response. For example, an article published 8 days later, detailing an attack by the Liberal Democrats on Michael Gove's new school reforms received n = 1161 comments (Helm, 2013).

To date, only a small number of studies have explored public perceptions of genetics in general, and even fewer have looked specifically at public perceptions of the role of genetics in education. On the whole, existing research suggests that both the general public, and education professionals, lack comprehensive knowledge about genetics, although educational professionals have so far been relatively accurate when asked to what extent they believe nature and nurture influence learning behaviour (Condit 2001, 2010; Walker and Plomin 2005; Etchegary et al. 2013; Chapman et al., 2018).

More is known about public perceptions of genetics applied to healthcare than applied to education. Etchegary et al. (2013), looked at public opinions about genetics in a healthcare context in Canada, and found that participants felt they did not know enough but were open to the potential value of genetic information in their own healthcare. In this study participants demonstrated a positive view of advances in genetic science (Etchegary et al. 2013). In a review of the literature on public perceptions of genetics Condit (2001) found that the public tends to approach advances in genetics with 'cautious optimism'. This review suggested that although the public does not act with ignorance towards advances in genetics, there remains a lack of means by which new information can be incorporated into public knowledge. It is crucially important therefore that any attempt to engage the public in debates such as whether genetic information is relevant to education acknowledges and responds directly to this challenge. This is an important science communication issue. Patchy or inconsistent information leads, according to Condit (2001) to a real mix within a society with the public seeing both "promise and risk" in genetics (Critchley et al. 2014). This conclusion is particularly pertinent to the current study as the media article to which commenters were responding presented a very strong view that could easily generate misconceptions among readers. This is coupled with the fact that the article did not present Cummings' essay wholly accurately. For example, despite the statement making up the title of the article, Cummings did not actually state that 'genetics outweighs teaching', only that we currently undervalue and ignore the significant role that genes have to play in influencing school outcomes (Cummings 2013).

The most comprehensive study to have been undertaken of public perceptions and opinions about genetics in the UK was carried out by the Human Genetics Commission in 2001. This is now somewhat outdated but findings can nonetheless provide us with a basic foundational knowledge of what the UK public thinks (or thought at that time). The Commission found, using a sample of >1000 UK citizens, that the vast majority of people agreed that genetic technology can be used to diagnose and cure disease. The vast majority also supported the use of genetic technology in solving crimes and finding perpetrators. Such uses have already begun to emerge. Recently, in the USA, genetic technology through a genealogy website was used to apprehend the infamous ‘Golden State Killer’ over 30 years after he first started his spate of attacks in California (BBC News, 2018).

Those with better knowledge of genetics were more likely to be supportive of the role of genetics and the use of genetic technology in a medical role. Most relevant to the current study is the finding that, when asked whether they thought nature or nurture determined intelligence, the general public tended to see a 50/50 split in influence (Human Genetics Commission 2001). In light of findings from behavioral genetics, this appears to be a relatively accurate perception (Plomin and Deary 2014; Polderman et al. 2015). It is interesting to note, on the basis of the Human Genetics Commission’s 2001 survey, that the general public appeared to accept roles for both nature and nurture, and to support the use of genetic technology. Progress in genetics has been fast since the completion of the Human Genome Project and little is known about how the public feel about genetics in the light of more recent developments.

However, more recently, interest in public perceptions and knowledge of behavioural genetics has increased. Chapman et al., (2018) have recently developed an International Genetic Literacy and Attitudes Survey (iGLAS) to provide a measure to use in such studies. Their preliminary unpublished findings also suggest that overall genetic knowledge was poor (Chapman et al., 2018). In their large international study of n=5404 basic genetic literacy (including intelligence and educational achievement) was tested and group comparisons made based on profession. Participants tended to overestimate the heritability of intelligence (58%) but underestimated the heritability of school achievement (37%). The small sample of teachers in their study scored slightly lower than average on their measure of genetic literacy, once again highlighting their lack of knowledge on the subject (Chapman et al., 2018). These findings make a valuable contribution to this scant research field. Findings largely support what has been found in the past but it is interesting to specifically look at the differences found between intelligence and school achievement. As reflected in the reaction towards the Cummings article, the public (including in this instance teachers) clearly believe that school plays an important role in a child’s outcomes.

Looking specifically at perceptions of genetics in education, Walker and Plomin (2005) explored teachers' and parents' perceptions of how genes and the environment influence educationally relevant behaviour, as described and discussed in Chapter 2. They surveyed n=556 UK primary school teachers and n=1340 parents and found that teacher and parent views are largely in line with findings from twin studies and findings from behavioural genetic studies so far, as described in Chapter 3 (Plomin et al. 2013). This suggests that there is in fact little conflict between what teachers and parents believe about the aetiology of learning abilities and what the research shows. This does not, however, lead to a lack of controversy particularly when the message is framed in a controversial or adversarial way as it was in this *Guardian* article. When strong reactions are likely to emerge it is worth thinking about their origins. It has been argued that the eugenics movement generated distrust towards genetic science in society (Critchley et al. 2014; Tabery 2015) causing the public to shy away from anything that represents a deterministic view of genetic influence. It is important to remember this in the context of the article on which the current study is based, which at least implies genetic determinism. However, commentators also stress the fact that much of the distrust surrounding genes and genetic science stems from a lack of understanding among the public (Asbury and Plomin 2013; Asbury 2015; Tabery 2015; Ritchie 2015). Mixed levels of understanding and misunderstanding are very likely to provoke a particularly high level of debate and disagreement.

Since this study was carried out, there has been a noticeable increase in research into the general public's perceptions of genetics. Genomics England notably have been conducting work to 'socialise the genome' as part of their 100,000 genomes project (Parry & Middleton, 2017). Their work has found that members of the public tend to be unsure and confused when it comes to conversations about the genome. They also highlight the lack of professional consensus when it comes to how best to disseminate information about genetics to the public (Parry & Middleton, 2017). Despite this, they stress the urgent need for better public understanding and education. Although their work focuses on understanding of the genome in general, rather than behavioral genetics per se, their findings and indeed their goals clearly reflect the same conversation that is happening with behavioural genetics and the general public's understanding.

Taking a very different slant and looking at the public's perceptions of genetics through sociology, another recent study by Schneider, Smith & Hibbing (2018) offers an interesting insight. Their more political and social slant challenged the notion that public acceptance of genetics equates to 'intolerance, prejudice, and the legitimation of social inequities and laissez-faire policies' (Schneider, Smith & Hibbing, 2018). They found that in the US, liberals were more likely to suggest genetic attributions and that this was actually associated with higher levels of tolerance towards those who may be genetically vulnerable (Schneider, Smith & Hibbing, 2018). This study is particularly interesting as they asked the general public to comment on intelligence and genetic attribution. The mean attribution for intelligence was 56.12% genetics, 20.39% environmental factors and 23.50% personal choice. Genetic attributions across a range of traits from being deeply religious to height ranged from a mean attribution of 8.42% to 88.52% (Schneider, Smith & Hibbing, 2018), showing that the American public were fairly on the fence with intelligence and were actually relatively accurate considering known heritability estimates for cognitive ability (Haworth et al., 2009). This study gives a comprehensive overview of the general public's perceptions and attitudes towards genetics. However, as mentioned, the fact that it was conducted in another country means that the cultural, political and social differences make it difficult to say if such findings would be reflected in a UK sample.

Another recent international study to emerge following the publication of this study, this time in the Brazilian context, looked to explore the perceptions and attitudes towards genetics amongst young adults (Carver, Castéra, Gericke, Evangelista & El-Hani, 2017). They used and tested the Public Understanding and Attitudes towards Genetics and Genomics (PUGGS) questionnaire to explore college students' knowledge about genetics and genomics, beliefs in genetic determinism and attitudes towards modern genomic technology (Carver, Castéra, Gericke, Evangelista & El-Hani, 2017). However, their main aim was to test the validity of the PUGGS questionnaire. This meant that little of note was discussed regarding what young adults thought but rather focus was placed on the findings that overall the PUGGS questionnaire was a reliable tool for exploring public understanding of genetics (Carver, Castéra, Gericke, Evangelista & El-Hani, 2017). The PUGGS questionnaire offers a valid, if somewhat lengthy, method and measure for conducting further work into public attitudes. The testing and refining of this measure hopefully means that more research in this area will emerge soon.

The current study was designed to explore reactions to Cummings' views as presented in the *Guardian* article, regardless of whether his views were represented accurately, with a view to shining a light on the attitudes and beliefs of a section of UK society more than 15 years on from the Human Genetics Commission (2001) report, and more than a decade on from Walker and Plomin (2005) study of teacher and parent beliefs. It is clear from the number of reader comments that Cummings' opinions sparked a great deal of debate among members of the public. The strongly worded and somewhat inflammatory reporting of his comments makes it an ideal case for an exploratory study of public attitudes to consideration of genetics in education. It is worth noting, in considering readers' comments, that it was clear that only a small number of commenters had actually read the original thesis by Dominic Cummings. There is also little evidence that many were familiar with the studies on which his comments were based.

Research questions:

This study was designed to address three main research questions:

1. To what extent did readers' comments support or oppose Cummings' reported opinions?

2. To what extent was there disagreement/agreement among the readers' comments?

3. Were objections to Cummings' reported comments about genes more common than objections to his reported views about teacher quality, quality of higher education and wasted government initiatives?

Hypotheses were as follows:

1. The majority of commenters will disagree with Cummings' reported comments on all educational topics covered in the article.

This hypothesis is based on the fact that the newspaper (The Guardian) is politically left-leaning and the advisor is associated with a right-wing political party (The Conservatives). Moreover, the reporting of the antagonistic nature of the advisors' comments was likely to prompt comments from those with strong adversarial reactions who wished to air their views.

2. Most commenters will disagree with Cummings' comments on genetics in particular. This hypothesis is based on literature detailing the somewhat controversial nature of discussing the relationship between genes and school outcomes (e.g. Tabery 2015). It is also based on the fact that twin study research paints a much more complex picture of the topic than is evident from the article.

3. There will be evidence of much debate and disagreement between commenters across all topics (genetics, teacher quality, weakness of higher education and usefulness of government initiatives). This is likely because of the diversity of the sample (the opportunity to comment was open to all members of the general public) and the range of different perspectives, knowledge bases and viewpoints likely to be represented.

Overall, the aim of this study was to provide new insight into spontaneous public reactions to the idea of embracing genetics as a relevant consideration in the planning and delivery of education. At a time when genetic research into factors such as intelligence and educational attainment is gathering pace, at both the behavioural and the molecular level, (Benyamin et al. 2013; Kirkpatrick et al. 2014; Knapton 2015; Okbay et al. 2016) it is important to understand how the public feels as a foundation for planning society's response to these scientific developments. It is also important to try to understand whether the accuracy and tone of the reporting affects readers' responses as this has important implications for science communication.

4.2 Method

A content analysis of readers' comments on the online article was conducted. Content analysis is the method most widely and successfully used for analysing documents and online content (Bryman 2012; Liamputtong 2013) and has the benefit of providing a basis for future longitudinal analysis. Should a similar article emerge in the future it could be easily analysed using a very similar coding scheme and the results directly compared. The opportunity to assess whether attitudes change over time would be valuable.

A systematic sampling technique was used in which the first 100 comments from every 3rd page as listed below the article in the comments section (comments pages 1, 4, 7, 10 and 13) were copied and pasted into a chart with each comment being assigned an identification number. It was subsequently decided to bolster the sample through the inclusion of a further 75 comments from each of pages 2, 5, 8 and 11 in order to create a final sample of $n = 800$ comments. Inclusion of the 300 comments on pages 2, 5, 8 and 11 meant that results could be accepted with a 99% confidence interval of 4.0. A confidence interval of 4.0 implies, for example, that if 50% of commenters said they disagreed with Cummings the researchers could be 99% certain that in the true population 46–54% of people would disagree with Cummings.

Prior to analysis a coding framework was developed. The decision to include particular codes was driven by the primary purpose of the study–to take the opportunity to gain an insight into the general public's perceptions of genetics in education. A deductive approach was therefore taken in line with this specific focus.

In order to be able to compare the amount of discussion of genetics with other topics also raised in the article it was necessary to include codes relating to all of the main themes mentioned (government initiatives, higher education and teaching quality). In order to be able to gauge the amount of discussion and debate that occurred between participants, to help gauge the relative level of controversy surrounding genetics, codes for comments between participants on relevant topics were also necessary. A final group of organisational codes was created to help the research team to gain a sense of comments that were not directly relevant to the research aims.

After a small amount of alteration and the addition of two new codes ('User makes a comment that makes reference to Nazi Germany, Hitler or WW2' and 'Comment that corrects factual or grammatical point but expresses no individual opinion') that emerged after coding began, the final list of codes was established and is shown in Table 4.1.

Table 4.1. *Full list of codes identified within the readers' comments.*

Comments directly related to article and the advisor's comments:	
Code number	Code title
2	Comments opposing Cummings in the article overall
3	Comments supporting Cummings in the article overall
4	Comments opposing advisor's comments on genetics
5	Comments supporting advisor's comments on genetics
6	Comments opposing advisor's comments on teaching quality
7	Comments supporting advisor's comments on teaching quality
8	Comments opposing advisor's comments on quality of higher education
9	Comments supporting advisor's comments on quality of higher education
10	Comments opposing advisor's comments on government initiatives
11	Comments supporting advisor's comments on government initiatives
Comments between participants (threads) on the comments section:	
12	Comments opposing another user who supports the advisor's comments
13	Comments opposing another user who opposes the advisor's comments
14	Comments supporting another user who supports the advisor's comments
15	Comments supporting another user who opposed the advisor's comments
16	Comments supporting a comment that promotes advisor's genetics view
17	Comments supporting a comment that opposes advisor's genetics view
18	Comments opposing a comment that promotes advisor's genetics view
19	Comments opposing a comment that opposes advisor's genetics view
Additional codes	
20	User makes criticism of government in general (beyond just Education)
21	User makes a comment that makes any reference to Nazi Germany, Hitler or WW2
22	User makes a troll (In internet slang, a troll is a person who promoted disagreement on the internet by starting arguments or upsetting people. They may also post inflammatory or irrelevant messages) comment or any form of personal attack (looks, background, ethnicity, sexual orientation .etc. This includes comments about the appearance of Cummings or government members)
23	User makes a completely unrelated comment to the article content or another user's comments
24	Comment that corrects factual or grammatical point but expresses no individual opinion.

Once the coding framework was established a single researcher carefully read and coded each individual reader comment. Every comment was also assigned a code showing whether it was an original comment directed at the article or a thread (i.e. a comment directed at another user's comment). On the whole, comments tended to fit into at least two coding categories.

Once the first researcher had assigned codes to all of the 800 comments sampled, it was necessary to check that coding was reliable. A second researcher coded a proportion of the data for the purpose of checking inter-rater reliability. This researcher read the original source (the online news article) and discussed it with the first researcher in order to become familiar with the context. The coding framework was then introduced and the researcher was asked to focus on coding comments for the nine most salient codes, those relating directly to the research questions (i.e. not organisational codes). Ten percent of the sample (n=80 comments) was coded independently in this way and both coders' decisions were entered into SPSS in order to assess inter-rater reliability.

During the data entry process a very small number of edits (n = 8) to the original coding were made, based on differences between coders. This reconciliation and reflection stage (Hruschka et al. 2004) allowed the original coder the opportunity to reassess a small number of original judgments in light of disagreement, and to make adjustments where appropriate. This resulted in an overall percentage change in the final results for only one code (21-User makes a comment that makes any reference to Nazi Germany, Hitler or WW2). Cohen's Kappa was used as the statistical test of inter-rater reliability. Each of the nine codes was analysed individually to assess the Kappa score. On the whole, based on parameters established in the literature, results suggested agreement was 'good' or 'very good' (McHugh 2012). However, one test suggested only 'fair' agreement and another was not possible to conduct as there was not enough variance in the codes (the code was judged as not being present in almost the entire sample). However, overall there was an acceptable level of inter-rater reliability (Table 4.2).

Table 4.2. *Kappa figures for codes used for the inter-rater reliability process*

Inter-rater code	**Measure of agreement - Kappa**
Comments opposing Cummings in the article	0.26
Comments supporting Cummings in the article	1
Comments opposing advisor's comments on genetics	0.735
Comments supporting advisor's comments on genetics	0.627
Comments supporting a comment that promotes the advisor's genetics view	No codes present in sample
Comments supporting a comment that opposes advisor's genetics view	0.64
Comments opposing a comment that promotes advisor's genetics view	0.794
Comments opposing a comment that opposes advisor's genetics view	0.82
Reader makes Nazi reference	0.874

Table 4.3 provides an example of some of the more frequently occurring codes and how they were defined. A number of typical examples have been shown to illustrate the nature of the comments that were sorted into the different coding categories.

Table 4.3. *Examples of deductive codes and operational definitions*

Code	Operational Definition	Example
Comments opposing the article overall	The overall tone of the comment suggests general disagreement with the advisor – may not be specific.	'Clearly this man has no idea what he is talking about. There is no evidence whatsoever. Quite frankly he is full of crisp…'
Comments supporting the article overall	The overall tone of the comment suggests general agreement with the advisor – may not be specific.	'The first few pages are not drivel [referring to the original thesis]. They discuss the importance and difficulty of managing complex organisations, and the idea of Odyssean education is interesting, at the very least.'
Comments opposing advisor's comments on genetics	Makes direct reference to the genetic content of the article and expresses a disagreement towards it.	'The idea that genetics plays a role in intelligence, is a dangerous ideology that can be used to afford false weight to elitist class discrimination, and ideas of superiority of certain genetically related groups…'
Comments opposing a comment that promotes advisor's genetics view	Thread – one commenter disagrees with another commenter who has displayed support for the advisor's views on genetics.	' ''Genetics plays a role in intelligence'' – ''An inconvenient truth for Guardian readers''. Why? I don't see this at all. The 'left' want fair chances for all – dim or geniuses…'
User makes criticism of government in general	Shows a general disagreement towards the Coalition government beyond the advisor's reported opinions.	'They're heading towards an extremely dark place at an incredible pace and they're dragging this country along for the ride.'
User makes a comments that makes any reference to Nazi Germany	Makes any reference, positive or negative, that is related to the Nazi genetics movement.	'Genetics doesn't play a Role, it's a myth that Black athletes are better at some sports than Whites, we're all EXACTLY equal, unt any von who diasagrees vis me ist eine racist and should be put in ze koncentrstion camp unt re educated.'

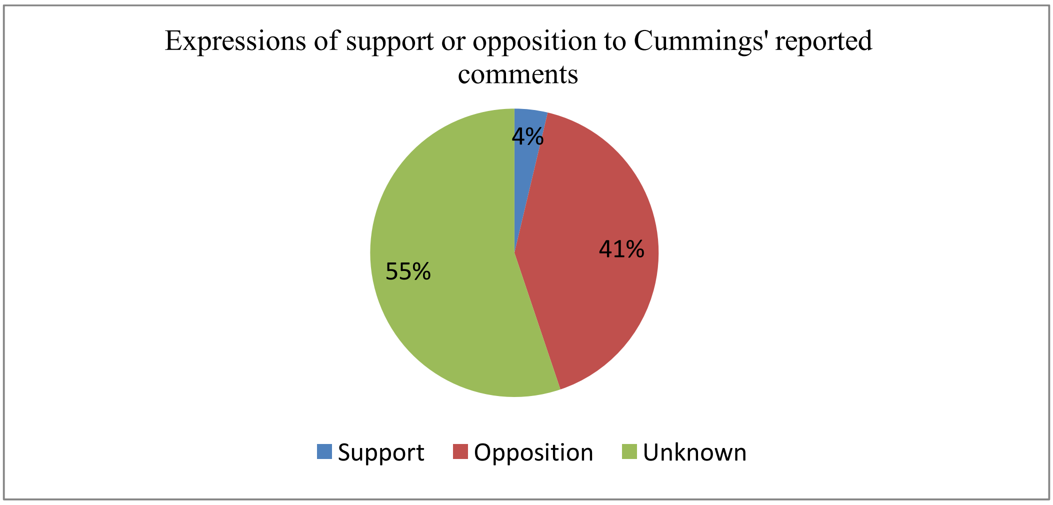
Once all 800 comments had been assigned code/codes then descriptive univariate analyses were conducted to provide a clear picture of the distribution of opinions/attitudes and the overall frequency of particularly strong views such as Nazi-related comments. Overall, analysis focused on the nature of original threads, and on the amount of agreement/disagreement within and between reader comments.

4.3 Results

Within the sample there was an almost equal split between comments that were original comments directed at the article (52%) and comments that were threads (48%), that is, comments directed at another comment. It was found that 34% of reader comments in the sample contained unrelated information (troll, personal attack or unrelated) or were grammar/fact corrections that expressed no relevant opinion. It is important to bear this in mind as it is the remaining 66% of reader comments (*n* = 528) that are of real interest and relevance to the current study.

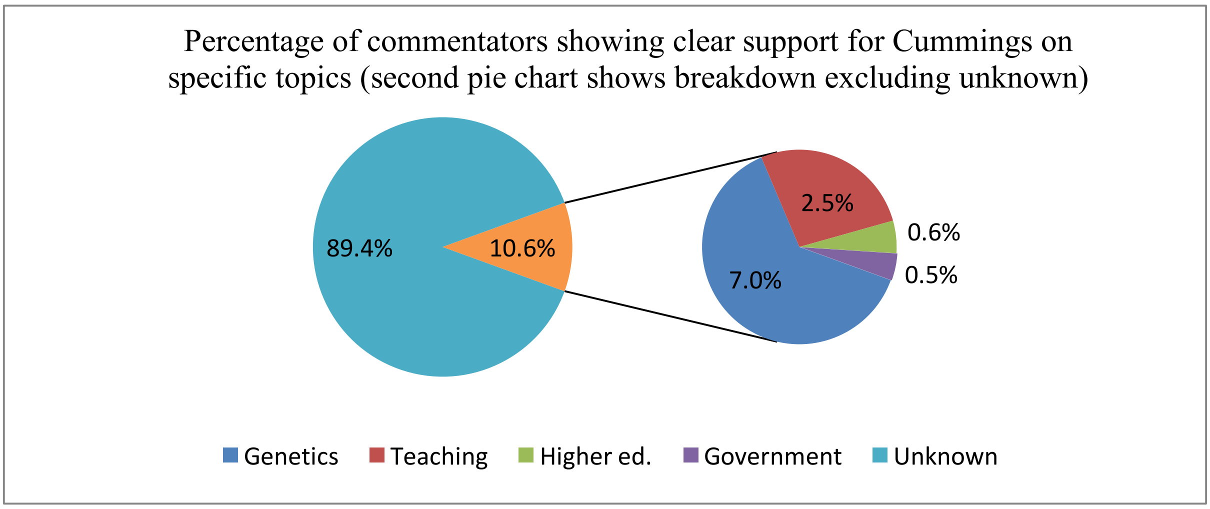
Looking at comments made generally by readers about the article, that is, not linked to one of the specific topics analysed–frequency analysis showed that 41% of reader comments expressed clear opposition to Cummings' general position as portrayed in the article, and only 4% showed clear support for his overall position as portrayed in the article. The remaining 55% of sampled commenters did not express anything that would allow a conclusion to be drawn as to whether they supported or opposed the overall tone and content of the article (see Figure 4.1 below).

Figure 4.1. Overall distribution of support or opposition to Cummings' reported comments



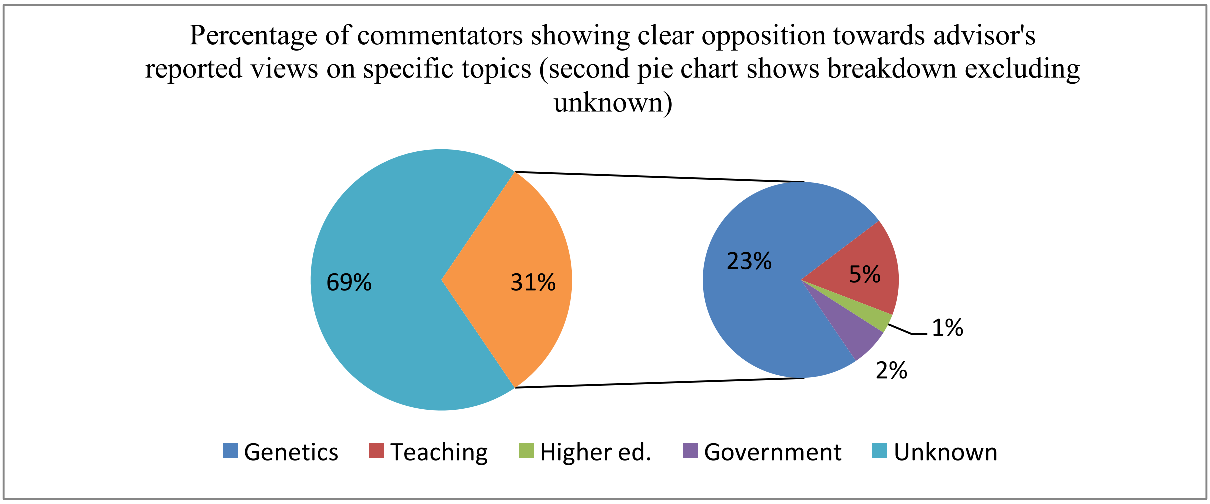
Looking specifically at the amount of support/opposition for Cummings' views on the individual topics covered by the article (genetics, teaching quality, standards of higher education and government initiatives), results showed a clear focus on genetics as the 'hottest' topic of discussion among reader comments. Overall, however, 89.4% of sampled comments (*n* = 715) did not clearly express support for Cumming's reported view on any topic. This left 10.6% (*n* = 85 comments) which expressed specific support for his view, as presented in the article, on at least one topic. We see that genetics received the most comments with 7% (*n*=56) of the overall sample specifically supporting Cummings' reported views. His views on teaching quality generated 20 comments (2.5% of sample) showing support for his position. His view on government initiatives generated only four supportive comments (0.5% of sample) and on higher education just 5 (0.6% of sample). It is worth noting that overall support for the general content and tone of the article and specific support for a particular topic were coded separately. It was possible for a commenter to agree with Cummings on an individual topic but to express overall disagreement with his position, and vice versa (Figure 4.2).

Figure 4.2. Distribution of support towards Cummings on the specific topics presented in the article – percentages in the pie of pie show proportion of overall comments that showed clear support for specific topics.



The proportion of those agreeing with Cummings' reported views on genetics was double that of the second most supported topic–teaching quality. A similar pattern was seen in comments which expressed clear opposition to Cummings' reported view on one of these topics. Percentage breakdowns regarding expressed opposition to Cummings' reported views are displayed in Figure 4.3. Overall 69% (n = 552 comments) did not clearly express opposition to a particular topic mentioned in the article. This left 31% (n = 248 comments) which specifically opposed one or more of Cummings' specific views. Once again we see that genetics received the most comments with 23% of the sample (n = 184 comments) specifically opposing his reported views on genetics. Teaching quality received 5% (n = 40) of overall comments showing clear opposition towards Cummings' reported views, government initiative opposition only 2% (*n* = 16) and higher education just 1% *(n* = 8). It is clear that Cummings' reported views generated more opposition than they did support.

Figure 4.3. Distribution of opposition towards Cummings on the specific topics presented in the article – percentages in pie chart show proportion of overall comments that showed clear opposition for specific topics.



The next step was to look at the amount of agreement and disagreement between reader comments, that is, in threads in which readers responded to each other's' views rather than directly to the article. For this purpose, two codes for agreement and two codes for disagreement were combined. Commenters that either agreed with other commenters who expressed support for Cummings' views, or disagreed with commenters expressing disagreement, were combined and coded as being 'in agreement' with Cummings. Conversely, commenters that either agreed with others who expressed disagreement with Cummings, or disagreed with supportive comments, were coded as 'disagreeing' with Cummings' view. On this basis, 10% of threads suggested overall opposition to the article and 3.3% suggested overall support (Table 4.4).

Table 4.4. *Demonstration of support/opposition towards the advisor's comments on genetics through agreement/disagreement between users in threads.*

Code	Present (%)	Not Present (%)	Overall support (%)
Comments supporting a comment that promotes advisor's genetics view	0.3	99.7	3.3
Comments opposing a comments that opposes advisor's genetics view	3	97	
			Overall opposition (%)
Comments supporting a comment that opposes advisor's genetics view	5	95	10
Comments opposing a comment that promotes advisor's genetics view	5	95	

An example of a thread in which a commenter disagreed with a previous commenter who, in turn, had disagreed with Cummings' reported view is shown here for illustrative purposes:

Original comment: *'Ridiculous, genetics may be a starting point but anyone (except those with brain damage/seriously disabled) can become as good as someone else if they have the proper opportunities and try hard.'*

Response on thread: *'Think about the people you have met over the years. Is this really true?'*

Finally, it is worth noting that 6.8% of reader comments (n = 54) made a clear reference to Nazis or eugenics in their response to the article. On the whole these references suggested that Cummings' reported views about genetics in education were comparable to Nazi ideology. For example:

'In the 30's they called this Eugenics, and it was part of the nazi education. Oooops'

'Yes it seems to be verging more than a little into 'master race' territory.'

A number of these references appeared to be made sarcastically, but these too insinuated the same concern. For example:

'Aaah. The joy of facism, They'll be doing experiments on the untermensch [German term for someone considered racially or socially inferior] soon....As if they're not already'.

A tiny handful of references to Nazis however, did explicitly challenge the comparison of Cummings to Nazis/Hitler. For instance:

'Genetics plays a role in intelligence. How on earth can anyone deny that this is the case? Accepting this as scientifically probable doesn't mean you are a member of the Nazi Party. An uncomfortable truth but a truth nonetheless.'

On the whole, of the 54 reader comments making an explicit reference to Nazis Hitler, WW2 or eugenics (6.8% of full sample) almost all did so as a criticism of Cummings, or an expression of fear. The shadow of eugenics remains clear.

4.4 Discussion

The results of this content analysis clearly indicate that even when included as just one of a range of potentially controversial educational topics, genetics evokes a disproportionate amount of debate, as argued by others (Asbury and Plomin 2013; Tabery 2015). This supports the study's third hypothesis that there would be a great deal of debate and disagreement among reader comments about Cummings' opinions as presented in the article. Both our first and second hypotheses, that most people would disagree with Cummings and that his comments regarding genetics would generate a particularly high amount of disagreement, were also supported. Genetics did prove to be the topic that most people specifically disagreed with. However, it is interesting to note that it was also the topic that Cummings received the most support on.

These findings mirror the findings of Condit (2001) who, having reviewed the literature on public perceptions of genetics, found no clear viewpoint but rather a mix of opinions. The fact that genetics was the most discussed of all topics presented in the article may be due, to some extent, to the inclusion of genetics – in a particularly provocative way – in the headline. However, in order to comment in a meaningful manner, at least a glance at the whole article would be necessary. The article itself contained a total of ten paragraphs of which only two talked specifically about Cummings' views on genetics in education. Moreover, these two paragraphs did not appear until near the very end of the article. This shows that even when discussed in the midst of other important topics, genetics remained a key focus of discussion and debate relative to the other topics discussed.

From the limited literature on public perspectives on genetics in education, the current findings make sense. A lack of knowledge and understanding can contribute to reasonable feelings of hostility towards a complex and historically tarnished subject like genetics (Tabery 2015). Moreover, Walker and Plomin (2005) found that most teachers and parents see genes as just half of the explanation for individual differences in educationally relevant behaviour (this was also found in the Human Genetics Commission survey 2001), so when Cummings was reported as saying that genes are substantially more important than environment, disagreement was likely.

This disagreement was likely further inflamed by the fact such views from a right wing political advisor were presented in a left leaning newspaper. For many, the suggestion that teachers and schools may not be highly influential is a hard concept to swallow. It could suggest (mistakenly) that we have little control over our destinies and that we are unable to influence the future of society's children even via education which is our biggest and most expensive social intervention. Over-simplified and misleading reporting of Cummings' message is likely to have exacerbated this commonly perpetrated misconception and generated further opposition. Results from behavioural genetic studies show that genes are rarely deterministic and that heritability does not imply immutability. Nor is it ever suggested that the environment does not have a vitally important role to play in education (Asbury and Plomin 2013). Genes work through environments and it is often difficult to disentangle their effects. However, the evidence for the effects of both is undeniable. It is complexities such as these that both Cummings and *The Guardian* failed to properly make clear, and this may have been a contributory factor in some of the negative reactions the article received. Combine this with the fact that for many genetics, particularly in the context of intelligence, can evoke associations with darker elements of genetics from the past. It's reasonable that the public, including teachers, hesitate in embracing genetics when it has played a part in historic atrocities.

Perhaps, a more balanced portrayal of the evidence, with an emphasis on the fact that heritability is a population statistic and does not imply a lack of malleability, may have generated a positive or open reaction from those who (with good reason) fear a link between genetic determinism and discrimination. In this article we see a prime example of over-simplification of science leading to hostility from the general public and potentially exacerbating preexisting misconceptions, particularly in a field such as education which the majority of the British public value and place great importance on. Such mistakes must be avoided when entering a dialogue with teachers. We perhaps also see the damage that can be done by having newspaper headlines written to be attention grabbing rather than to accurately represent the content of the article.

The high number of comments (and threads) generated by this article illustrates the amount of discussion and debate that this article generated. For comparison, a related article that subsequently appeared in the *Guardian*, also talking about the role of genetics in education with the word 'genes' in the headline but from a pro-nurture stance, received only n = 763 comments (James 2016). It is advocating the influence of nature that appears to provoke particularly high levels of debate. Many threads under the Cummings article were made up of numerous commenters going back and forth in their discussions. This suggests that genetics in education is of particular interest and importance to the general public as found in previous literature (Condit 2001; Human Genetics Commission 2001).

It was also interesting to note the occurrence of reader comments related to Nazis, Hitler and eugenics. On the whole these were used as an expression of disagreement or anger at Cummings' comments on genetics in education. Although these reader comments demonstrate the strength of disagreement and anger felt by some readers they perhaps also suggest a misunderstanding or lack of knowledge of the difference between the suggestion that genetics plays an important role in learning abilities and achievement (as suggested by Cummings) and the misuse and abuse of genetics for harm by the Nazis. This lack of knowledge, prevalence of misunderstanding, hostility and fear around genetics was one of the key points to emerge from the literature (Condit 2001, 2010; Etchegary et al. 2013; Asbury and Plomin 2013; Asbury 2015; Tabery 2015) so it is valuable to see it demonstrated clearly in such a public arena. However, these associations with eugenics and Nazis, even if misplaced in this specific instance, shouldn't simply be brushed away. We must remember that genetics has historically not always been used for good and that advances in the technology must come hand in hand with careful consideration of ethics. It is worth remembering that Cummings' comments on the role of genetics are largely based on reliable scientific evidence (even if somewhat inflated by the reporting in this article) and are not in any sense extreme or unsubstantiated views. This negative association with Nazis and eugenics in a notable minority of reader comments is reasonable and suggests that geneticists may have a significant public engagement challenge that needs to be addressed if the public are to embrace their science in the context of education and understand it's uses for good. However, it is also worth noting that some of the reactions within the article may have been politically rather than scientifically motivated and there remains a need for further research to establish the true nature of public understanding and misunderstanding of genetics.

Limitations

Due to the politically partisan nature of the newspaper in which the article was published, and some emotive and misleading reporting, the generalisability of these findings is limited. It could be argued (with the advisor working for a right wing party) that such hostile reactions were to be expected. Although this must be taken into account it remains unknown what sort of reaction might be received in another newspaper. Given the divisive nature of the topic it seems likely that, even if Cummings' comments been reported in a right wing newspaper, reactions would have been mixed. It would be interesting to test this hypothesis in future research with a relevant article.

We cannot say that the views represented in the sample are those of the UK population at large but they do represent a snapshot of how a large (self-selecting) sample of the general public reacted to a story suggesting a deterministic view of genetics in education. The inclusion of the misconstrued statement that 'genetics outweighs teaching' is also likely to have drawn commentators who had a specific interest in the role of genetics in education or a vested interested in teaching.

Future research

Directions for future research could involve a comparative analysis of reader comments from related sources. For instance, analysis of a similar article in a more right-wing newspaper could provide a valuable insight into potential differences in public opinion based on political allegiance. Analysis of an article in favour of environmental determinism in a left-leaning paper could also prove interesting and the James (2016) article cited earlier could be a good candidate for this. Moreover, the method of comments analysis used is well suited to longitudinal analyses and analysis such as the one reported in this paper could easily be repeated over time in response to the emergence of new articles relating to behavioural genetics in education. This could be a useful and interesting way of documenting stability and change in public perceptions as this science advances.

Overall, findings from this study contribute to the currently limited picture of how the general public feels about the potential application of genetics in an educational context. The data suggest that, as predicted, this topic evokes particularly strong feelings and that at least some opposition may be based on misunderstanding. More commenters disagreed than agreed with the views expressed by Cummings. This is in spite of the empirical evidence supporting the notion that genes play a substantial role in explaining individual differences in academic achievement (</=50%) and that, although environmental factors (and measurement error) explain all of the remaining variance, teaching is just one aspect of the child's environment that also includes society, school, home and even prenatal environments (Turkheimer 2000; Kovas et al. 2007; Plomin and Deary 2014). Hostility and misunderstanding needs to be addressed effectively by researchers in behavioural genetics, particularly those who hope their research could have a positive impact on education. In this sense, it is hoped that the current study can provide some useful insight for those wishing to spread their research and findings beyond the scientific community to the general public.

In addition, it is important to identify and understand teacher views of genetics, as primary agents in education. The remainder of this thesis is therefore focused specifically on the knowledge and beliefs of this particular group. ***Link to full paper available in Appendix.***

5. What do teachers know and believe about the role of genetics in education?: General Methodology

5.1 Introduction and research questions

Behavioural geneticists study the aetiology of individual differences in human behaviour and have claimed that this research is relevant to teaching and learning in schools (Asbury & Plomin, 2013; Kovas, Malykh & Gaysina, 2016).While a large body of robust and well replicated evidence supports the idea that educationally-relevant behaviour has both genetic and environmental roots (Kovas et al., 2007; Krapohl, Rimfeld et al., 2014; Polderman et al., 2015) much less is known about teachers' knowledge, beliefs and understanding of this evidence-base, and its relevance in a real world setting such as a school or a classroom. The major exception to this was published over a decade ago, as outlined in previous chapters (Walker & Plomin, 2005).

It is important to note that the science of genetics, particularly molecular genetics, has advanced rapidly since 2005 and genetics has become a more prominent topic for discussion in education over the same time period (Asbury & Plomin, 2013; Plucker and Shelton, 2015; Lee et al., 2018; Yong, 2018). This raises the question of whether Walker and Plomin's (2005) findings still hold true today, in light of new findings and more public discussion occurring both before and after data collection for this project. Furthermore, in the Walker & Plomin (2005) study only primary school teachers were surveyed, leaving a gap in our knowledge of UK secondary school teachers' beliefs about genetics.

Research questions:

1. What attitudes towards, and perceptions of, behavioural genetic research into cognitive ability do teachers in the UK have?
2. How growth minded are UK teachers?
3. Do teachers in the UK have a good factual knowledge of behavioural genetics?

4. Do beliefs, attitudes and knowledge vary according to factors including gender, age, years of teaching experience, age of pupils taught, state vs. independent, subject taught, geographical location, or SENCO role?
5. How open are teachers in the UK to applying findings from behavioural genetics in education now and in the future?
6. Are perceptions of the relative influence of nature and nurture, mindset, openness to genetic research in education (OGRE) and knowledge about the genetics of cognitive ability associated with, or predictive of, each other?

5.2 Participants

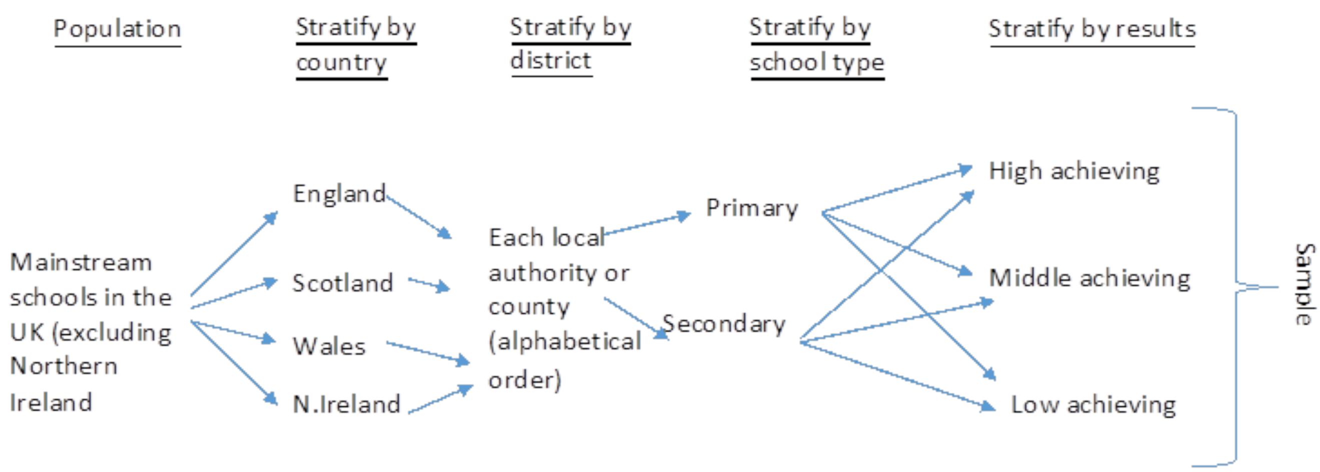
Target population

The population for this study was comprised of all full and part-time teachers in the UK. Teachers at primary, secondary, state and independent schools of all types were considered to be members of this population of UK teachers. However, there were some exclusions - special schools and pupil referral units. The original plan was to include special schools but this was revised for two main reasons. The first was that, on reflection, it was felt that the children taught in special schools, and the experiences of the teachers working there, may not be representative of the mainstream teaching population. In most special schools, due to a drive to integrate as many children as possible into the mainstream, only children with particularly severe cognitive or physical impairments are taught. It was decided that the research instrument and the research aims were not developed with special schools in mind and, as such, including teachers in these schools was not in fact appropriate. The second, more minor, reason was related to the sampling strategy. Special schools tend not to be part of school league tables or ranking systems, making it more difficult to include them in the sampling frame. The same was true of pupil referral units. They did not appear on the same table as mainstream schools and it was likely that the teaching population within these schools came with a much more unique set of experiences and opinions in comparison to mainstream teachers. However, it is worth noting that a very small number of mainstream schools contacted had special needs facilities within the school. As such, the questionnaire may possibly have been answered by teachers who focused solely on special needs. For this reason, the option of saying they taught in a special school on one of the demographic questions was left in the questionnaire. However, no wholly special schools or pupil referral units were contacted, although whether teachers in special schools significantly differ in their opinions about genetics in comparison to mainstream school teachers is addressed by a subsequent study presented in Chapter 9.

Sampling strategy

Once this population had been identified, a sampling strategy was designed to collect data in a way that would adequately represent the population. A systematic stratified random sampling technique was used in the hope that it would allow all schools and teachers an equal chance of being invited to take part in the study and would therefore capture the full diversity of the population. The sampling strategy can be seen in Figure 5.1.

Figure 5.1. Stratified sampling diagram



In order to create a sampling frame a number of resources were used. These differed for primary school and secondary schools, as well as for England, Scotland, Wales and Northern Ireland. This was due to the public data available which differs between the four countries. As closely as possible, the sampling frame was based around the idea that for each local authority, a high, middle and low (HA, MA and LA) achieving school would be contacted both at primary and secondary level in the first wave of data collection. In England, this was straightforward due to the availability of league tables. Primary schools were assigned a high, middle or low ranking place on the sampling frame based on 2015 data of average point scores in reading, writing and maths at the end of primary school. However, the data changed in December 2015 to be updated with 2016 results, unfortunately, this meant the same 2015 data was no longer available and the average point score had changed to the percentage of pupils meeting the expected standards in reading, writing and maths. However, overall, schools remained in roughly the same categories of high, middle and low achieving as they had done previously. Therefore, it was felt this would not significantly disrupt the sampling technique. For secondary schools in England, it was based on the percentage of children achieving 5+ A*-C GCSEs including English and maths in 2015.

Scotland and Northern Ireland differed in that they have no formal league tables in primary school. In order to select as randomly as possible three primary schools in each local authority were selected based on their alphabetical name, the first school alphabetically, then one around the middle point and one at the end of the alphabet. This was not ideal but in the absence of achievement data, this represented a fair and hopefully unbiased approach. For secondary schools in Scotland, more detailed data was available. Again, three schools from each local authority were chosen but they were based on the percentage of children in the school gaining 5+ Highers at A-C in 2015. As with England, a high, middle and low attaining school was chosen.

Wales also differed with a colour-coded system based on school performance and effectiveness. Once again, three schools from each county in Wales were contacted in the first wave of data collection, one from each colour group (green for effective school, amber/yellow for schools on their way to being effective and red for those schools with concern). For Wales 2016, data was used.

For schools in the independent or private sector a slightly different approach was necessary. Schools were still drawn from the UK but were not separated by country. A database of UK independent schools was provided by the ISC (Independent schools council). The same local authorities used for state schools were searched in this database and a preparatory school (primary school level) and a secondary school level independent school was chosen from each and invited to participate in the first wave of data collection. No performance data was used for independent schools because in many local authorities, there was in fact only one preparatory or senior independent school and, as such, there was only one school to contact. Secondly, independent schools are not constrained by the national curriculum or the same examination regulations, so results information is often incompatible or scarce. However, this strategy still allowed the independent school teacher population to be sampled systematically and randomly.

Once the first wave of data collection was completed a second wave began, based on exactly the same principles. This process was continued until a sufficient and representative sample of responses had been gathered.

Systematic random sampling is not without its flaws. In choosing to adopt systematic stratified random sampling researchers forfeit knowledge of the exact demographics of a teaching population in a school. Systematic random sampling is based on the assumption that by selecting participants in a coherent but random, unbiased way, one is more likely to develop an accurate and representative snapshot of the population under study (Bryman, 2012). However, this cannot be guaranteed. A random sample could potentially still be biased if, for example, a greater number of schools with religious affiliation or a greater number of grammar schools were included. Moreover, due to the anonymity of the participants, we cannot know exactly which schools responded and it might be that more teachers with a vested interest in the topic decide to take part. However, despite these limitations, this was the best way to sample the population while attempting to give all teachers in the population an equal chance of being invited to participate. Arguably, even if they chose not to take part, a representative sample of schools had the opportunity. Moreover, due to the initial demographic questions asked, we do have some insight into how representative our participants were of the teaching population nationwide. This specific participant information is presented in Chapter 7. This information gave us the capacity to bolster certain sections of the population where needed, for example rural schools or faith based schools. Once the main body of data collection had been completed, it was decided to bolster primary schools particularly those not in England, as these were the most underrepresented.

Online questionnaire

In order to gather data the online survey programme Qualtrics was used. This programme was recommended early on in the research process by academics who had undertaken similar studies successfully using it. Qualtrics allows you to build a user-friendly and flexible questionnaire that can include a range of response styles (e.g. multiple choice or Likert scales) and looks clean and professional when opened by a participant. It also records all responses anonymously and allows the researcher to monitor responses as they come in to allow assessment for any action that may need to be taken before data collection is finished – for example bolstering a certain sample demographic that may be falling short.

Using online survey tools to carry out research comes with a number of advantages such as accessibility to a large sample, ease of delivery and cost savings (Wright, 2006). It would be near impossible for a sole researcher to reach the target sample size in person, face-to-face, within the study timescale (Wright, 2006). Moreover, the use of postal questionnaires would represent a huge cost in terms of posting; funds which simply weren't available to the researcher. Aside from these logistical advantages, an online survey allows participants to be reassured of their anonymity and, in this way, hopefully reduces social desirability bias in responses (Bryman, 2012) as individuals can respond honestly in privacy. In terms of convenience to the participants, the survey could also be completed whenever was convenient for them, an important consideration with busy teachers.

However, using an online survey to carry out research is also not without its disadvantages. Perhaps the major disadvantage is the inability to chase up non-responders and identify individual schools and teachers who have not responded (Payne and Barnfather, 2012). This is compounded by a potential self-selection bias by which only those with a particular interest in the survey will respond

(Wright, 2005; Payne and Barnfather, 2012). Yet this issue would likely not be unique to an online method and in some ways, the concern is outweighed by guaranteed anonymity to participants.

In the current study, a further minor issue arose in relation to accessibility to the sample. It was only possible to contact schools to distribute the questionnaire to their staff if they had their email accessible in the public domain. In a small minority of cases, the school's email address could not be located and as such, they could not be contacted online to take part. However, such schools made up only a tiny percentage of the population and there is no reason to think that a similar problem would not arise with other techniques, had an address or telephone number been relied upon.

Overall, it was felt that Qualtrics and online survey/questionnaire collection was a well trialled and sufficiently robust method that its use was justified for this study. No data collection method is without its disadvantages and it was felt that, as a solo researcher, online survey tools and data collection offered the most efficient and realistic method of collecting a large number of anonymous responses from a geographically diverse population.

5.3 Measures

A research instrument was developed which included a combination of existing scales and some that were developed specifically for the current study.

Demographic Information

Items relating to the demographic characteristics of the participants were included as a means of checking the extent to which our sample adequately represented the UK teaching population. These items were also included as grouping variables to allow for comparison of responses from primary versus secondary teachers; state versus independent teachers; male versus female teachers. Nine items asked participants to report their gender, age, years employed as a teacher, primary or secondary school teacher, type of school, school location (urban or rural), geographical area, majority subject and whether or not they held a SENCO role within their school.

The relative influence of nature and nurture

Teachers' beliefs about the relative influence of nature and nurture were measured using a single item, with a follow up question. This item, which was used in a previous study by the researcher (Crosswaite, 2013), closely mirrors one used in a related published study (Walker and Plomin, 2005). Participants were asked to what extent they believe that cognitive ability is influenced by nature (genes) or nurture (environment). They were asked to respond using a 5-point scale in which: 1= all environment, 2=mostly environment, 3=even split between genes and environment, 4=mostly genes and 5=all genes. Inclusion of this measure in the current study allowed us to explore how results compare with those found in previous research. This single item was followed with a question asking whether participants believe the balance of nature/nurture influence changes over time. Participants selected 'definitely yes' through to 'definitely not' on a four point Likert scale and were then asked about what they saw as the direction of change (if any) - genes becoming more important, environment becoming more important, constantly changing balance or unsure of the relationship. These follow-up items were included in the pilot study but were subsequently dropped (as discussed below in Chapter 6).

Mindset

'Mindset' is a construct that suggests that individuals have either an entity theory of intelligence or an incremental theory of intelligence (Butler, 2000; Jonsson, Beach, Korp and Erlandson, 2012). As described in Chapter 2, an entity theorist believes that individuals have a fixed level of intelligence that is open to little manipulation. By contrast, incremental theorists champion the idea that an individual's intelligence is malleable and can change and adapt over time (Jonsson, Beach, Korp, Erlandson; 2012). These two theories of intelligence have been found to affect how an individual perceives their own ability to learn (Dweck, 1999) but also their beliefs about the ability of others to learn and grow (Gutshall, 2016). This is clearly relevant when considering the role of teachers' attitudes and beliefs and their impact on children's learning. It was also felt that the inclusion of this well validated study, would add an extra dimension to the current study. Offering an insight into how changeable teachers' feel cognitive ability is. It was simple to add, being a ready-made measure, and it was felt it was closely tied to the main study aims so should be included.

In this study, mindset was measured using a published scale made up of six statements to which participants responded using a 6 point Likert scale (Dweck, 1999). These items were then combined in a composite measure of mindset. The six items were as follows:

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. No matter who you are, you can significantly change your intelligence level.
4. To be honest, you can't really change how intelligent you are.
5. You can always substantially change how intelligent you are.
6. You can learn new things, but you can't really change your basic intelligence.

Respondents are asked to select a level of agreement or disagreement with these statements. This scale has been used in other studies which have supported its validity and reliability (α= .94 to .98) (Blackwell, Trzesniewski, & Dweck, 2007; Jonsson, Beach, Korp and Erlandson, 2012). In this sample the reliability was high (α= .94). In this study so as to not disrupt the analysis, those cases where missing data was present were excluded. Participants must have answered at least 4 out of the 6 questions to be included in this composite measure.

Knowledge about Behavioural Genetics

A new measure was developed to explore teachers' factual knowledge of behavioural genetics. This was developed on the basis of a recent paper entitled 'Top 10 replicated findings from behavioural genetics' (Plomin, DeFries,Knopik and Neiderhiser, 2016). The summary of key findings in this paper represents the most up to date and rigorous summary of knowledge available to us with which to 'test' teachers. Some statements from the paper were re-worded in lay terms and terminology was explained as necessary. For example, ‘Phenotypic correlations between psychological traits show significant and substantial genetic mediation’ (Plomin et. al, 2016, pg.7) was judged as being difficult to understand for a lay audience so was reworded to ‘Some traits and behaviours are linked to each other for genetic reasons’ with an example provided. Therefore, it was hoped that the language of the statements would be clear to participants, allowing them to make a true/false judgement. The ten statements were as follows:

1. All psychological traits show substantial genetic influence.
2. No psychological traits are 100% heritable.
3. The heritability of traits and behaviour is caused by many genes each with a very small effect.
4. Some traits and behaviours are linked to each other for genetic reasons e.g. IQ is related to school test results because the same genes influence both.
5. There is likely to be a single gene that is responsible for the differences between people in intelligence. It is just a matter of time before it is identified.
6. Our intelligence becomes more heritable as we get older.
7. The neighbourhood we live in and the parenting we experience are influenced by our genes.
8. Behaviour problems are usually explained by parenting.
9. Most psychological disorders (e.g. ADHD, anxiety) are the extremes of normal behaviour, rather than genetically distinct disorders.
10. Most mild to moderate leaning disorders (e.g. dyslexia) are the extremes of normal behaviour, rather than genetically distinct disorders.

Participants were given the ten statements and asked to indicate, using a 5 point Likert scale, whether they felt a statement was true or false, and with what degree of confidence. Initially, items were coded to ensure that 1 = an incorrect judgment of the true/false nature of the statement and 5 = a correct judgment of the true/false nature of the statement. The statements were then combined and a mean score was created to give a composite measure that would reflect the number of statements participants had correctly identified as true or false. A score of 5 would suggest that all answers were correct and chosen confidently – a high level of knowledge - with 1 suggesting all answers were answered incorrectly with surety – suggesting a low level of knowledge. When this composite measure was trialled in the pilot study, those cases with any missing data on the knowledge questions were excluded. In all of these cases in the pilot study data was missing for more than half of the statements. In order to try and reduce the wasting of data in the main study, it was decided that responses should be used if they have only one or two missing answers for this measure. Missing data in the pilot study did not appear to be due to the nature of the items in the knowledge section, as in all cases of missing data it was simply that participants stopped half way through, probably because of the challenging nature of the task.

Following the pilot study (although no pilot participant mentioned a specific problem with the knowledge questions) and after re-review by the researchers, one of the knowledge questions was broken down into two separate questions to avoid it being double-barrelled. We had asked: 'Most psychological disorders and learning difficulties are the extremes of normal behaviour, rather than genetically distinct disorders.' However we felt that although we had done this to try and keep the questionnaire as short as possible, psychological disorders and leaning difficulties needed to be placed separately as teachers may have differing ideas about them. This meant the knowledge question section went from having nine statements in the pilot study, to ten statements in the main study. Further information is presented in the description of the pilot study in Chapter 6.

Following the use of this measure in the pilot study and a judgement decision that the measure was too ambiguous, it was decided that the measure would be re-coded for the main study. This allowed us to use Knowledge as an ordinal variable.

This new variable is referred to as Knowledge Test. In order to create the variable each case was given either a '1' for correct or a '0' for incorrect (those who answered 'neither true nor false' were assigned '0') on each of the 10 questions drawn from the literature that created the original composite measure. These were then summed together in a new variable to give each participant a score out of ten. This then allowed us to have a Likert scale where an increase in the number did in fact represent increased knowledge without the confusion of the ‘don't know’ category in the middle. This Knowledge Test score was then used as an outcome measure along with nature-nurture, Mindset and Openness to Genetic Research in Education (OGRE). Participants must have answered at least 6 out of the 10 questions to be included in this composite measure. Those who answered fewer than 6 questions were excluded from analysis.

Openness to Genetic Research in Education (OGRE)

A new five item measure of ‘openness to genetic research in education (OGRE)’ was developed for this study and was found to have acceptable reliability in the pilot and main study sample (α= .80). It comprised five items with a 5-point Likert-style response format. Items were phrased both positively e.g. ‘I would like to know more about behavioural genetics and its implications for child development’ and negatively ‘Personally I would not like to see findings from behavioural genetics influencing my day-to-day classroom decisions.’ Although these negatively phrased statements reduced Cronbach's alpha score slightly they were included in the hope that they would reduce the chance of participants just ticking the same box repeatedly without reading the question properly. The five items were recoded to ensure that 1 = a low openness to behavioural genetics and 5 = very open to the role of behavioural genetics in education and a composite openness score was calculated. The five items were as follows:

1. Research that explains genetics and environmental influences on cognitive ability could be useful to teachers.
2. Overall, I feel that the science of behavioural genetics has a role to play in education.
3. I do not think that findings from behavioural genetics should be used to inform future educational directions.
4. Personally, I would not like to see findings from behavioural genetics influencing my day-to-day classroom decisions.
5. I would like to know more about behavioural genetics and its implications for child development.

Those cases with too much missing data were excluded. Participants must have answered at least three out of the five questions to be included in this composite measure.

This measure has also been tested by another researcher in a sample of Greek teachers. In this sample the Cronbach's alpha score for reliability was reinforced with the researcher calculating a very similar Cronbach's alpha ($\alpha = .73$). With a sample size of $n=213$, the Greek study found that for postgraduates entering the classroom as trainee teachers, the mean score for OGRE was $M=4.07$. Whereas, amongst the undergraduates training to be teachers the mean score was $M=3.82$. This difference was calculated as significant. It is felt that the successful use of this measure in a similar study, helps to validate the measure created as part of this study.

Existing and future role of behavioural genetics

A series of four questions was developed exploring teachers' attitudes towards genetic research playing a role in education, both now and in the future.

The first question asked participants to choose from a list of potential advantages behavioural genetics could bring to education, for example 'Increased focus on personalised learning' from which participants could select as many as they felt were likely to be beneficial. Questions then followed to help establish the role of behavioural genetics now and in the future. These included whether participants felt behavioural genetics already played a role in their school or classroom, whether they had received any training on behavioural genetics either during teacher training or as CPD, whether they would value future training and finally a selection of potential training delivery methods from which to select their preferences.

5.4 Procedure

A pilot study was conducted in order to test and refine the study measures (described below in Chapter 6). At this stage, the sampling frame was developed.

After completion of the pilot study, the main data collection began. The first schools to be contacted, in the first wave of data collection, were primary schools in England. In order to identify the first three schools (LA, MA and HA) within each local authority an online government resource was used ("School and college performance tables: 2015 to 2016", 2018). This resource allowed schools to be searched by local authority then sorted in order based on a range of measures. A random selection was then made for one school in each category. All of the selected schools were recorded in an Excel-based sampling frame. If an email was successfully sent to a school, then the name of the school was highlighted in yellow. If the school selected could not be contacted (no email address or just an enquiry form) or a mail delivery failure notice was received, then the name of the school was highlighted in red. This allowed a running count of the number of schools contacted to be kept.

This searching and recording process was repeated until all of the local authorities in England had been covered. This same process was repeated for secondary schools in England, then primary and secondary schools in Scotland and finally primary and secondary schools in Wales and Northern Ireland. The sampling plan was designed for schools to be selected in waves with the same sampling process repeated with new schools for each category until the desired sample size (c.600 teachers) was reached. This desired sample size was based on a rough estimation of the number of teachers currently teaching in the UK. Based on the most up to date statistics the number of teachers currently teaching in UK state schools stands at n=456,900 (Department for Education, 2016). As independent schools were also included an additional n=113,300 teachers as of 2016 were added to this figure. This figure was established after contacting a representative body for independent schools – the Independent Schools Council (ISC) – who represent approximately half of all teachers in UK independent schools (n=56,650 as of 2016) so this figure was doubled to provide an approximation of the distribution (ISC, 2016).

Overall, this gave us a rough estimate of n=573,200 teachers across the state and independent sector. A sample size of n=406 was achieved. As a rough guide, had the sample been a simple random sample, then this number was sufficient to have a confidence level of 95% and a margin of error at 5%, so it was felt that this was satisfactorily representative.

Once the first stage of the sampling frame had been created, the process of contacting schools began. Each school's website was searched online and explored until a contact email address (preferably for the head teacher), and the name of the head teacher, was identified. If the school had no website or did not have the relevant information available, then the school was also searched more generally as some local authorities had webpages dedicated to school details. Once this information was collected, an email was sent with the subject of 'For the attention of the head teacher...' it was hoped that this would urge the gatekeeper (often a receptionist) to send the email to the head teacher. When it was possible to find the head teacher's own email address, then it was sent directly to them. Overall, very few email responses back were received from invited schools. Responses to the actual questionnaire were the only real indication of willingness to participate.

In this sense, there is a weakness to this method of data collection. It was necessary to rely on the gatekeeper to pass on the invitation and questionnaire link to the head teacher. Additionally, it was then the head teacher's prerogative to answer the questionnaire and pass it on to their teaching staff as requested, or not. Although, these barriers to an ordinary teacher receiving the questionnaire link are evident it was the most practical and coherent method of contacting them that was available to us. Individual teacher email addresses are not publically available in most schools.

The email that was sent to each school had been drafted multiple times to include all of the relevant information whilst keeping the tone friendly and the content brief. A copy of the email sent to schools can be found in Appendix 1. The email asked for the participation of the head teacher and their teaching staff as well as providing the link to the questionnaire.

Once a wave of schools had been contacted and been given, on average, one month to respond a generic reminder was sent. This reminder contained exactly the same information as the first email but also an extra reminder paragraph. The word 'reminder' was also featured in the subject of the email. These emails were not individually addressed and were sent out to multiple schools at once. This was a practical solution to the challenge of sending a reminder individually to every school. Despite this generic reminder a spike in responses was noticed after reminders were sent, suggesting their effectiveness. Of course, due to the anonymity of the responses it cannot be known if this was solely due to the reminders but it is deduced that they were effective and played some part in the spike in responses. This process continued for around eight months until it was decided that sufficient data had been collected.

At around five months into the systematic sampling, the decision was made to bolster the sample using a convenience sample. A parallel and identical questionnaire was set up to ensure that the results from the convenience sample could be kept separate to those from the systematic sample. This made it possible to compare both sets of data and to judge if there was a significant difference or whether the two samples were sufficiently similar to allow them to be combined. The convenience sample plan consisted of two main target groups: teachers on social media (Facebook and Twitter) and the teaching unions. A tweet was sent out by the researchers asking for participation and containing a link to the new parallel questionnaire. This was shared and 'retweeted' numerous times and such reminders resulted in a spike in responses. A similar post was also shared on a personal Facebook account and in teaching groups on Facebook; this also received a number of 'shares'. The second element of the convenience sample was to contact teaching unions in the hope that they would be willing to share the questionnaire link amongst their members. Overall, ten unions were contacted including the most well-known such as the NUT and ATL. Responses were mixed with the majority simply failing to respond. However, the NUT did respond saying they were unable to participate and the Voice responded not to the researcher directly but they did take up the Twitter post and 'retweet' it amongst their followers. Despite the lack of union engagement, the convenience sample did boost the sample numbers by n=117. Similarities and differences between the two samples are discussed below.

Around seven months into the data collection process the distribution of responses was analysed to establish how closely it matched the UK wide teaching population. By this point all the sampling demographic groups (i.e. English primaries etc.) had been covered and contacted twice in two waves. Therefore, it was decided that the next wave would act as a bolster to the groups that were currently underrepresented. Having analysed the data collected by this point, the main groups that were underrepresented were primary school teachers, particularly in Wales, Northern Ireland and Scotland. Consequently, the third wave of data collection consisted of only contacting the above mentioned target groups using the same systematic sampling method. It was also decided to include English primaries in this third wave, as they had been particularly responsive in the previous two waves, so it was hoped to at least boost the primary school teacher responses to a more even level.

After eight months of data collection and an estimated *n*=3,500 schools contacted by email in the systematic sample the final sample stood at *n*=402 (*n*=285 from the systematic sample and *n*=117 from the convenience sample).

Merging systematic and convenience samples

The first step to be made before analysis began was to establish how similar the two samples were and, therefore, whether it was reasonable to combine them in a single dataset for the purposes of analysis. Upon initial comparison, using independent samples *t*-tests to explore whether the sample means differed significantly for the main study variables; it was found that the two samples were similar enough to warrant being combined.

Table 5.1. *Independent samples t-tests to explore differences between samples.*

Study variable	**Systematic N**	***M(SD)* Systematic**	**Convenience *N***	***M(SD)* Convenience**	***t***	***p***
Nature-nurture	271	2.77 (.704)	111	2.79 (.764)	-.265	.791
Mindset	274	4.10 (1.03)	113	3.97 (1.19)	1.07	.286
Knowledge Test	228	4 (1.60)	97	4.58 (1.91)	-2.67	.005*
OGRE	219	3.93 (.644)	91	4.03 (.645)	-1.21	.229

More specifically, only one statistically significant difference was found and that was for the knowledge variable. Four out of the ten items used to make up the knowledge test variable emerged as significantly different (items 1, 3, 7 and 8). Although the difference was significant the means were still relatively close, with the systematically gathered sample only slightly less likely to get a higher knowledge score (*M*=4) than the convenience sample (*M*=4.58). Both samples scored slightly below chance. When the effect size was calculated the figure was found to be d = 0.329, a small effect, so it was decided that the merging of the samples for this measure was justified.

Once the two samples were combined and the measures coded correctly analysis began in an attempt to answer the main research questions. Chapter 7 details the full results of the study.

5.5 Analysis

The combined sample then went through a wide range of analysis to draw as much information from the data as possible. The first step was to carry out a range of comparative analyses between the demographic make-up in the sample and the demographic make-up of the UK teaching population as it stands now. This was carried out using descriptive statistics allowing us to compare percentages between the two groups in an easy to understand format. Data on the UK teaching population overall was collected through a range of sources (primarily government statistics) to try to create a comprehensive comparison source. This is discussed further in Chapter 7.

Following this, analysis moved onto the main study measures (nature-nurture, mindset, OGRE and knowledge test). Firstly, means and standard deviations were calculated for the four main study measures to establish the overall pattern of results for all the participants and build an overall picture of teachers' attitudes and knowledge of behavioural genetics in education. The results of the main study variables were also presented in figures to give a clearer image of how the sample was distributed across each measure.

After the main descriptive statistics had been established, analysis moved onto correlations and regressions. The main purpose of the Pearson's correlations was to establish if there was any relationship both between the main study measures themselves and then between the main study measures and the demographic variables. Multiple linear regressions were then carried out for any study variables that showed significance with a main study measure in the correlations. The correlating demographic variables and then the correlating main study variable to a measure, were entered in two separate blocks which allowed us to establish how much each variable group contributed to regression model and therefore the variance in the measure.

The final element of analysis was to carry out MANOVAs on the main study measures. This was to establish if there are significant differences in responses to the main study measures based on teacher demographic characteristics. If significance was found, then either an independent *t*-test or one-way ANOVA was carried out to compare the means between groups for the main study measures. Independent t-tests were selected as most suitable for characteristics with only two groups, for example gender (male or female) and one-way ANOVAs used for all those demographic characteristics with more than two groups (Muijs, 2010). For the gender measure the third group 'would rather not say' were excluded from the final analysis because this group comprised of only n=4 participants and couldn't really provide any useful insight into gender differences. However, these cases were included in all analysis not focused specifically on gender.

Finally, post-hoc tests were carried out alongside the ANOVAs and *t*-tests to establish where the significance lay if it was found in the ANOVAs or *t*-tests. It was felt that the combination of these methods helped to give us a broad view of the data and then an increasingly narrowed view of the data to establish not just overall differences but also exactly where these differences stemmed from.

6. Pilot Study

A pilot study was conducted to allow the research instrument to be tested before being used in the main study.

6.1 Method

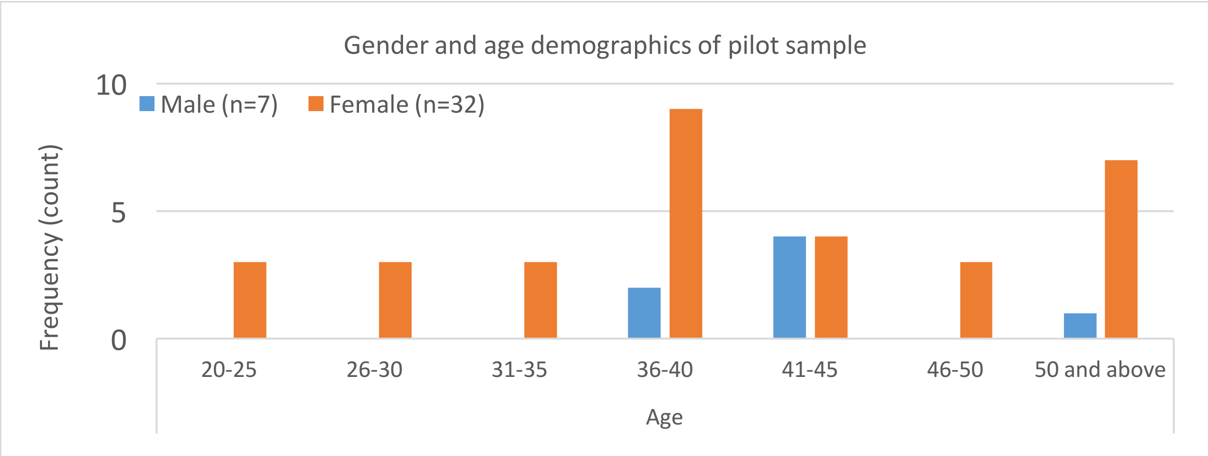
Participants

A convenience sample of *n*=39 teachers was recruited for this pilot study. Participants were asked to complete the study questionnaire and to provide qualitative feedback on its content and user-friendliness.

Initially it was proposed that only a small handful of schools would be contacted directly with the request that they ask as many of their staff as possible to participate in the pilot study. However, recruitment of schools through this method turned out to be unsuccessful. This was most likely due to the timing of the request and the volume of research requests to schools local to the University. Therefore, it was decided that the request would be sent to a wider audience via personal contacts and social media. In many ways this created a more diverse pilot study sample as, of the *n*=39 participants, 41% came from the North of England, 36% from the South of England and one from Northern Ireland (21% missing data). Although contacting participants through personal contacts is not ideal as it can introduce systematic bias into the data, had the original method been successful this increased geographical diversity would not have been present.

Overall, the gender split of this small sample mirrored that of the UK teaching population reasonably accurately. At the last official count, the teacher gender split in the UK was 74% females and 24% males (Department for Education, 2015). This pilot study had a split of 82% females and 18% males (See Figure 6.1). In terms of age distribution, the pilot study was successful in sampling a relatively even distribution (See Figure 6.1), with all groups being represented (*M*=40.5, *SD*=1.8) and each age category making up at least 8% of the sample and no more than 28% of the sample. However, when compared to the English teaching population as a whole there was a slight overrepresentation of teachers over the age of 35 (Department for Education, 2015). This is unlikely to have significantly affected the study's results but it will be worth bearing in mind the potential need to bolster certain age groups for the main sample should the same disparity arise. However, the small imbalance observed here is most likely to be an artefact of recruiting participants via personal contacts

Figure 6.1. A graph to show gender and age distribution in the pilot study sample.



Figures for the current distribution of level of teaching experience among teachers in the UK were not available so it was not possible to compare the pilot sample to the general population in this respect. However, the pilot study comprised at least *n*=3 teachers from every bracket of experience, suggesting all levels of experience were represented to some extent.

The primary/secondary teacher split seen in the pilot study mirrored that of the wider UK teaching population quite closely. In the pilot study the split was even, 46% primary and 46% secondary; 8% described themselves as 'other'. The most recent statistics available show that in the wider teaching population 59% are primary teachers and 41% secondary (Department for Education, 2012).

Establishing how accurately the pilot study mirrored the general teaching population in terms of the type of school they worked at proved somewhat more difficult. There are no official statistics for the size of the teaching workforce in independent schools in the UK. However, after contacting a representative body for independent schools – the Independent Schools Council (ISC) – it was established that they represent approximately half of all teachers in UK independent schools (*n*=56,650 as of 2016) so this figure was doubled to provide an approximation of the distribution (ISC, 2016). Based on this it was established that teachers in independent schools account for around 20% of teachers in the UK (113,300) with the state sector making up the remaining 80% (455,000) of which 4% work in special schools (21,300). The pilot study sample relatively closely mirrored this distribution with 72% (*n*=28) from state funded schools, 8% (*n*=3) from special schools, 15% (*n*=6) from independent schools and a further 5% (*n*=2) reporting 'other' as their school type. Perhaps a slight over-representation of special schools is present but this too is likely to be an artefact of recruiting personal contacts, a limitation we were willing to accept in order to collect sufficient pilot data for meaningful initial analyses to be conducted.

The most unrepresentative demographic element of the pilot sample was the geographical distribution of teachers. Although the revised sampling plan meant that participants were not as limited geographically to just the York area as originally planned, the pilot sample only represents teachers from England (36% from the South and 41% from the North) with a sole participant from Northern Ireland. Although England does have the most teachers nationally (83%), the pilot study should ideally have had some representation from Scotland and Wales. This is something that was addressed directly in the sampling plan for the main study, as described in Chapter 5 (UK Department for Education, 2012).

A good spread of subjects taught was represented in the pilot sample. Twelve school subjects were present in the pilot study sample from English and Maths through to Music and Languages and including those who taught multiple subjects. In this sense, this small, convenience sample quite effectively mirrored and represented the different subjects taught more widely in the UK. Participants were asked in the pilot study to report the subject they taught. From a feasibility point of view, there was some confusion over terminology here (e.g. numeracy vs. maths). Therefore, changes were made to this item in order to make it more user-friendly for the main study.

Procedure

Participants were recruited using personal contacts via social media (Facebook) and email. This included generic posts on appropriate pages asking for participants as well as a small number of people being personally contacted. A number of schools (*n*=5) in the local vicinity to the university were also visited and given paper copies of the questionnaire for their staff to fill in. The time scale was around one month to allow time for teachers to fit filling in the questionnaire into their schedules. The schools that were contacted in person were re-visited by the researcher a number of times to collect any responses and to act as a reminder. In both cases (online and in-person), an information sheet was provided and completion of the questionnaire was taken as an indication of informed consent.

Questionnaire responses gathered online were automatically transferred from Qualtrics to SPSS. The small number of additional paper questionnaires were entered manually. The data was then checked and missing data noted. Qualitative feedback was written up in a Word document to be analysed separately.

Analysis

The first step was to describe the demographics of the pilot study in terms of their representativeness of the wider teaching population (as detailed above).

Statistics from official websites were used to compare the nature of the general teaching population to that of this pilot sample.

Once the make-up of the pilot study had been established frequencies, means and standard deviations were calculated for all study variables.

Subsequently, independent *t*-tests and one way ANOVAs were carried out to explore differences between teachers from different backgrounds in how they perceived the nature-nurture question, and in their knowledge of genetics, openness to genetics and mindset.

Finally, Pearson's correlations between study variables were calculated. Significant correlations would have led to regression analysis but, in this pilot study, this was not necessary.

6.2 Results

The first step in the analysis was to calculate descriptive statistics for the main study measures overall within the sample. Means and standard deviations were calculated for all study variables, are presented, together with range, and sample size in Table 6.1.

Table 6.1. *Descriptive statistics of main study questions for full sample.*

	Mean	***SD***	**Range (min and max)**	***N***
Nature-nurture	3.37	.718	2-5	35
Mindset	4.03	.916	2-5.7	38
Knowledge	3.37	.410	2.2-4.1	31
OGRE	3.77	.654	2.2-5	30

What do teachers believe about the influence of nature and nurture?

Teachers, on average, reported themselves as perceiving nature and nurture as playing an equal role in influencing general cognitive ability (M=3.29, SD=0.75). The scale was coded so that 1= all genes, 2=mostly genes, 3=even split, 4=mostly environment and 5=all environment. No individuals selected 'all genes', 13% selected 'mostly genes', 41% selected 'even split between environment and genes', 33% selected 'mostly environment' and only 3% selected 'all environment' (10% missing data).

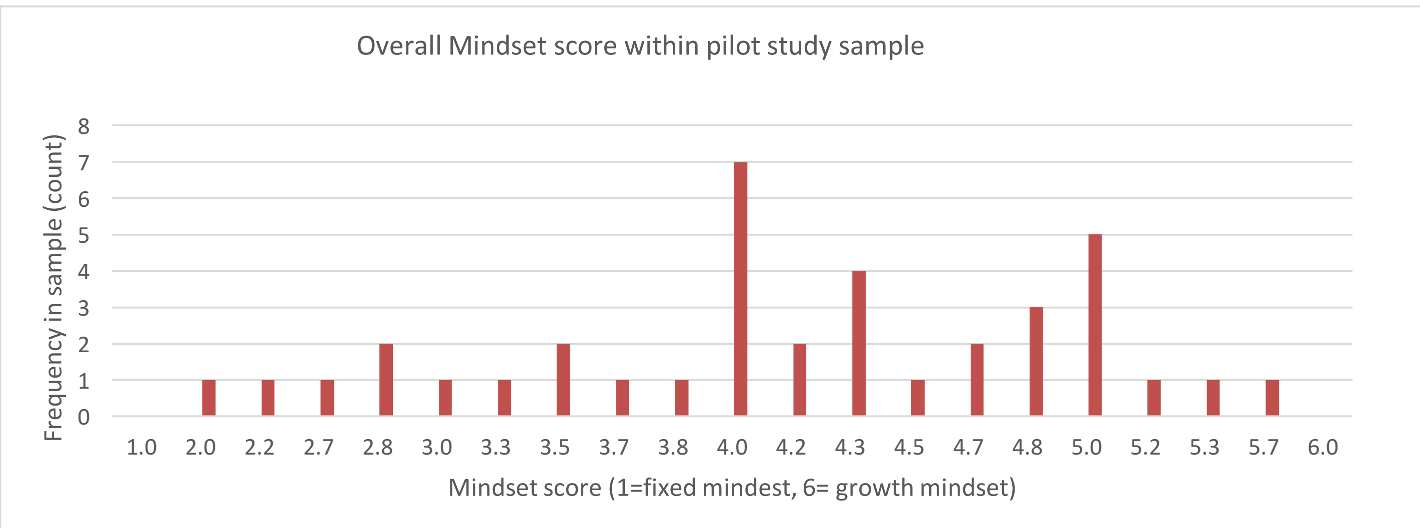
An additional element to this question asked whether participants felt the role of nature/nurture changes over time and if so, how. The pilot study data showed that 44% of teachers thought that the balance of nature/nurture probably did change over time with only a tiny fraction (3%) stating they thought it definitely didn't change over time. When asked to choose how they thought the balance changed over time, the largest group (23% felt that the environment became more important and genes less important as a child got older with the next biggest group at 18% stating they felt the balance was ever changing.

When comparative mean tests were carried out (independent *t*-tests for variables with two categories and one-way ANOVAs for those with multiple categories) no significant differences in response to the nature-nurture question (asking the extent of influence) were found between genders, teacher age, school type (independent vs. state) or whether they taught primary or secondary (Tables 6.3 and 6.4). However, a near significant result (p=0.52) emerged in relation to teachers who taught at different types of schools.

Mindset

Mindset was assessed in all participants and, on average, participants tended towards a growth mindset (M=4.12, SD=0.87, as in previous research; 1 = fixed Mindset and 6=growth Mindset). However, Figure 6.2 shows that a wide range of scores were represented within the pilot data (all but the two extremes). As with the other composite measures, when comparative mean tests were carried out (independent t-tests and One-way ANOVAs) no significant differences in teacher Mindset were found between genders, teacher age, school type or whether they taught primary or secondary (Table 6.3 and 6.4). However, once again a near significant result (p=0.52) emerged in relation to teachers who taught at different types of schools.

Figure 6.2. A graph to show the range of mindset scores amongst the pilot study sample.



Knowledge of behavioural genetics

Table 6.2 shows the distribution of mean scores and the range of responses of participants to the knowledge confidence question in the pilot sample (knowledge test score was created after the pilot). Most of the means sat in the middle of the spectrum with only the statement on behaviour suggesting a larger number of incorrect responses to this statement. When the individual scores were combined to create the composite knowledge question the mean score was *M*=3.37, *SD*=.410 (see Table 6.1), in the case of the composite score and the individual question coding, a score of 1 represents a low level of knowledge and an incorrect individual answer respectively. In comparison, 5 equates to an overall high level of knowledge in the composite measure and a correct answer in the individual knowledge question.

However, the overall means suggest (*M*=3.37, *SD*= 0.4) that most respondents were undecided (3 = 'neither true nor false', 1=confidently wrong, 5=confidently correct) about behavioural genetics. Results show no individual was confidently correct for all statements but equally no individual got all answers completely wrong. However, it is worth noting that *n=6* individuals chose not to declare any of the statements true or false but answered that they felt each statement was 'neither true or false', it cannot be said whether these individuals have a good understanding or not as they did not declare either way. Due to this ambiguity highlighted in the pilot study, this question was recoded and reworked for the main study to hopefully provide more insightful results.

Table 6.2. Mean and range of responses to knowledge statement.

Knowledge statement:	***N***	***Mean***	***Range (min and max)***
All psychological traits show substantial genetic influence	31	3.19	2-4
No Psychological traits are 100% heritable	31	3.45	1-5
The heritability of traits and behaviour is caused by many genes each with a very small effect.	31	3.45	2-5
Some traits and behaviours are linked to each other for genetic reasons	31	3.32	1-4
There is likely to be a single gene that is responsible for the differences between people in intelligence.	31	3.81	2-5
Our intelligence becomes more heritable as we get older.	31	3.71	2-5
The neighbourhood we live in and he parenting we experience are influenced by our genes.	31	3.52	2-5
Behaviour problems are usually explained by parenting.	31	2.77	1-5
Most psychological disorders and learning difficulties are the extremes of normal behaviour, rather than genetically distinct disorders.	31	3.06	1-5

Once again, when t-tests for gender and primary/secondary and one way ANOVAS for teacher age and school type were carried out no significant differences in knowledge of behavioural genetics were found between groups (Table 6.3 and 6.4).

Openness to Genetics in Education

Descriptive statistics for Openness to Genetics in Education suggested that, on the whole, teachers in the pilot study leant slightly towards a more open attitude to behavioural genetics playing a role in education and in their educational decision-making (M=3.76, SD = 0.65; a score of n=5 would suggest complete openness and a score of 1 would suggest no openness to behavioural genetics playing a role of any sort). The range of responses was 2.8 (min=2.20, max=5) showing there was some variance in the sample.

When comparative mean tests were carried out (independent *t*-tests and One-way ANOVAs) no significant differences in openness to genetics were found between genders, teacher age, school type (state/academy, state/academy with religious affiliation, free school, independent, independent with religious affiliation, special school, other) or whether they taught primary or secondary (Tables 6.3 and 6.4).

Table 6.3. *Descriptive statistics and independent t-tests by gender and school type*

Variable:	Gender			School – primary or secondary		
Measures:	*t*	*df (total)*	*p*	*t*	*df (total)*	*p*
Nature – nurture	1.01	33	.319	.344	30	.733
Mindset	.912	30	.733	.838	33	.408
Knowledge	1.01	29	.322	-1.12	26	.270
Openness to genetics	-1.57	28	.127	.843	25	.407

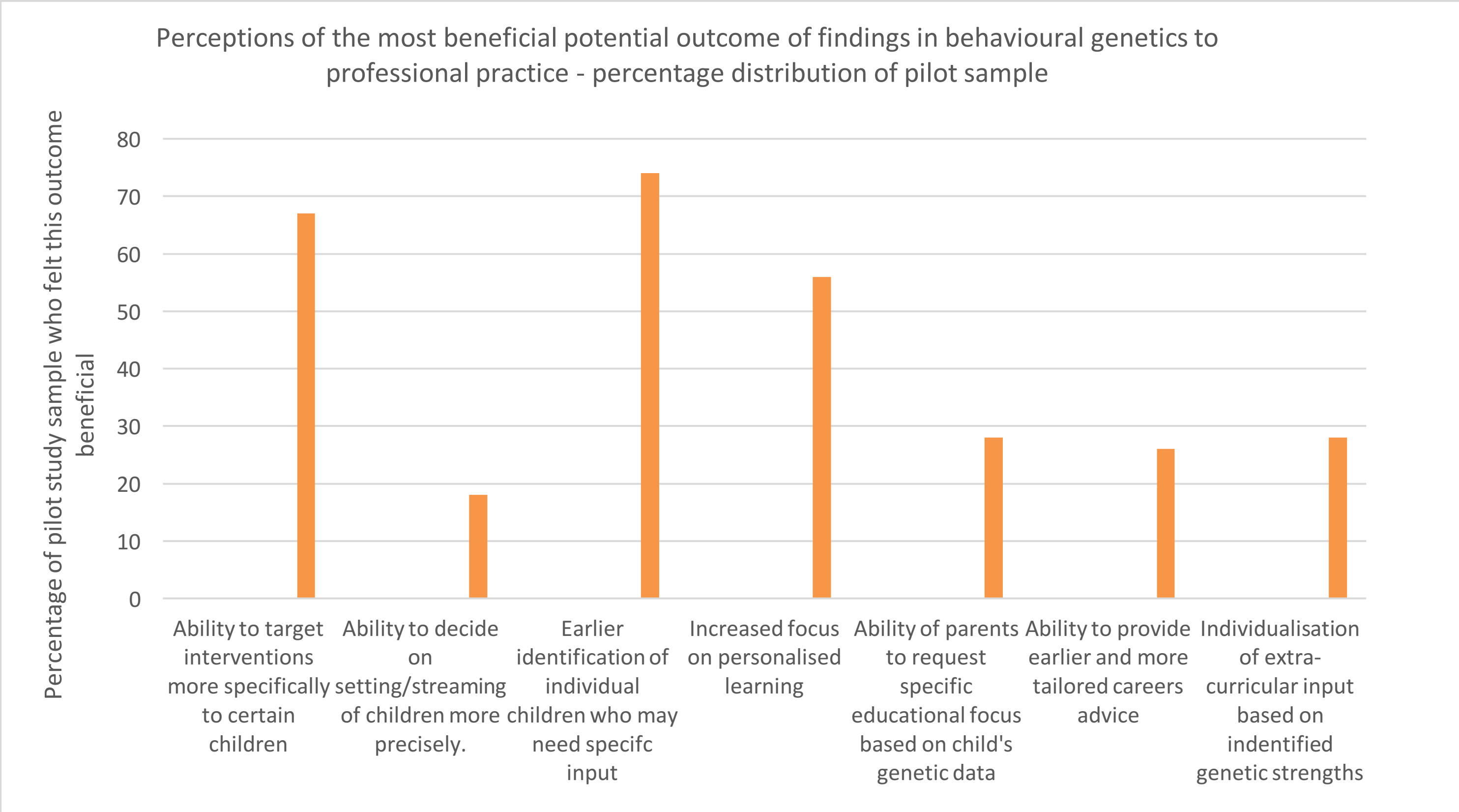
Table 6.4. *One Way ANOVAs to compare means on the basis of teacher age and school type.*

Variable:	Teacher age			School type		
Measures:	*F*	*df (total)*	*p*	*F*	*df (total)*	*p*
Nature – nurture	.994	34	.448	2.39	37	.052
Mindset	.754	37	.754	2.39	37	.052
Knowledge	.738	30	.738	.758	30	.609
Openness to genetics	.175	29	.175	.425	29	.855

Existing and future role of behavioural genetics

Results for participants' views on the potential advantages of behavioural genetics are presented in Figure 6.3, with earlier identification of children in need of particular input and ability to target interventions more specifically being the most popular (over 60% of respondents selected these) and ability to decide on setting/streaming more precisely being the least popular with (under 20% of participants selected this).

Figure 6.3. A graph to show the perceived most beneficial outcome of behavioural genetics in education amongst the pilot study sample.



When asked if they felt the science of behavioural genetics already played a role in their school or classroom, as would be expected the majority (62%) said they felt it didn't with only 15% saying they felt it did (9% missing data). Those who said they did feel behavioural genetics played a role in their school already were asked to elaborate. Responses to this focused primarily on helping children with special behavioural and education needs (n=4) and one response focused on allowing the individual to understand progress and 'lifelong education'. However, it was unclear how behavioural genetics was actually playing a role.

Moving on to look at the perceptions of training regarding behavioural genetics, as would be expected, few teachers had received formal training in behavioural genetics either during their time as trainee teachers or as part of their continuing professional development (CPD). With regards to training received during teacher training only 3% reported having some kind of formal training on behavioural genetics and only 5% said they had received such training while working as a qualified teacher.

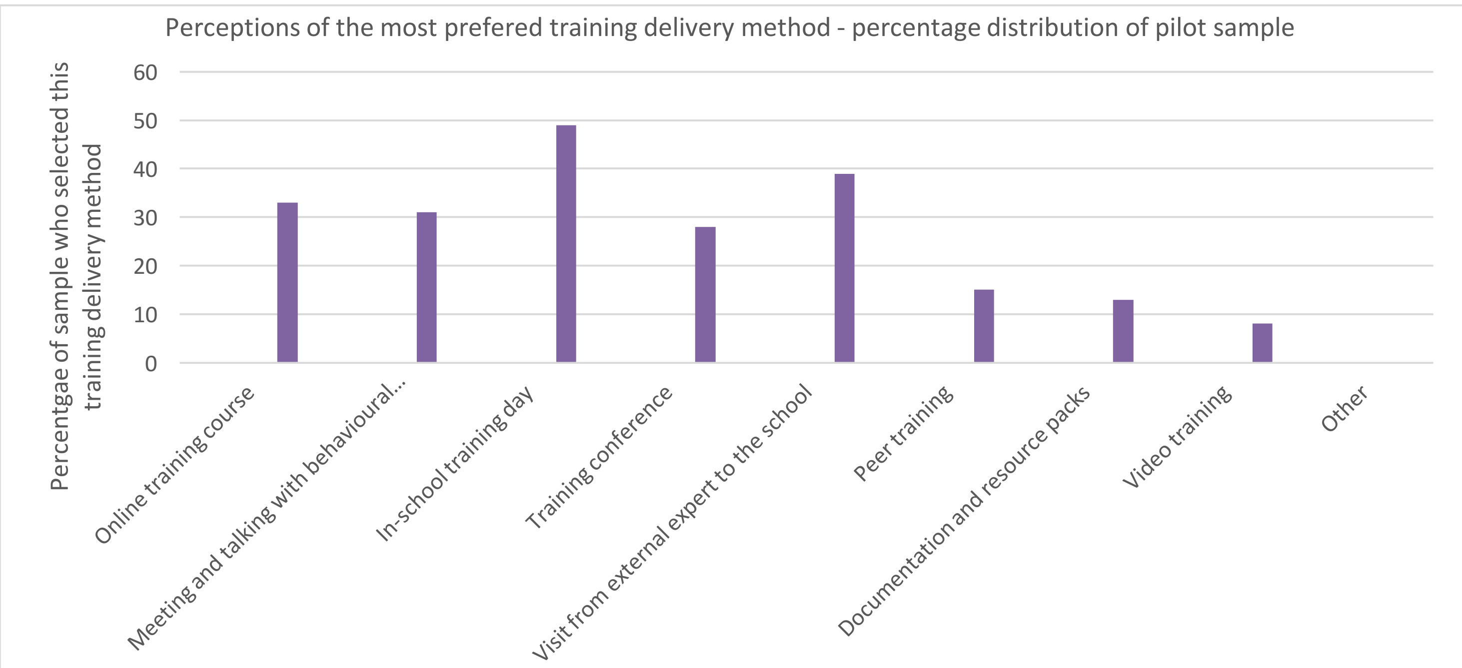
When asked about further training, 72% teachers in the pilot study said they would value further training on behavioural genetics in the future. The 5% (*n*=2) (23% missing data) who said they would not value further training cited two very different reasons. The first suggested a fear around behavioural genetics being limiting for students:

'I believe behavioural genetics has the potential to limit students by opposing the idea that hard work and a growth mindset can cause children to improve in any area of their life'.

The second reason cited provided a response that was somewhat irrelevant and was simply to do with the fact that the teacher was due to retire soon so was not interested.

The final question in the questionnaire showed how, and in what format, participants said they would most like to receive this training. Figure 6.4 shows the most popular methods of training delivery selected when teachers were asked to pick up to three. Results showed that an in-school training day would be the most popular (49% selected this) followed by a visit from an external expert (39% selected this) with the least popular option being video training with only 8% selecting this.

Figure 6.4. A graph to show the preferred method of training delivery for behavioural genetics



Correlational Analyses

Correlations between mindset, nature-nurture beliefs, knowledge and openness were calculated and all correlations were non-significant. It was, however, interesting to note the direction of the correlations. Openness to genetics in particular negatively correlated with responses to the nature-nurture question (1=all environment, 5=all genes) asking to what extent a child's cognitive ability was influenced by nature or nurture (not the change over time additional question). However, due to the small sample and lack of significance no firm conclusions can be drawn (Table 6.5)

Table 6.5. *Pearson's correlations between study variables.*

		Nature-nurture	Mindset	Knowledge	Openness
Nature-nurture	Pearson Corr.				
	Sig.(p)	-			
	N				
Mindset	Pearson Corr.	.208			
	Sig.(p)	.271	-		
	N	30			
Knowledge	Pearson Corr.	.213	.059		
	Sig.(p)	.260	.755	-	
	N	30	30		
Openness	Pearson Corr.	-.105	-.004	.265	
	Sig.(p)	.580	.984	.157	-
	N	30	30	30	

Based on the finding that no measures significantly correlated with each other, no regression analyses were carried out at this stage.

Qualitative feedback for feasibility purposes

In order to develop a richer picture of the process teachers went through when filling out the questionnaire they were encouraged to leave written feedback about how they found the process and *n*=5 individuals left such feedback. On the whole feedback was positive with teachers responding with statements such as:

'Interesting, clear, straightforward and easy to use.'

However, a number of issues with the questionnaire were highlighted by teachers. Some were technicalities such as having more choices on questions or being able to tick fewer boxes before moving on – for example on the options where participants were asked to pick 'up to three' Qualtrics wouldn't allow them to select fewer and move on. Others related to difficulty in understanding elements of the questionnaire such as:

'...I did start to get confused when there were questions that seemed to state the same point in a different way.'

'Also, many teachers are hesitant that the language of such research will prove inscrutable and so they are naturally hesitant.'

These findings were used to help edit and improve the questionnaire for use in the main study.

6.3 Discussion

This pilot sample was small and, as such, results are not generalizable. However, it did begin to build a picture of what might emerge from the main study and tested the feasibility and user-friendliness of the research instrument.

The first point of note was the relative representativeness of the pilot sample when compared to the wider UK teaching population. For a small sample it appeared to be reasonably representative of UK teachers. However, one or two demographic features were slightly over or underrepresented, namely geographical distribution and over-representation of teachers from special schools (not included in the main study sample).

The first question addressed in this pilot study was to what extent teachers felt a child's cognitive ability was influenced by nature or nurture. Findings here were as expected with the mean score showing that teachers on the whole felt that there was an even split between the influence of nature and nurture on a child's cognitive ability. This closely mirrors previous findings on the topic

(Walker and Plomin, 2005; Crosswaite, 2013). These findings could suggest a reserved attitude amongst teachers when it comes to making a call between nature and nurture and perhaps also signify a lack of certainty in their perceptions of behavioural genetics, perhaps stemming from a lack of knowledge in the area. However, it is important to note that teachers suggesting roughly even roles for nature and nurture are in fact roughly in line with the evidence (Polderman et al., 2015). The research supports what teachers believe.

An additional element to this question asked whether participants felt the role of nature/nurture changes over time and if so, how. When asked to choose how they thought the balance changed over time, the largest group (23%) felt that the environment became more important and genes less important with the next biggest group (18%) believing that the balance was ever-changing. These results show an interesting misconception as research suggests that actually the environment plays the biggest role early on in a child's life with regards to cognitive ability and that the role of genes explains more variance as the child matures (Plomin, DeFries, Knopik, & Neiderhiser, 2016). It was decided, based on feedback and revision of the questionnaire, that this question was unnecessary as a very similar question is asked in the knowledge measure. Therefore, this item was removed from the questionnaire before the main study was conducted in order to try to reduce and simplify the final questionnaire.

Looking at the results for 'knowledge of behavioural genetics' we see that most teachers were unsure and struggled to decide whether facts about behavioural genetic findings were true or false. This is likely to be connected to the finding that few teachers have had any training in the field of behavioural genetics and, as such, are not confident or always correct in their responses. However, it will be interesting to see if in the main sample, which will involve many more participants, there will be more individuals who may have a better understanding of the science. For instance, it will be interesting to explore whether science teachers respond more correctly and confidently than others. The lack of knowledge and confidence about genetics in education illustrates the need for further study in this area to help work out how to help teachers to come to understand and be aware of the science of behavioural genetics. This pilot study suggests shortcomings in knowledge about genes might be more of a problem for teachers than their beliefs or attitudes. Overall when asked for their views on a series of questions regarding the potential future role of genetics a relatively positive picture emerged. Although, as expected, hardly any of the sample had received any training in behavioural genetics either during their teacher training or as a professional (CPD) most were open to the idea of finding out more. Most said that behavioural genetics did not currently play a role in the classroom, which was expected considering the emerging nature of behavioural genetics. Interestingly, when those who claimed behavioural genetics did play a role in their classroom were asked to elaborate their responses most indicated a misunderstanding of what behavioural genetics is. For example, three of the elaborations related to teachers saying it helped them with children who had special educational needs. Others said it was seen in behavioural intervention plans. This suggests a slight misunderstanding as these comments suggest they are simply conflating behavioural genetics with learning and behaviour difficulties.

Currently, most felt that the role of behavioural genetics would or could be most beneficial in areas such as targeted intervention and early input for specific needs rather than used for practices such as setting or streaming. Again it will be interesting to see if this remains a consistent finding or whether teachers will differ significantly in how they perceive the potential future role of behavioural genetics in education.

The most popular methods for delivering future training – in-school training day or external expert – suggest that teachers want a thorough and in-depth training with the opportunity to ask questions of an expert. This is likely to be due to the complexity of the subject, with more basic training like videos or resource packs proving the least popular option for further training. This is likely to be important information for organisations such as the Wellcome Trust with an expressed interest in building bridges between scientists and teachers. Collecting further data on this will be valuable for any future research into how best to help teachers understand and use findings from behavioural genetics in their teaching practice.

With regards to 'openness to genetics', cautious optimism is indicated. Teachers in the sample were, on average, slightly more open to genetics than not. However, there was a good deal of variance within the sample and this new measure will be best explored in the larger sample recruited for the main study. This measure has also been tested with a sample of Greek trainee teachers, as mentioned in chapter 5.3. The diversity of responses here highlights the diverse nature of the teaching population and how much individual teachers can differ in their attitudes and perceptions. Bearing in mind the convenience sampling method used for this pilot study, we must also remember that the participants, knowing the researcher, may have been slightly more generous towards the topic in terms of their openness to research and the study. Therefore, it will be interesting to see if cautious optimism towards openness to genetics amongst teachers is replicated in the main study.

With regard to 'mindset', on average teachers leant more towards a growth than a fixed mindset. This was the expected result as literature looking solely at teacher mindset has tended to find that teachers lean towards a growth mindset (Gutshall, 2013). However, there were ranges of mindset present in the sample including much more fixed mindset than the average. However, based on existing research the trend amongst the wider teaching population in the main study is expected to continue to tend towards a growth rather than a fixed mindset. This in many ways makes sense as the nature of teaching is based around helping to nurture children academically and help them improve academically. Perceiving intelligence and achievement as completely fixed and unchangeable would undermine the primary aim of their own profession.

No significant group differences emerged in this pilot study. However, the type of school a teacher taught at did reveal a near significant value, therefore it will be worth paying particular attention to this demographic element in the main study to see if a larger sample pushes this figure over into significance, and what the effect size is. However, in a number of analyses there were too few participants within each category for meaningful comparative analysis to take place. This will not be the case for the main study where all groups will be sufficiently populated.

No significant correlations were found. However, it is predicted that with a much larger sample some significant associations will be observed.

Based on qualitative feedback, and other indicators such as the questions that most commonly had missing data, a few important changes were made before proceeding to the main study. These included cutting out three items which were covered elsewhere, thus reducing the chance of teachers finding the questionnaire too lengthy. Rewording of some of the knowledge items was also undertaken in the interests of clarity. Here it was important to maintain the integrity of the statement while simplifying the language to ensure the meaning of the phrase/ question was clear to participants. The technicalities raised were also rectified. A recoding of the knowledge variable was also carried out. This was to create an ordinal variable much more suited to the analysis – further details chapter 5.3. Both the pilot version and the main study version of the questionnaire can be seen in the Appendix.

In conclusion, although the geographical distribution of the pilot sample and its overall size means these findings are merely an initial indication rather than anything generalisable, conducting the pilot study proved very valuable. It allowed a number of questionnaire technicalities to be highlighted and addressed and therefore has ensured the research instrument is fit for purpose in the main study. The pilot study has also acted as reassurance that teachers are not overly hostile to behavioural genetics and are willing to engage in research on the subject. Although initial analysis has not revealed any findings of statistical significance or substantial effect it has begun to reveal patterns that are likely to emerge in the main sample. It is hoped that the pilot study has helped to improve the validity and effectiveness of the research instrument and also acted as a practice for the main research study in the hope of ensuring the best data outcome possible in the main study.

7. Mainstream teachers' beliefs of, knowledge about and openness to genetics in education

7.1 Introduction and Aims

This chapter presents the majority of the findings from the main study. However, findings from the Continuing Professional Development (CPD) section of the questionnaire will be presented separately in Chapter 8. The primary aim of this study was to gain a detailed understanding of the attitudes towards, and perceptions and knowledge of, behavioural genetics among a broadly representative sample of UK teachers in mainstream schools. The study was designed to add to the currently limited picture of how teachers perceive behavioural genetics (and whether different types of teacher differ in this regard); what teachers know and understand about the genetics of cognitive ability; and how open they are to this body of research playing a role in their schools and classrooms.

These findings have been published as: Crosswaite, M., & Asbury, K. (2018). Teacher beliefs about the aetiology of individual differences in cognitive ability, and the relevance of behavioural genetics to education. British Journal Of Educational Psychology. doi: 10.1111/bjep.12224

7.2 Method

7.2.1 Participants

Participants were full and part-time teachers from across the United Kingdom. Overall, *n*=402 teachers took part in the study. Participants were recruited using two methods; systematic sampling and convenience sampling. The systematic sample consisted of *n*=285 participants and the convenience sample consisted of *n*=117. Following analysis (see Chapter 5, Section 3), the two samples were combined as they were found to be broadly comparable. All analyses were therefore conducted using the combined sample of *n*=402 participants.

Demographic information was analysed in order to explore how closely the study sample mirrored the UK teaching population and, therefore, how reasonable it would be to generalise the findings to UK teachers. To the best of our ability with the information publically available, table 7.1 shows direct comparisons between the demographic characteristics present in the sample and the known UK teaching population demographic statistics. It is worth nothing that in some instances data was estimated or reconfigured based on the data available in order to try and get as accurate a comparison as possible. However, for some demographic characteristics, there was unfortunately simply no comparable population data available.

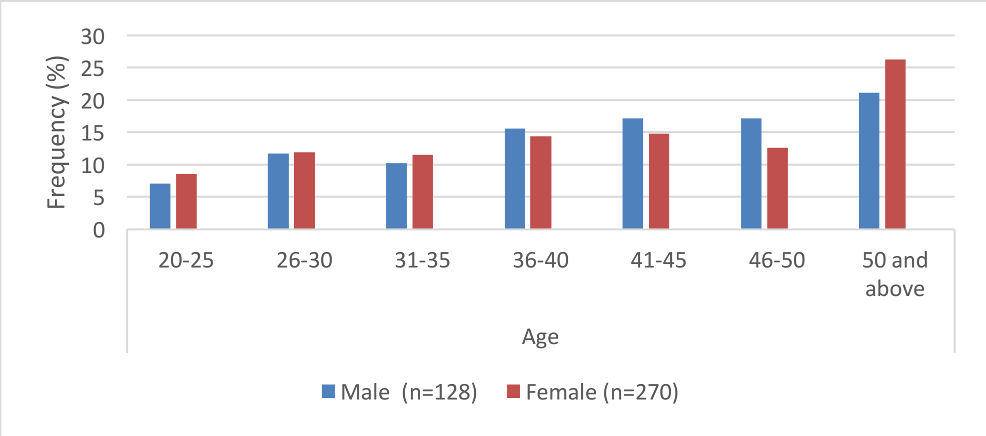
Table 7.1. Demographic breakdown of sample in comparison to UK teaching population (if statistics available)

Demographic	Achieved sample breakdown (%)	Known population breakdown (or best estimate) (%)
Gender		
Male	32.6	26.6
Female	65.8	73.8
Prefer not to say	1.6	-
Age		
Under 30	22.4	25.8
30-50	57	57
Over 50	23.7	17.3
Years of teaching experience		
NQT	4	5.2
1-5 years	18.1	28.5
6-10 years	15.9	24.2
11-15 years	18.6	
16-20	12.7	42.1
20+	29.5	
Age of pupils		
Primary	48	24.1
Secondary	46	63.3
School type		
State	80	65.7
Independent	20	32.2
Location		
Urban	52.5	No available statistics
Semi-rural	31	
Rural	16.5	
Location		(General population statistics)
England	90.9	84.2
Wales	0.2	4.7
Scotland	7.9	8.2
Northern Ireland	1.2	2.8
Subject specialism	See figure 7.6	No available statistics
SENCO		
SENCO role	6	No available statistics
No SENCO role	94	

Gender and age

Figure 7.1 below shows the gender and age demographics of the sample.

*Figure 7.1.*Gender and age demographics in the study sample



The sample was reasonably close to being representative of the UK teaching population as a whole in terms of gender. In the study dataset 65.8% of the sample was female and 32.6% male, with the remaining 1.6% preferring not to say. In the UK teaching population, at the last count of state employed teachers, 73.8% of teachers were female and 26.2% were male (Department for Education, 2016). Therefore, in the current sample females were a little under-represented and males a little over-represented.

Information on teacher age was gathered and in the current sample it was found that teachers aged 50 or above were the biggest group making up 23.7% of responses. However, all but one age group had at least 10% representation (the 20-25 age group made up only 7.8% of the sample). When this is compared to the UK teaching workforce we see that figures are very close with only the over 50s being slightly overrepresented. According to the most up to date statistics, 25.8% of teachers are under 30, in this study sample that figure was 22.4%. Teachers aged 30-50 made up 57% of the teaching population in state schools according to most recent statistics and they made up slightly less in this sample at 53.9%. For teachers over the age of 50, most recent statistics show they make up 17.3% of the teaching workforce (Department for Education, 2016), however in the study sample they were slightly overrepresented at 23.7%. However, overall age representation in the sample was generally in line with the wider UK teaching population.

Years of teaching experience

Participants were also asked about how much teaching experience they had and the sample included teachers with less than one year of experience through to those with more than twenty years.

Figure 7.2. Distribution of years of teaching experience in the study sample

As shown in figure 7.2, those teachers employed for over 20 years formed the largest group, followed by those with 11-15 years of experience and 1-5 years of experience. Those with 16-20 years of experience or just an NQT year formed the smallest proportion of the sample. Sources with which to compare these figures to were limited. However, some rough data was found in a government document on teacher retention which showed drop-out rates and head counts based on years since qualification (i.e. years of experience). This data was presented in graph format, with the Y axis displaying only intervals of 10,000 so reading the graphs cannot give us an exact number but can give us a rough guide (Department for Education, 2017). According to this data, as of 2014 there were roughly 20,000 NQTs across UK primary and secondary schools, 24,000 with one years' worth of experience, and around the same for two years' worth of experience, around 22,000 with three years' worth or experience, around 41,000 with four to five years' worth of experience, 94,000 with six to 10 years of experience and 164,000 with over ten years' worth of experience (numbers fall short of the study calculated total as the government census (Teachers analysis compendium, 2017) was conducted a few years ago (2010-2015) and does not receive full information back from every school), (Department for Education, 2017).

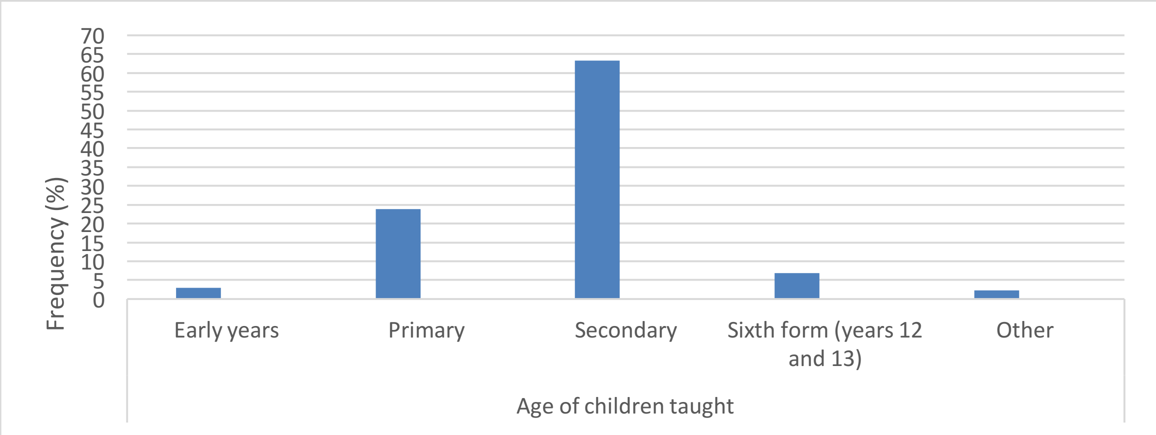
If we recalibrate this into the format used in the current study we have 20,000 NQT teachers (5.2%), 111,000 (28.5%) with one to five years' worth of experience, 94,000 (24.2%) with six to ten years' worth of experience and 164,000 (42.1%) spanning the remaining three categories (11-15, 16-20 and 20+). Therefore we can see that in comparison to the study data, NQT teachers are fairly accurately represented, teachers with one to five years' worth of experience are just slightly underrepresented, as our teachers in six to ten category with teachers in the remaining three categories (above 10 years) being around 20% overrepresented.

However, all categories were represented in the data, with only teachers in their newly qualified teacher (NQT) year falling below 10% representation in the current sample. This is not surprising as the NQT category includes only those teachers with less than one year of experience whereas the other options included a wider spectrum, making it more likely that more teachers would fit into those options. It could be said that those with over 20 years of experience made up noticeably larger per cent at 29.5%; this is likely due to the slight overrepresentation of those aged 50 and above in the current study.

Age of pupils

Participants taught the full age range of pupils. The representativeness of the sample in this respect can be aligned with some statistics relating to the wider UK teaching population. However, it should be noted that the official statistics are not broken down beyond early years (ages 3-4), primary (ages 5-11) and secondary (ages 12-18).

Figure 7.3. School age of pupils taught by teachers in the study sample



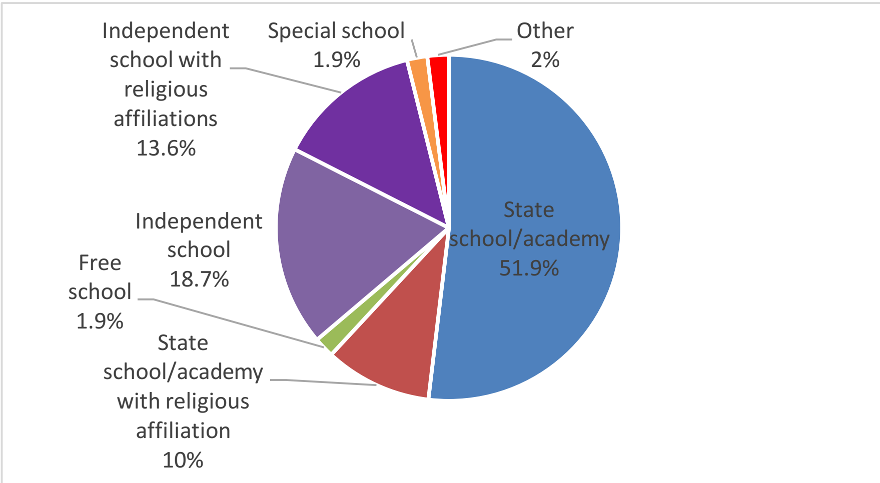
As seen in figure 7.3, secondary school teachers made up the majority of the sample, with teachers from early years and 'other' (mainly primary and secondary or senior leadership not actively teaching in the classroom) forming the minority.

According to the most recent government statistics on the teacher workforce, there are 220,000 full time equivalent early years/primary school teachers and 210,000 secondary school teachers. Overall, there are around 456,900 full time equivalent teachers in UK state schools meaning that 48% are in the early years/primary sector and 46% are in the secondary sector (there is no explanation as what age the remaining 6% teach). These statistics are useful but it must be remembered that the current study included part-time teachers and those from the independent sector also, so it is not a completely accurate comparison. Figure 7.3 shows the distribution of teachers in primary and those in secondary. It is clear from the outset that secondary teachers are overrepresented substantially with 63.3% of the sample being secondary school teachers whereas early years and primary make up only 24.1%. Despite attempts to bolster the sample of primary school teachers (see Chapter 5) this inequality remained and this must be borne in mind when generalising from the study findings to the UK teaching population as a whole. It represents a limitation of the data.

School Type

Teachers were asked to state what type of school they currently teach at. Figure 7.4 shows the distribution in the sample based on school type. Teachers from state schools or academies made up over half of the sample with those teaching at independent schools also making up a noticeable proportion. Teachers from special schools and free schools made up the smallest proportion.

Figure 7.4. School type teachers taught at in the study sample



Establishing current statistics for school type in the UK overall, required piecing together information from several sources. As established in the pilot study, after contacting a representative body for independent schools – the Independent Schools Council (ISC) – members of the ISC represent approximately half of all teachers in UK independent schools (*n*=56,650 as of 2016) so this figure was doubled to provide an approximation of the actual number of independent school teachers in the UK (ISC, 2016). Based on this it was established that teachers in independent schools account for around 20% of teachers in the UK (113,300) with the state sector making up the remaining 80% (456,900) of which 4% work in special schools (21,300) and 0.8% in free schools (3700). Figure 7.4, shows the distribution of teachers by school type in the current sample.

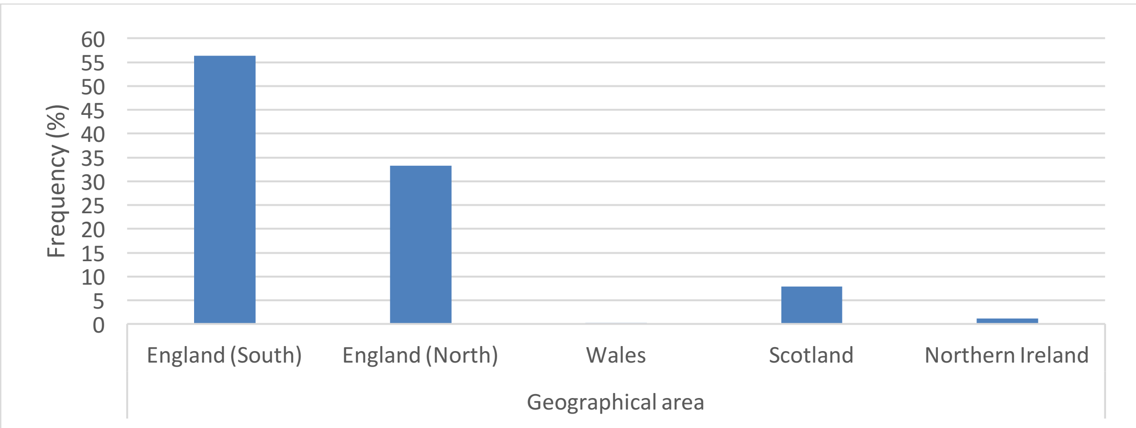
By comparison with the official data, the four state school categories combined (state school/academy, state school/academy with religious affiliation, special school and free school) represented 65.7% of the sample, and independent categories combined represented 32.3% with 2%

being classed as other (on the whole currently no teaching role or primary and secondary combined). Therefore, we can see that the independent school teachers are overrepresented in this sample. Once again, despite bolstering the state primary schools in data collection this imbalance remained, with implications for generalizing findings to the UK teaching population.

Location

Finally, participant data was gathered on school location and type of geographical area. Overall, 52.5% of teachers reported their school as being 'urban', 31% reported their school as semi-rural and 16.5% reported their school as being 'rural'. There are no statistics available with which to compare this but, as expected, more participants taught in urban areas. Figure 7.5 shows where in the UK participants' schools were located.

Figure 7.5. Geographical distributions across the UK in the study sample

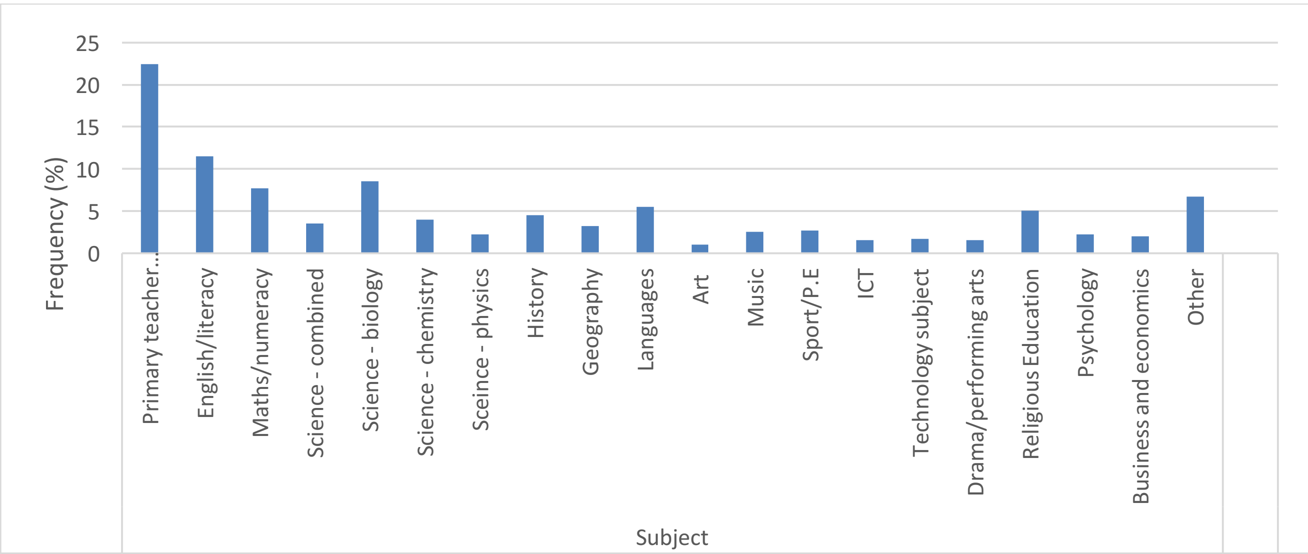


Once again there are no official statistics available for how many teachers work in different regions of the UK. However, if we compare with populations of different countries within the UK we can see that, on the whole, the sample appears reasonably representative. Across the whole of the UK, the population of England makes up 84.2% and it makes up 90.9% of the sample; Scotland accounts for 8.2% of the UK population and in the study sample Scotland made up 7.9%. However, Northern Ireland and Wales were both underrepresented in the study sample with Northern Ireland making up 2.8% of the UK population but only 1.2% of the study and Wales making up 4.7% of the UK population but only 0.2% of the sample with only one single response from a teacher in Wales (Office for National Statistics, 2017). This persisted despite additional bolster sampling being carried out for Wales and Northern Ireland. Obviously, these comparisons are only a rough guide; however, it is clear that Wales, despite being targeted in the bolster sample, is not represented in this study.

Subject specialism

Finally, participants were asked about the subjects they teach. As seen in figure 7.6, many participants reported teaching multiple subjects, as most primary school teachers will have selected this. The second largest proportion of teachers were teaching English/literacy (11.5%), maths/numeracy (7.7%) and biology (8.5%) – which is unsurprising as these are core curriculum subjects. Teachers who taught art, ICT, drama and technology formed the smallest proportion of the sample at around only 1.5% of the sample.

Figure 7.6. Distribution of subjects taught for majority of teaching time in the study sample



For teaching subject, there is some limited information from government statistics with which to compare the current sample. According to the most recent statistics 64.2% of teachers teach what is referred to as the English Baccalaureate subjects (maths, English, science, history, geography and modern foreign languages) (Department for Education, 2016). With the exclusion of primary teachers, who on the whole teach multiple subjects we can see that for the English Baccalaureate subjects we have representation across those subjects, with maths, English and combined science particularly well represented.

SENCO (special educational needs coordinator)

Participants were also asked whether they held a SENCO role in their school. There are no official statistics for this information; however, 6% of respondents in the current study said they did hold a SENCO role in school. Due to the nature of the study and its partial focus on the factors playing a role in cognitive ability it is likely that this group may be overrepresented; due to self-selection bias as SENCO teachers may have more interest in the topic of behavioural genetics.

7.2.2 Measures

Study measures have been described previously in chapter 5. After downloading and combining all data in a single dataset, composite variables were created (see Chapter 5.2). (Main study variables included: perceptions of nature-nurture balance, mindset, knowledge test score and Openness to Genetic Research in Education (OGRE)). Mindset and OGRE, the two scale scores, showed good internal reliability in the current sample, as shown in table 7.7.

Table 7.7 *Reliability statistics*

Variable	α	M	SD
Mindset	.94	4.06	1.08
OGRE	.80	3.95	.645

Note: perceptions of nature-nurture balance and knowledge test are not composite scale scores so internal reliability analysis was not appropriate.

Although there is no single agreed figure for an acceptable Cronbach's alpha value, on the whole, a value of .65-.80 and above is considered acceptable in human research with anything above being a sign of excellent internal reliability (Vaske, Beaman & Sponarski, 2016). For both composite measures this benchmark was achieved. This was expected for mindset as this measure has already been used in many studies and contexts (as mentioned in chapter 5) and our own measure of OGRE, developed as part of this PhD research, also showed a good level of internal reliability.

7.2.3 Procedure

The study design and data collection procedure has been described in detail in Chapter 5. As discussed there, two samples were combined following analysis, main study variables were recoded and those cases with too few responses to calculate the composite measures were excluded.

7.2.4 Analysis

Descriptive statistics and frequencies were calculated for all study variables. Between group comparisons were made using MANOVA, Univariate ANOVA and *t*-tests. Finally, relationships between study variables were explored using Pearson's correlations and multiple regression.

7.3 Results

7.3.1 Descriptive statistics for the main study measures

Means and standard deviations were calculated for all study variables. Table 7.8 shows that teachers reported balanced beliefs regarding the relative influence of nature and nurture on cognitive ability, seeing them as playing a roughly equal role (3 = equal split between nature and nurture). Teachers also tended towards a growth Mindset. Knowledge test scores were low with the average number of correct answers being 4 out of 10. Finally OGRE suggested that, on average, teachers report being relatively open to a role for genetic research in education.

Table 7.8. *Descriptive statistics for main study measures for the full sample*

	Mean	**SD**	**Measure scale**	**N**
Nature-nurture	2.78	.721	1-5	382
Mindset	4.1	1.1	1-6	387
Knowledge test	4.1	1.7	1-10	325
OGRE	4	.65	1-5	310

To look at these statistics in a little more detail, Figure 7.7 shows the distribution of teachers' responses to the item regarding their perceptions of the relative influence of nature and nurture on children’s cognitive ability. Here it is clear that an ‘even split’ represented the view of the greatest number of participants, followed by a belief in the relatively greater influence of the environment. Those who believed cognitive ability was down to ‘all genes’ made up the smallest proportion of the sample with only n=1 individual stating they believed a child’s cognitive ability was solely down to genes.

Figure 7.7. Distribution of responses regarding the relative influence of nature and nurture on cognitive ability

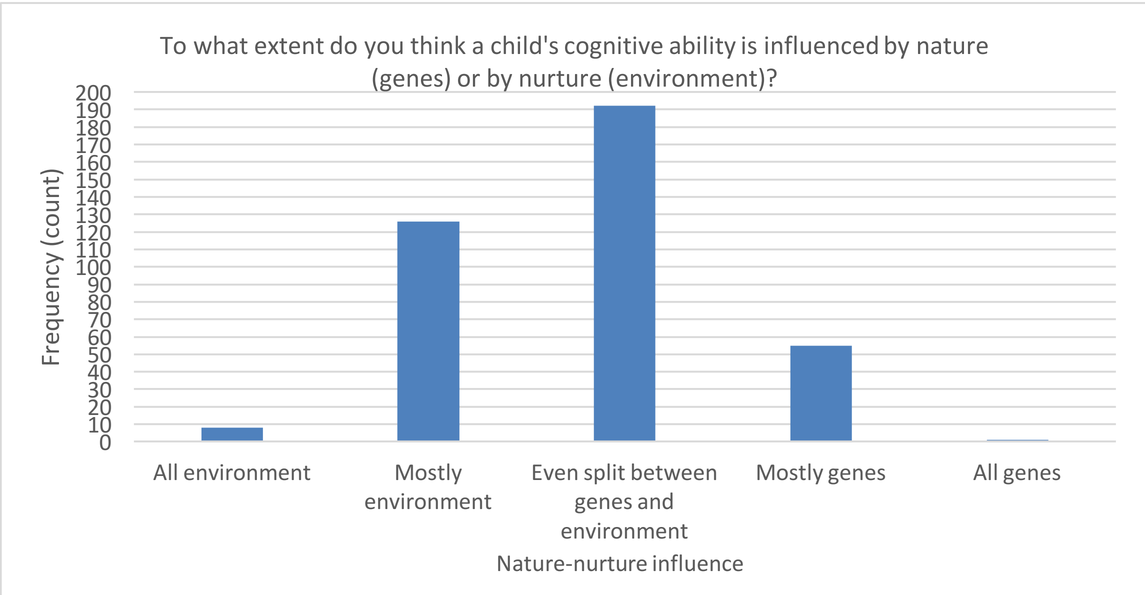


Figure 7.8 shows the distribution of mindset scores. It is clear that the majority of participants leant slightly more towards a growth mindset but that there was good variability with a small number of participants reporting both extreme fixed (1) and growth (6) mindset beliefs.

Figure 7.8. A graph to show mindset composite score across the combined samples

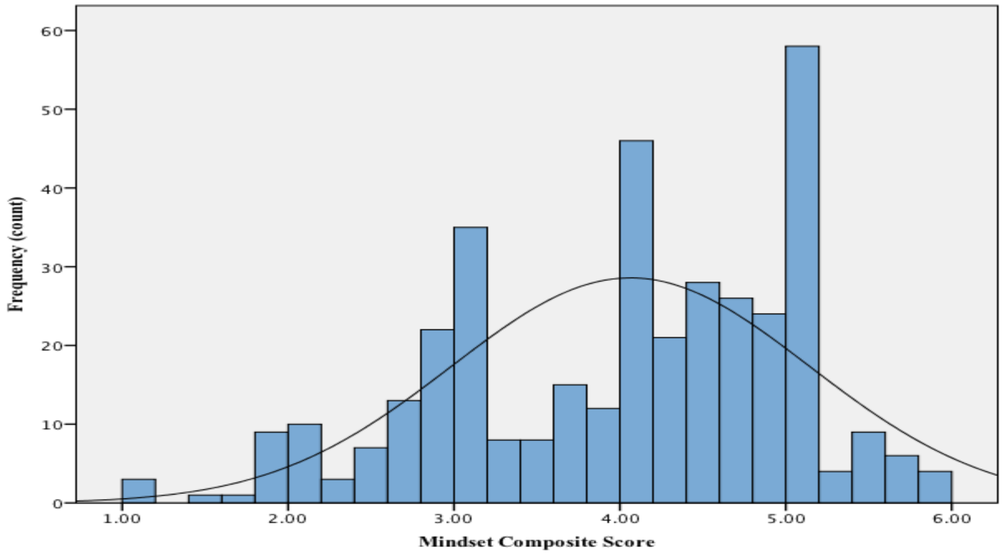
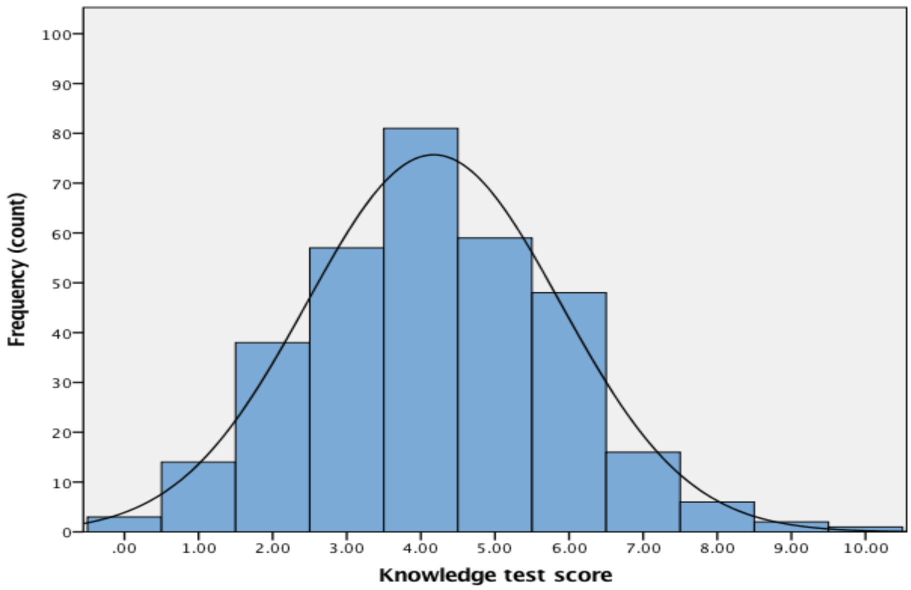


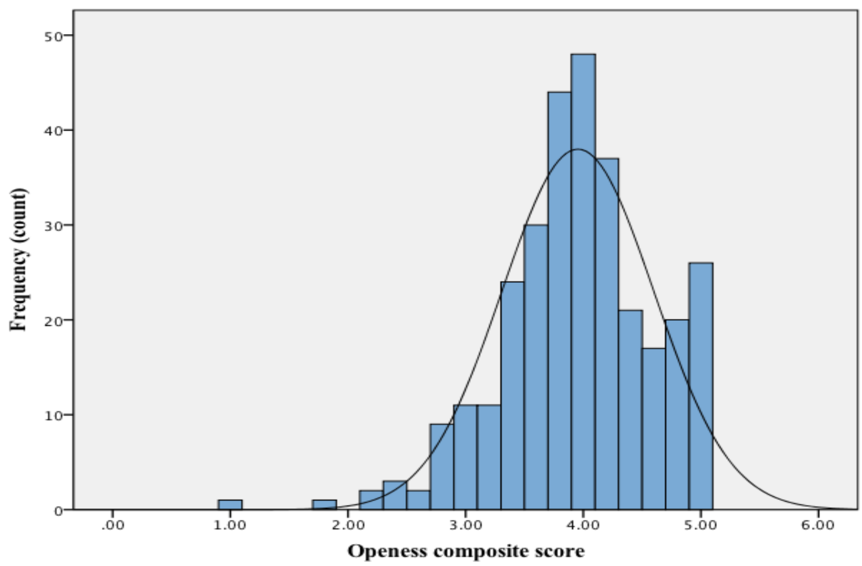
Figure 7.8. shows participants' knowledge test scores. As can been seen very few participants scored over 8 (out of a possible 10), but equally few scored 0. Overall, participants' knowledge was low but 22.4% of the sample did score more than 50%. Given that we would expect a score of 50% (5/10) just by chance, the fact that the majority (77.6%) scored below this chance threshold suggests that many were actually misinformed.

Figure 7.9. A graph to show knowledge composite score across the combined samples



The distribution of responses for the final main study variable – OGRE (openness to genetic research in education– are shown in figure 7.9. As can be seen in the graph, most participants leaned towards being open to genetic research in education; with very few being completely closed minded to the concept.

Figure 7.10. A graph to show the OGRE composite scores across the combined sample.



Despite a seemingly positive skew for mindset and OGRE, data was not transformed following tests of normality (see figure 7.11 and figure 7.12) for two reasons. Firstly, the first stage of statistical testing planned – linear regression analysis (MANOVAs and ANOVAs) – does not require normal distributions; these analyses are robust enough to stand up to violations of normality (Kim, 2015). It has also been argued that for a reasonably large sample (figures as low as 40 have been suggested as acceptable) violating the normality assumption in analysis should not cause any major problems (Pallant, 2007; Ghasemi & Zahediasl, 2012). With the sample exceeding well over this figure, then it was judged that the slight positive skew would not damage the results. A statistics expert from the university was also consulted and their opinion was also that the distributions on the Q-Q plots were acceptable.

Moreover, following discussions with other researchers it was agreed that perhaps we shouldn't expect this data to be normally distributed. The two measures of mindset and OGRE are attitudinal in nature and; therefore, it seems reasonable for the results to not follow a normal distribution curve, as it is likely, due to the individuality of people's opinions, that some individuals have outlying opinions. Teachers are not a 'normal' group in relation to the UK population and as such, it could be expected that their opinions may be skewed.

Figure 7.11. Normality test for Mindset – Q-Q plot

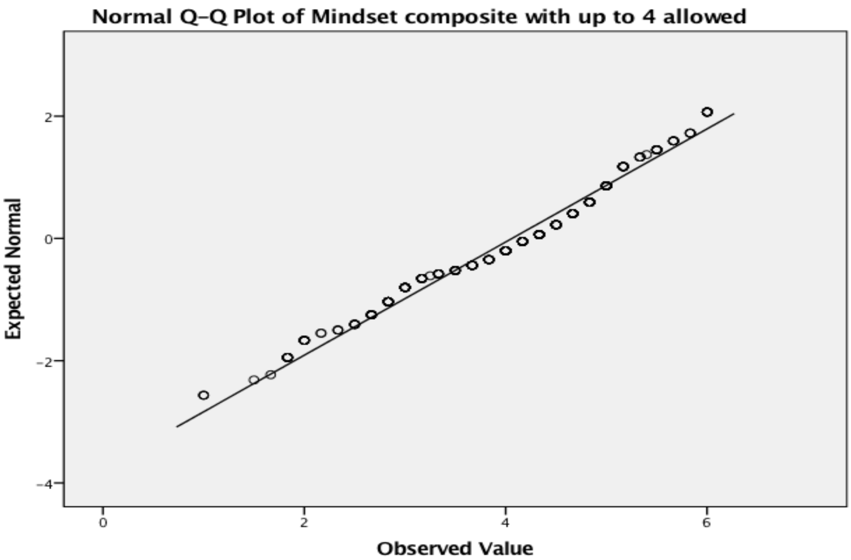
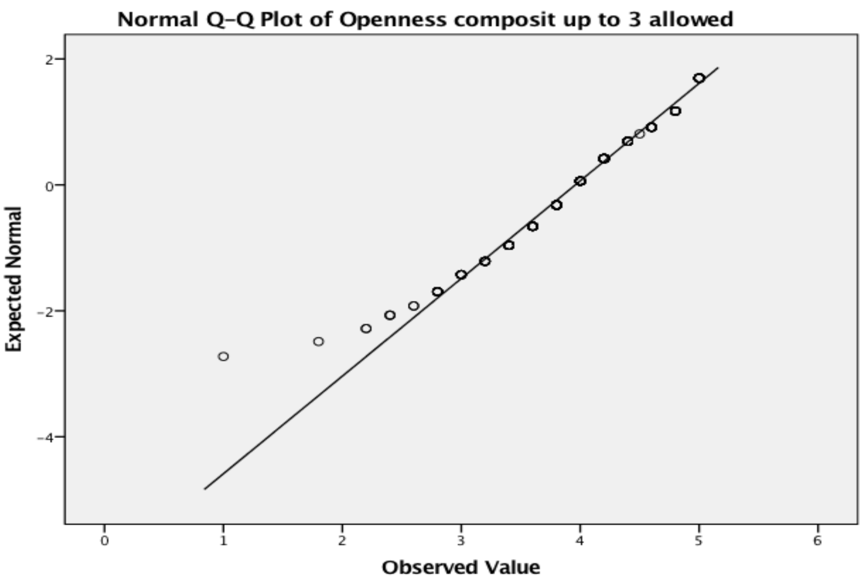


Figure 7.12. Normality test for OGRE – Q-Q plot



However, that said, Q-Q plots exploring normality were prepared as it is good practice to at least investigate the normality of data. Q-Q plots were chosen as they are recommended over statistics for larger sample sizes (over 100) (Samuels & Marshall, 2017). This was done for mindset and OGRE as these variables looked non-normal in their distribution (see figures 7.8 and 7.10). Figure 7.11 and 7.12 show the Q-Q plots for Mindset and OGRE. As can be seen in figure 7.12, mindset scores did in fact fall on the expected line despite the initial appearance of the curve. OGRE, as shown in figure 7.12, did not present such a normal plot. However, it was not exceptionally deviant from the expected norm and for reasons already discussed it was decided to leave the data for OGRE as it was and not transform for normality.

7.3.2 Differences based on demographic characteristics

It was explored whether participants' responses varied based on demographic characteristics or background factors. One-way MANOVAs were conducted to explore whether each demographic factor had an overall effect on the main study variables.
Findings are shown in Table 7.9.

Where an effect was detected, univariate analysis of variance (ANOVA) was conducted for all significant variables. These were followed by post-hoc tests (Tukey) to identify the precise source of any effect. No effect on any of the main study variables was found based on gender, teacher age, years of teaching experience, school geographical location, subject taught, or SENCO role. However, the age of the children a teacher taught and state versus independent were found to have a significant effect on one or more study variables.

School type initially showed significance when no groups were excluded however, special schools, free schools and 'other' had numbers below n=5. Therefore, it was decided they should be excluded as the group size was too small for data to be meaningful and there was a strong chance they would skew findings. However, when independent and state schools with and without religious affiliation were grouped into two groups (independent and state, regardless of affiliation) to provide larger groups, then some significance emerged. Below in table 7.9, the first school type is schools divided based on religious affiliation, the second school type listed is after religious affiliations, and non-religious affiliations in state and independent were simply grouped into just state and independent.

Table 7.9. *Multivariate Effects on the overall model (significant at p<.05 level)*

Variable(s)	Wilks' Lambda	*F*	*df*	Error *df*	Partial η2
Gender	.115	1.87	4	303	.024
Teacher age	.087	1.42	24	1047.9	.028
Years of experience	.724	.794	20	992.6	.013
Age of children taught	.013*	1.97	16	923.26	.025
School type (special school, free school and other excluded)	.086	1.6	12	764.91	.022
School type (state and independent grouped)	.020*	2.97	4	291	.039
School location	.246	1.29	8	600	.017
School geographical location	.866	.625	16	917.15	.008
Subject taught	.570	.963	76	1132.90	.060
SENCO role	.451	.923	4	303	.012

Relative influence of nature and nurture on cognitive ability

For relative influence of nature and nurture on cognitive ability One-way ANOVAs found no significant differences in teachers' perceptions of nature–nurture based on any of the demographic characteristics studied.

Mindset

School type (independent and state schools grouped)

MANOVA identified an overall effect of school type, [$F(4, 291)=2.97$, $p=.020$, $\eta2=.039$], on study measures. One way ANOVAs showed significant variation, at the $p < .05$ level for the mindset measure [$F(1, 294)=11.31$, $p=.001$, $\eta2=.037$]. When this relationship was examined further by comparing the means, we can see that teachers from state schools had a more growth mindset ($M=4.28$, $SD=1.04$) than teachers from independent schools ($M=3.85$, $SD=1.10$) and that this difference was statistically significant at the $p<.001$ level. Mindset is measured on a scale of 1-6 with

1 suggesting a completely fixed mindset and 6 suggesting a completely growth mindset. Therefore, from this analysis we can see that although both state and independent school teachers on average lean towards a more growth mindset, state schools teachers tend to be significantly more growth minded than teachers at independent schools.

OGRE

Age of children taught

Results from the MANOVA suggested that age of children taught had a significant effect on OGRE [$F(16, 923.3)=1.950$, $p=.013$, $\eta 2=.025$]. One way ANOVAs identified a significant effect [$F(4,305)=2.48$, $p=.044$, $\eta 2=.032$] between teachers who taught children of different ages. Following post-hoc tests (Tukey) it emerged that those teachers who taught children at a primary school level were significantly more open to genetic research being used or considered in education ($M = 4.16$, $SD = 0.532$) than those teaching in secondary schools ($M = 3.90$, $SD = 0.654$).

Knowledge Test

Age of children taught

MANOVA results suggested that age of children taught had a significant effect [$F(16, 923.3)=1.950$, $p=.013$, $\eta 2=.025$], on study variables. One way ANOVAs identified a significant effect on knowledge test [$F(4,305)=3.08$, $p=.017$, $\eta 2=.039$] between teachers who taught children of different ages. Following post-hoc tests, it emerged that those teachers who taught children at early years level were significantly ($p<.05$) less knowledgeable about the genetics of cognitive ability ($M=3$, $SD=1.69$) than teachers who taught at sixth form level ($M=4.95$, $SD=1.12$).

7.3.3 Correlation analyses

Table 7.10 shows that the relationship between nature–nurture beliefs and mindset was significant and moderately strong ($r = -.501$, $p < 0.01$); having a belief that genes exert more influence than environment on cognitive ability was associated with having a more fixed mindset (all environment = 1, all genes = 5; fixed mindset=1, growth mindset=6). A belief in the relative importance of genetics also had a small but significant positive association with knowledge test scores (r = .138, p < 0.05). Those with greater knowledge of the genetics of cognitive ability were slightly more likely to see a role for genes. Mindset and knowledge test scores were also significantly negatively correlated, suggesting that teachers who know more about genetics, scoring higher on the knowledge test, were slightly more likely to lean towards a fixed mindset (r = -.253, p < 0.01). No significant correlations were found between OGRE and the other main study variables.

Correlations were also explored between the only demographic factor to have a significant effect in MANOVA that was also an ordinal variable suitable for correlational analysis, age of children taught. Age of children taught was weakly but positively correlated with knowledge test scores (r = 0.11, p < .05), but no other significant associations were identified. Knowledge was significantly higher among teachers of older pupils, but only slightly. The group differences and correlational findings already presented were used to select potential predictors of nature–nurture beliefs, OGRE, mindset, and knowledge for multiple regression analysis.

Table 7.10. *Correlations between main study variables - nature-nurture, OGRE (openness to genetic research in education), mindset and knowledge test score*

Main study measures	**1**	**2**	**3**
Nature-nurture			
Mindset	-.501**		
OGRE	.078	.002	
Knowledge test score	.138*	-.253**	.069

7.3.4 Regression analyses

Both findings from ANOVA and correlations were used to identify potential predictors of each of the main outcome variables in this study, to use in regression analyses. On the basis of this logic the following predictor variables were chosen.

For belief in the relative importance of nature over nurture, Mindset and knowledge were identified as correlated variables and potential predictors; for Mindset the predictor variables to be tested were school type (state and independent grouped), beliefs about nature-nurture and knowledge. For openness to genetic research in education (OGRE) only age of children taught was used as a predictor; and, finally, for knowledge, age of children taught, nature-nurture beliefs and Mindset were used as predictor variables.

Table 7.11. *Multiple linear regressions between main study variables based on correlating demographic variables and other main study variables.*

Step 1	**Nature-nurture**				**Mindset**				**Knowledge test**		
Variables	β	*t*	*p*	**Variables**	β	*t*	*p*	**Variables**	β	*t*	*p*
Mindset	-.511	-11.26	.000**	School type (grouped)	-.179	-3.21	.001**	Age of children	.114	2.06	.041*
Knowledge test	.007		.887								
	R^2=.270	*F*(1, 379)=126.8			R^2=.029	*F*(1, 309)=10.28			R^2=.013	*F*(1, 323)=4.29	
Step 2					β	*t*	*p*		β	*t*	*p*
				School type (grouped)	-.137	-2.82	.001**	Age of children	.097	1.80	.073
				Nature-nurture	-.461	-9.46	.000**	Nature-nurture	.009	.146	.884
				Knowledge test	-.152	-3.13	.002**	Mindset	-.242	-3.84	.000**
					R^2=.272	*F*(3, 307)=39.59			R^2=.065	*F*(3, 321)=8.51	

Note: R^2 value reported is adjusted R^2 and β value is standardized coefficients Beta. Significance *p<0.05 and **p<0.01

Table 7.11 shows that multiple regression analysis found that for nature–nurture beliefs, teacher mindset significantly explained 27% (R^2 = 0.270) of the variance, and knowledge was not a significant predictor. Three variables significantly predicted mindset. However, school type only explained 2.9% of the variance, while the addition of nature–nurture beliefs and knowledge score increased the amount of variance explained to 27.2%. Finally, for knowledge, the study variables only explained 6.5% of the variance, with mindset as the only significant predictor.

7.4 Key findings

Overall

- Teachers on the whole, felt nature and nurture had an equal influence on cognitive ability– this is relatively in line with research findings.
- Teachers tended towards a more growth mindset. However, teachers from state schools were significantly more growth minded than teachers from independent schools.
- Teachers' knowledge of behavioural genetics was low. Significantly lower amongst early years teachers compared to sixth form teachers.
- Teachers on the whole, were open to the role of behavioural genetics in education. But primary school teachers were significantly more open.

Demographic findings

- Both age of children taught and school type (grouped) showed significant group differences.
    - Teachers from state schools had a more growth Mindset than teachers from independent schools.
    - Teachers who taught children at a primary school level were more open to genetic research being used or considered in education than those teachers who taught at secondary schools.
    - Teachers who taught children at early years level were less knowledgeable about genetics than those teachers who taught at sixth form level.
- Age of children taught correlated positively with knowledge test, suggesting that teachers of older children had better knowledge.
- School type explained 2.9% of the variance in mindset.

Main study measures

- Perceiving genes as playing a bigger role was correlated with a more fixed mindset.
- Greater knowledge of the genetics of cognitive ability correlated slightly with being more likely to see a role for genes.
- A higher score on the knowledge test score was correlated slightly with a more fixed mindset.
- Around a quarter of the variance in nature-nurture can be explained by Mindset.
- Around a quarter of the variance in Mindset can be explained by nature-nurture and knowledge.
- Around 6.5% of variance in knowledge can be explained by Mindset.

7.5 Discussion

Overall, the picture emerging from the research is a positive one. Results indicated that teachers see genetic and environmental factors as playing roughly equal roles in explaining individual differences in cognitive ability; that they lean towards a growth mindset; and that they are open to a potential role for behavioural genetics in education. However, it was also clear that teachers lacked knowledge and were potentially even misinformed about behavioural genetics (with most scoring below chance on our knowledge test).

Regarding the relative influence of nature and nurture, findings were in line with previous studies (Walker & Plomin, 2005) with teachers perceiving nature and nurture as playing a relatively equal role in explaining individual differences in cognitive ability and accurate in terms of the evidence which estimates the heritability of cognitive ability at approximately 50% on average (Polderman et al., 2015). Very few teachers placed themselves at either extreme, with only one individual seeing differences in cognitive ability as being fully explained by genes. However, we also know that over time, cognitive ability becomes increasingly heritable with genetic factors explaining more variance than environmental factors by the end of schooling so we may have expected teachers of older pupils to err more in favour of genetic explanations (Haworth et al., 2010).

It was also found that aetiological beliefs were significantly predicted by mindset and that a growth mindset was associated with a tendency towards an environmental explanation for individual differences in cognitive ability that is incorrect, certainly beyond the early years (Haworth et al., 2010). In terms of mindset, participants expressed a similar growth mindset to those in previous studies (Patterson, Kravchenko, Chen-Bouck, & Kelley, 2016). However, there was variation in responses, with some teachers leaning towards the extremes of both growth and fixed mindsets.

Knowledge of behavioural genetics was tested using a variation of the 'Top 10 replicated findings from behavioural genetics' (Plomin et al., 2016). It was found that teacher knowledge of the subject was low with a below-chance mean score of only 4 out of a possible 10 that suggests genuine misunderstanding or misinformation. This was not a surprising finding as behavioural genetics is not covered in school or in teacher training. The association between a higher score on the Knowledge test and holding a more fixed mindset is also interesting to note. It perhaps suggests a notion that knowing more about behavioural genetics may promote a more fixed vision of intelligence and how children can learn. This is just an initial findings and more research is warranted to understand this link, however, it does highlight the fact that increased knowledge may result in more deterministic views of cognitive ability and intelligence. Moving forward, careful observation will be necessary to ensure that knowing more about behavioural genetics doesn't lead teachers to become too deterministic in their views of their children's intelligence.

The study also showed that teachers are open to learning more and to improving their knowledge. It is encouraging that most teachers gave positive responses to OGRE items.
The overall distribution sat towards the open end of the scale with almost no participants at either extreme. Therefore, although no one was extremely open, nor was anyone extremely closed to the idea of behavioural genetics playing a role in education. This openness, combined with low current levels of knowledge, suggests that a working relationship between education professionals and researchers could benefit teachers and help them to consider their teaching practice in a new way.

Not many group differences were observed. The age of children taught and the type of school participants taught at were the only demographic characteristics studied that had a significant effect on study variables. Teachers who taught at primary schools were significantly more open to behavioural genetic research in education. This was surprising but could possibly reflect a view that there is more time to make effective changes for their pupils. It is interesting to note that although primary school teachers were more open to genetic research, teachers of younger pupils were also less knowledgeable about the science than teachers of older children.

The type of school a teacher taught at (state or independent) appeared to be linked with teacher mindset. Teachers from state schools reported a significantly more growth mindset than those from independent schools. The reasons for this are unclear but would be interesting to consider in future research, especially given the association between mindset and other study variables.

8. Continuing Professional Development: How can we educate teachers about behavioural genetics?

8.1 Background and Literature Review

Data presented in Chapter 7 shows that many teachers in the sample reported wanting to know more about behavioural genetics, and appeared to be open to a role for behavioural genetics in education. It was found that although teachers had low knowledge of behavioural genetics they were open to the possibility that genetic research could potentially be useful to teachers. These findings suggest a need to find out more about how teachers would ideally like to receive further information on behavioural genetics and to offer some practical ideas about how best to build a constructive and valuable relationship between researchers and teachers.

Continuing Professional Development (CPD) is at the forefront of teaching as a profession. The practice is encouraged by government who see it as key to effective teaching (Department for Education, 2016). In defining CPD the government refer to activities or programmes designed to sustain and embed good practice. They suggest that professional development can take various forms, such as individual activities or expert input, but should lead to improved practice and therefore improved pupil outcomes (Department for Education, 2016). Research suggests that teachers perceive CPD as beneficial and as a means to improve their professional practice and discourse (Powell, Terrell, Furey & Scott-Evans, 2003) and that their motivation and engagement with CPD is key to its impact on pedagogy and student outcomes (King, 2013; McMillan, McConnell and O'Sullivan, 2014). Effective CPD has also been found to improve pupil attainment, for example one study evaluated a CPD initiative focused on helping teachers use collaborative group work skills. It was trialled in 24 primary classrooms, with over 300 pupils, and resulted in the promotion of effective discourse and pupil dialogue during science lessons (Thurston, Christie, Howe, Tolmie & Topping, 2008). However, it is also important to note that engaging with CPD can be challenging for teachers who are subject to increasing workloads and enormous time pressures (Bubb and Earley, 2013; Murphy & de Paor, 2017). One study investigated the usefulness of teacher training days for CPD, in the context of time being a barrier to successful CPD and training days being time specifically allocated for such tasks (Bubb and Earley, 2013). A survey of over n=1600 teaching staff found that teachers perceived the usefulness of training days for CPD as limited, often citing that such days were needed for other more pressing work. This shows that, even when specific time is allocated, teachers still find it difficult to use this time to engage with useful and meaningful CPD. It is essential to address this when considering how, and in what format, CPD related to behavioural genetics could or should be delivered.

Meaningful work has been carried out in neuroscience, a similar area of advancing research that has implications for education, that has helped teachers better understand some complex scientific concepts (Dekker et al., 2012). The Wellcome Trust's "I'm a scientist – get me out of here" project ran a project specifically aimed at 'neuromyths' following research that found misconceptions about the science were common among teachers (Dekker, Lee, Howard-Jones & Jolles, 2012; Wellcome Trust, 2014; "The Science of Learning - Learning Zone", 2017). Dekker, Lee, Howard-Jones & Jolles (2012), identified these 'neuromyths' as less prevalent amongst those teachers who engaged with popular science literature and who had an increased general knowledge of the brain, highlighting that many of the most common myths centred around myths perpetuated by commercialised neuroscience education programmes (Dekker, Lee, Howard-Jones & Jolles, 2012). Neuroscience offers us a warning. If we fail to help increase teacher knowledge they may fall victim to false information, often peddled in the name of profit. Dekker et al. (2012) highlight that as well as being a waste of time, money and resources, teachers engaging in education programmes and information that are later found to reinforce myths, may later result in decreased teacher confidence in collaborations with scientists. Obviously this is something to avoid and it is suggested that high quality teacher training and CPD on topics such as neuroscience and behavioural genetics could be part of the solution (Dekker, Lee, Howard-Jones & Jolles, 2012).

With this in mind, a study from within the field of neuroscience set out to explore the effectiveness of a collaborative programme between scientists and educators consisting of a series of seminars, which could be seen as a form of CPD (Dommett et al., 2010). Teachers reported not only that they found the seminars useful and informative but that they felt more confident in implementing changes in their classroom practice, based on a sounder knowledge of the science (Dommett et al., 2010).

In addition to this, a case study by Dubinsky, Roehrig & Varma (2013), aimed to also tackle the prevalence of 'neuromyths' through their 'BrainU Workshops'. The workshop aimed to cover the core concepts of neuroscience and was given to in-service teachers in the US. After the workshop, they found that teachers' knowledge of neuroscience had increased across a range of topics, as had teachers' confidence in their own knowledge. Despite being a case study, the 'BrainU' workshops were comprehensive and long running (3 years, 160 hours). This offers us an insight into not only the value of CPD in terms of ensuing understanding and reducing myths for complex scientific ideas; but also suggests a template of how CPD could look and be made possible for behavioural genetics.

Studies related to behavioural genetics, including this one, show that most teachers have never received any formal training in behavioural genetics (Plomin and Walker, 2003; Walker and Plomin, 2005). This is in line with the current study's hypothesis that teachers will have received little or no training on behavioural genetics.

In the current project teachers' openness to learning more about the roles of genetics in education has been identified. It is therefore important to seek to understand how to balance further training in genetic research with the demands teachers face daily.

The aim of this part of this part of the study was to lay foundations for the development of useful CPD materials. In addition, the aim was to begin to suggest how behavioural genetics could be included in ITT (initial teacher training). Having found that teachers are open to a role for genetic research in education it makes sense to explore how to work with that in terms of training and dissemination in a way that would be welcomed by, and useful to, teachers.

8.2 Methods

Participants

Participants were drawn from the main study sample of full and part time teachers from across the UK in both primary and secondary schools as well as both state and independent schools. Of the full sample of n=402 participants, n=308 provided data on their views regarding CPD and training. The demographic breakdown of these n=308 was as follows: gender – 32.4% male, 67% female and 0.6% would rather not say; school age - 25.6% primary and 71.9% secondary (2.6% other) and school type – 61.8% state school, 33.7% independent school and 4.5% free, special or other school. These demographic statistics closely mirror those of the overall sample.

Means of all the main study measures were compared, using ANOVA, to explore whether there were significant differences between those who provided CPD data, presented at the end of the questionnaire, and those who did not. There was a significant difference in OGRE between those that answered 'Would you value further training?' and those who did not answer this question [$F(2,307)=33.9$, p=.000]. Following post-hoc (Tukey) analysis it was found that, as expected, those who did not answer were less open to the role of behavioural genetics in education that those who answered yes to the question 'Would you value further training?' (M =2.9, SD=.141, p=.015) but not, more surprisingly, in comparison to those who did answer but said they would *not* value further training (M=3.26, SD=.733). This suggests that the observed attrition can be partly explained by those more opposed to considering genetics in the context of education discontinuing their participation when asked about further training. None of the other main study measures showed any significant mean differences between those who answered the CPD questions and those that did not. It is likely that time constraints and distractions also had a part to play but we can see that unfortunately we lost the chance to collect more data from some of those participants more opposed to the potential role of behavioural genetics in education. It is important to bear this in mind when interpreting the findings. There is likely to be a bias in favour of teachers who are open to considering genetics in education that does not reflect the full teaching population.

Measures

Exploratory measures were developed to begin to build a picture of how teachers may want any training or education in behavioural genetics to look. All of the CPD questions used in the study were initially trialled in the pilot study (See Chapter 6) to ensure they could be clearly understood by participants.

The questions relating to CPD were asked at the end of the main study questionnaire. The first CPD section contained items that explored teachers' perceptions of some of the potential benefits that researchers in the field have claimed for behavioural genetics. A seven item checklist was developed and participants were asked to select any option they agreed would be beneficial. These potential benefits included for example 'increased focus on personalised learning' and 'ability to provide earlier and more tailored careers advice'. They were devised with the help of a researcher in the field and literature on the topic (e.g. Asbury and Plomin, 2014). The aim was to begin to establish what teachers perceive as potential benefits of applying genetic research in educational contexts.

Teachers were also asked whether behavioural genetics already played a role in their school and if 'yes' then how. This question was asked to begin to build an understanding of whether there are already the beginnings of dissemination of behavioural genetics in schools.

Section 2 of the CPD section aimed to explore questions surrounding training. A series of 'yes/no' questions were posed to establish where we currently stand in terms of teacher training and behavioural genetics. For this, three questions were posed:

- 'Did you ever receive any formal training on behavioural genetics as part of your teacher training provision?'
- 'Have you ever received any formal training on behavioural genetics during your time as a fully qualified teacher? (e.g. CPD)'
- 'Would you value further training in the future on behavioural genetics and its implications for education?'

If participants responded ‘no’ to the final question they were asked to explain ‘why not’ to begin to build a picture of resistance that may exist towards teacher training in behavioural genetics.

Finally, participants were asked to select three choices out of a possible nine with regards to how they would most like to receive training on behavioural genetics. These choices were devised from existing examples and models of CPD for teachers, for example ‘online training course’ and ‘visit from external expert to the school’. To ensure all possibilities were covered an ‘other’ option was also included with space for participants to provide their own responses.

Procedure

CPD items appeared at the end of a larger online questionnaire that was distributed via email to schools across the UK (See Chapter 5 – General Methods).

Analysis

Frequencies were calculated and presented as graphs. For qualitative open responses thematic analysis was conducted as it offers a flexible approach applicable to most data (Braun & Clarke, 2006). Qualitative data should be analysed in a rigorous and systematic manner just as quantitative data is, to ensure that results are as free from bias and as valid as possible (Nowell et al., 2017). Thematic analysis is recognised as an effective methodology for analysing qualitative data and provides an easy to use but clear, well-structured method that is easy to interpret (Nowell et al., 2017). Although thematic analysis limits specific analysis of language use and any importance that might hold, it was felt that the most important element in this study was to ensure that key themes surrounding teachers’ perceptions and opinions were grouped and clearly laid out to help begin to build a picture of the areas of fear, misunderstandings and disinterest surrounding some teacher’s opinion of behavioural genetics as well as highlighting key areas for development and dissemination (Nowell et al., 2017).

8.3 Results

Potential advantages of behavioural genetics research

Teacher participants were presented with a list of seven potential advantages that behavioural genetics may be able to offer education now or in the future and asked to select as many as they felt would in fact be beneficial to their professional practice. Figure 8.1 shows the proportion of the sample to identify each of the seven suggestions as something that could benefit their practice.

Figure 8.1. Preferred potential advantages of behavioural genetic research that may benefit professional practice

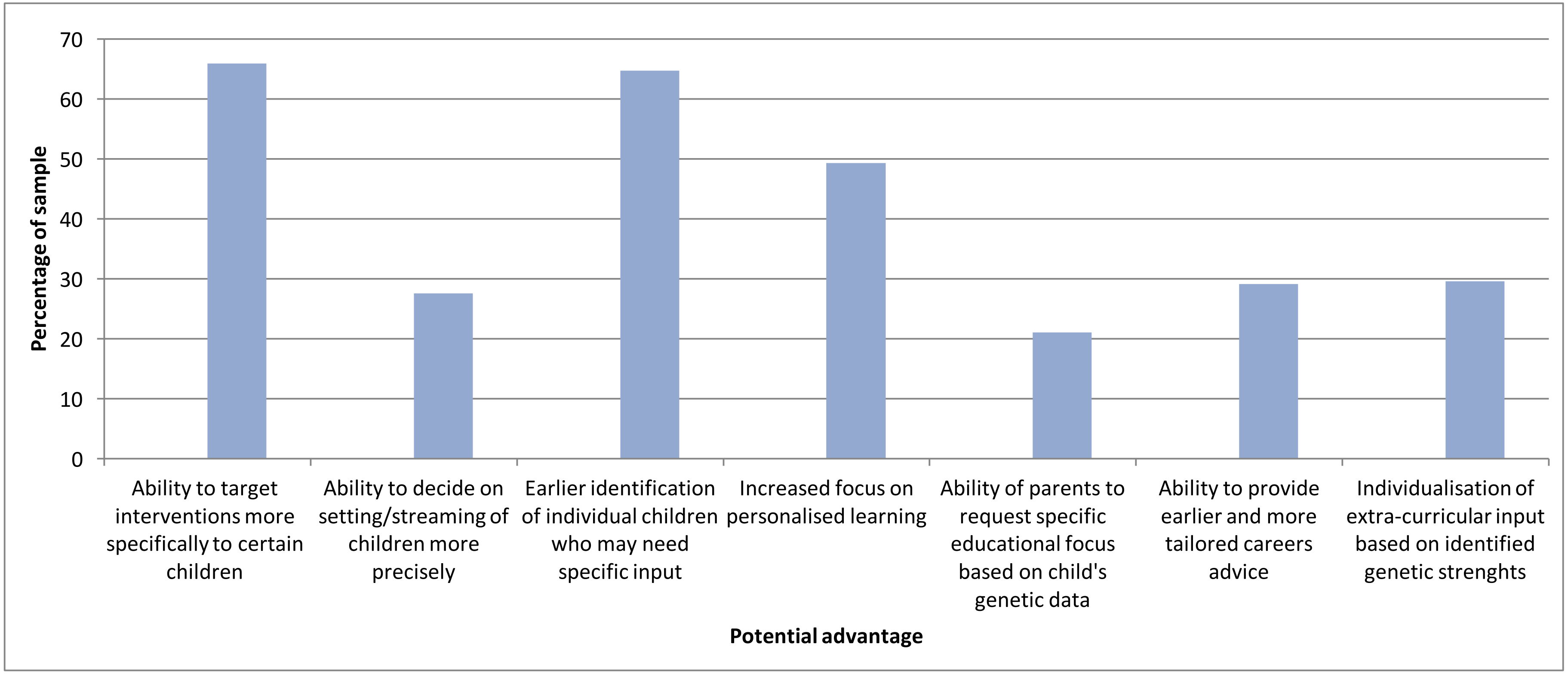


Figure 8.1 shows that the two advantages most frequently identified as potentially beneficial to professional practice were the ability to target interventions more specifically (66%) and the earlier identification of children who may need more specific input (65%). The third most selected choice was an increased focus on personalised learning (49%). These three potential advantages of behavioural genetic research were noticeably more popular than possibilities centred on segregating children or singling children out, such as more accurate streaming and setting or parental requests for individual focus for their children (28%). Here we have begun to build a picture of how teachers may envisage behavioural genetics playing a positive and realistic role in their practice, if the research reaches a stage where this could realistically be offered. What we can see is an appetite for bespoke educational solutions – personalised education along the lines of developments in personalised medicine (which has begun to emerge as an alternative to the 'one size fits all' approach (NHS England, 2016))

Behavioural genetics already in the classroom

Teachers were asked whether they felt that behavioural genetics already played a role in their classrooms. As expected, only 14% of respondents felt that it did play some kind of role. This figure was expected to be low, as previous research has suggested that on the whole, findings from psychological and neurological research fail to filter down into the profession or into teacher training (Dekker et al., 2012). Participants who said behavioural genetics *did* play a role were asked *how* they thought behavioural genetics already played a role in their classroom and results from a thematic analysis of free-response data, provided by n=35 teachers are presented in Table 8.1.

Table 8.1. *Thematic analysis of qualitative responses to item: how behavioural genetics already plays a role in the classroom*

Theme/category	Example(s)	N
Assisting with behavioural issues and family problems	'If you know about certain behaviours then you can develop strategies to cope with them…' 'A lot of children at our school have behavioural issues, potentially down to inadequate parenting…Therefore the behavioural issues can hinder the child's learning…It would be hugely helpful to have more research into this area…to be able to tailor our teaching to push those children to reach their full potential.'	8
Assisting in the teaching of children with a specific diagnosed learning needs– autism, dyslexia, mental health conditions .etc.	'When dealing with a child on the autistic spectrum, we approach their issues very much from a sense of it being a genetic thing…regardless of the environment…' 'CAMHS [child and adolescent mental health service] fails our students due to lack of funds/expertise, we try our own intervention but are mostly in the dark. We apply genetically diagnosed SEN profiles…from ed. psychs.'	6
Personal engagement with the research in professional practice	'Have read Kathryn [Dr Kathryn Asbury]'s book and seen her talk…led me to be more open to what is affecting learning and behaviour…'	4
Personalised learning and holistic learning approaches	'…Personalisation of learning but this knowledge comes with some reservations.' 'Holistic approach taken to child's education – looking at the bigger picture.'	6
Individual learning plans and specific interventions	'Individual learning plans are written for identified pupils.'	3
Mindset/self-esteem beliefs and mindset teaching in schools	'We promote 'growth' mindsets and 'grit'…not sure if these research ideas count as genetics…' '…no fixed intelligence belief is actively taught in schools…'	4
Early childhood development	'Work with the early years collaborative…has raised our awareness of how epigenetics can affect children's development…'	1
Personal views and criticisms of behavioural genetics	'I am very wary that information attending to genetics is misused in education…' '…we need to discriminate between good and bad research in all fields…some people believe that intelligence is inherent…I find that profoundly anti-educational.'	3

It is clear from Table 8.1 that some respondents misunderstood the question, focusing on what behavioural genetic research *could* contribute rather than describing how it already played a role in the classroom. Overall, issues regarding behaviour, specific educational learning needs and personalised learning emerged as the most frequently used in schools by teachers who felt behavioural genetics already played a role. However, it was not clear from responses that behavioural genetic research did in fact play a role in most instances. A number of respondents used this platform to just express an opinion or to mention something their school was doing that wasn't necessarily related to behavioural genetics. This adds to the picture found in the main results that teachers lack knowledge of the subject. For example, 'We promote 'growth' mindset and 'grit'…not sure if these research ideas count as genetics…' highlight some of the misconceptions present. Another major source of misunderstanding emerged when teachers frequently related behavioural genetics to behaviour difficulties. For example, one teacher suggested that behavioural coping strategies were related to behavioural genetics. It's difficult to tell from their short response exactly what was meant by this, but it's also difficult to see how they think behavioural genetics is helping them deal with bad parenting and behavioural issues. It seems in some cases teachers used the open elements of the questionnaire to vent their general frustrations about the education system at the moment. The clearest understanding seems to emerge amongst teachers who mention behavioural genetics playing a role in helping with children with additional learning needs. They made mention of genetically sensitive learning plans and the acknowledgement of genetic conditions. This difference amongst teachers who teach children with additional learning needs has been explored in more depth and these findings suggest that some alternative provision teachers may display a greater insight into the role of genetics and be aware of the impact it can have on the children they teach.

Training received

Participants were asked whether they had ever received any training on behavioural genetics, either as part of their initial teacher training or subsequently. Findings here were in line with the hypothesis that teachers would have received little to no training on behavioural genetics, with only 4% answering 'yes 'for teacher training and 6% saying 'yes' during their subsequent career. Teachers were also asked if they would welcome training on the subject of behavioural genetics and responses were encouraging, and in line with the OGRE statistics reported in the last chapter. When asked 'Would you value further training in the future on behavioural genetics and its implications for education?' 88% said they would value further training with only 12% saying they would not value further training on the subject. It is important to note though that the ~100 participants that did not provide data for this section were, on average, more likely to be less open to behavioural genetics.

Qualitative explanations were sought from those participants who did *not* want further training. Table 8.2 shows the themes/categories that emerged from these responses, the frequency of their occurrence and some examples.

Table 8.2. *Qualitative responses as to why participants did not want to receive additional training on behavioural genetics*

Theme/category	Example(s)	N
Lack of time/not priority/too many other initiatives	'Need to focus on more immediate things' '…This wouldn't be a priority…that being said I am always interested in further reading about learning…'	9
Lack of interest	'Perhaps the title doesn't enthuse me.' 'I don't really believe in it.'	5
Opposition/doubts in relation to the research	'Ethically, not sure what the implications would be…implies a eugenicist style state?' 'It depends on how established the information is. Are we still guessing or do we have factual evidence?'	9
Doubts surrounding how it could be used in school	'Not until the evidence is clearly linked to teaching and outcomes.' '…It just provides them with more excuses and a reason to behave how they want without consequences.'	5
Unsure as to what behavioural genetics is/what info on that first	'I would like to receive information about the findings initially…' 'Not really sure what it is'	3
Due to retire/change career soon	'Retiring shortly'	3

Here we can see that some teachers have reservations that reflect the reputation of genetic research in some quarters (Tabery, 2015). The main areas of concern focused around lack of time and lack of behavioural genetics being a priority – this is unsurprising in the face of a crisis in teaching driven by increased workload and demands on teachers (Adams, 2018). It is likely that the topic here is not the issue and that this response would likely appear a concern for any additional work that teachers were being asked about. The priority then, is to ensure that any dissemination of the research is manageable for teachers. The other popular reason to emerge as to why participants would not like to receive further training was due to opposition and doubts surrounding the research – primarily twin studies – behind the findings in behavioural genetics. This is a difficult situation to necessarily remedy. It is likely that a lot of this fear stems from misunderstandings and misrepresentation of the subject, and without training then we will struggle to begin to address this problem. Perhaps as behavioural genetics continues to enter the public sphere, then a better knowledge will be gained by teachers. However, there is also the risk that this problem could only get worse if media coverage fails to portray the science and the potential positive outcomes accurately.

Preferred training style

Finally, participants who were interested in further training were asked how they would prefer to receive any training about genetics in education. Participants were asked to select up to three choices of training delivery. Figure 8.2 shows how popular each of the options was.

Figure 8.2. Popularity of training delivery methods based on selection in top three

Those who selected ‘other’ numbered only n=5 and these participants made suggestions such as research papers to read, in school sessions and exams for teachers to sit on the topic.

It is clear that an in-school training day or a visit/meeting with an expert were the most popular choices. This suggests that teachers want direct and intensive training. Perhaps it also suggests that they want to be able to discuss the ideas and their application with the experts, and to have a more face-to-face experience. However, less direct (and less expensive) methods such as online training courses and documentation weren’t dismissed. The least popular methods included peer training and video training, perhaps reflecting a sentiment that teachers want the information directly from the ‘experts.’

8.4 Discussion

Overall, what has emerged from this initial exploration of how CPD on behavioural genetics might look is that teachers have not received training in behavioural genetics, do not feel that behavioural genetics currently plays a role in the classroom, but are open to learning more.

Benefits and cautions

Despite behavioural genetics in education currently not being in the mainstream, teachers did identify the potential benefits they would like to see concerning what behavioural genetics could offer their schools. Most selected developments surrounding the improvement of helping children who may need additional support and being better equipped to do this. As well as knowing how to help them more specifically and with greater accuracy. It also reflects the sentiment that teachers understand that there are individual differences and they want to be able to acknowledge this in their practice. Perhaps this personalisation could reflect the move in medicine towards a more personalised approach. The National Health Service in the UK has already begun to release reports on personalised medicine and termed it 'a new era for medicine' (NHS England, 2016). Would it be so far-fetched to begin to think that this could be the way forward for education? Based on the results of teachers' opinions reported in this study it would seem not. From the qualitative data analysis, we can already see inklings of this emerging, for example, some teachers expressed support for personalised learning in general, and others mentioned taking personalised approaches towards children with conditions such as Autism. One teacher also mentioned the Early Years Collaboration in Scotland, designed to offer a multi-disciplinary approach to early years for each child in Scotland (The Scottish Government, 2008). This is not too far removed from how this idea of personalised learning could be conceptualised and suggests this teacher feels that such programmes are beneficial and a continued move in that direction is desirable.

It is for behavioural geneticists, in consultation with education experts, to responsibly evaluate whether the science is at a stage where such contributions could reliably be made. The risk here is that the science enters educational discourse too soon and without full understanding by those in the professions – this creates the risk of misconceptions and misunderstandings becoming rife and we risk repeating the mistakes seen in similar situations, as with neuroscience (Dekker et al., 2012; Howard-Jones & Fenton, 2011). In the case of neuroscience the issue mainly centred on the fact that teachers were misinterpreting findings from neuroscience which in turn led to incorrect interpretations in their classrooms (Dekker et al., 2012). Obviously this is not a desirable outcome for behavioural genetics, particularly when we bear in mind the controversies surrounding the subject. As Dekker et al. (2012) suggest, the emphasis must be on the need for enhanced communication between researchers and educational professionals, this, rather than simply giving teachers the information without on-going conversation seems to be key. We should heed what happened in neuroscience as a cautionary tale.

When it came to what benefits teachers were not so keen to see… informing practices that segregate or separate children, such as setting and streaming, came to the fore. Perhaps this is down to the fact that this is already a routine practice in schools and teachers either feel that it is not working or that they do not need anything else to help them make decisions about setting and segregating children. Prior attainment is likely to be a more realistic guide than genetic potential. Or indeed it may be that they feel that is something that should not be done in schools. Currently it is common practice in secondary schools to set or stream children based on ability. The lack of popularity surrounding this potential benefit may reflect a growing dislike of this practice. A number of studies suggest that teachers may have reservations about ability grouping, with teachers mentioning issues surrounding setting such as difficulty in motivating students in lower sets (Hallam & Ireson, 2003; Smith & Sutherland, 2003). Other research also suggests that ability grouping as well as being unpopular is actually also unhelpful and even harmful to students (Francis et al., 2017). Full exploration of this is beyond the scope of this study but it something interesting to consider for future studies.

Current role of behavioural genetics

On the whole teachers felt that behavioural genetics did not already play a role in their classroom. When questioned, teachers who suggested behavioural genetics did play a role were often mistaken in what they thought behavioural genetics was (for example many cited special needs plans as behavioural genetics), highlighting misconceptions. This adds impetus to the need to address these misconceptions and misunderstandings in order to ensure that behavioural genetics is understood fully by the people who may want to use it in their professional practice in the future. This is a pressing, practical concern as genomewide polygenic scores are increasingly being calculated and have some potential to be commercialised and applied to the science of teaching and learning (Plomin and Von Stumm, 2018).

Training

Training at both the teacher training level (ITT) and during Continuing Professional Development has contained, for the majority, no content on behavioural genetics. This was the finding we anticipated.

However, a large proportion of respondents expressed a desire to receive some education and training in this area. This is encouraging as it suggests that despite low exposure to the science (and therefore low knowledge); teachers are keen to learn more. This fits with the positive responses to the OGRE scale reported in Chapter 7. Some reservations were expressed in the qualitative comments options when the minority who suggested they didn't want training were asked for their reasons why. These reservations can be roughly split in two. On one side, there were teachers who just did not see it as a high priority. Some said they simply didn't have time, were retiring soon or were not interested enough to make time for training in this area. This is understandable, teachers' schedules are hectic and we cannot expect them to devote any significant amount of time to a new science that would require their attention, especially when the potential for application may yet be a long way off. This suggests that any training should be concise and not overly time consuming. However, even this initial training could prove valuable in terms of beginning to get educators interested and working with scientists, as well as guarding against the risk of misunderstanding and misconceptions as behavioural genetics comes increasingly to the fore in public discourse and media (Morin-Chassé, 2014; Crosswaite & Asbury, 2016).

For others there were clearly fears and misconceptions about behavioural genetics itself, including doubts about the validity of the research. Of course, with training it is possible that these opinions may shift but if a small minority of teachers are hostile towards behavioural genetics the opportunity may not arise to tell them about the research. The reservations expressed show us that any attempts to disseminate genetic research to teachers won't come without some level of discontent and opposition, as has been seen in the public arena (Crosswaite & Asbury, 2016). For future research that may look to inform teachers, it is worth bearing this in mind and considering how to address the common misgivings teachers might have about behavioural genetics research and how we might approach this as a research community. The solution to this, based on what has been found in this study, centres around increasing teachers' knowledge of the subject as well as ensuring that we address common misconceptions, particularly around fears of segregating or singling out individuals.

In terms of deciphering how teachers may want to receive any training – face-to-face options (in-school training day, visit from external expert and meeting with behavioural geneticist) all proved to be the most popular options. On-line training courses also proved relatively popular, although less so. It would obviously be difficult to facilitate face-to-face training (the most popular delivery method) for a large number of teachers in a large number of schools and online training, led by experts, and may offer a more feasible alternative, perhaps in MOOC format – although this would have to be well thought out as 'video training' was not a popular choice. We know that CPD is valued by teachers and that it can have positive impacts on their classroom pedagogy (Powell, Terrell, Furey & Scott-Evans, 2003; King, 2013; McMillan, McConnell and O'Sullivan, 2014). Online resources such as those developed by the Wellcome Trust (2014) provide us with a potential model for valuable teacher CPD. However, that is not to say other methods should be ruled out. Further exploration into the inclusion of training on behavioural genetics in ITT is also an area that needs addressing. From these findings it is suggested that the best next steps would be to first establish an online resource for teachers, something they can refer to that offers information that is relevant to their practice and suggests ways in which they could incorporate lessons from behavioural genetics.

Overall, these findings offer us a unique insight into not only the situation in teaching at the moment regarding the role of behavioural genetics but also a clear picture of how we can move forward. Currently there is almost no mention of behavioural genetics or its possible applications appearing anywhere in teacher training. For us, this seems like a missed opportunity. Teachers have clearly expressed their desire to know more and to receive more training, suggesting that they see the potential for behavioural genetics to offer a genuine contribution and even alternative to some current directions in education. We must see this as a positive incentive to encourage the conversation between teachers and researchers and to ensure that we guard against the mistakes in dissemination that have been made in the past. When looking to the research questions we can see that our predictions were accurate – behavioural genetics is not present in ITT or CPD for most teachers and often those who think it is are mistaken. Yet, as predicted, many teachers want to know more. However we cannot ignore the minority who have voiced concerns and the sentiments they have expressed provide us with guidance and insight into the areas of the science that may prove particularly challenging to disseminate. With some further research, and by beginning to make the first steps towards useful CPD and potentially ITT for teachers, we can hope to dispel such misconceptions and fears and maybe offer teachers a genuinely useful and informative insight into behavioural genetics that could change their teaching practice for the better.

Limitations and future research

There are a number of limitations to these findings which extend across the whole of the study. Firstly, the sample was self-selecting. Teachers could choose whether or not to take part and as such we may not have garnered opinions from teachers not interested in the topic. Moreover, we relied on the receptionist in most cases to pass on the email; so some teachers, although included in our sampling strategy, may never have had chance to respond. Also, despite attempts to boost underrepresented groups we still did not manage to recruit a representative number of teachers from Wales and Northern Ireland, or from state primary schools. However primary school teachers have been focused on in previous studies (Walker & Plomin, 2005). These issues were somewhat exacerbated by the fact that the sample was reduced by around n=100 by the time it got to the CPD section of the questionnaire. Although the sample size was still reasonable at n=308, findings can only act as a foundation for beginning to build up a better picture of how a conversation between researchers and educators might look.

In terms of future research directions there are several avenues to explore. There is a need to explore why some teachers express resistance towards behavioural genetics and what can be done to address this – why do some teachers fear behavioural genetics? There is also a need to continue exploring the misconceptions and misunderstandings teachers have at the moment as this could help inform the focus and direction of any future training/CPD materials that may be created. Do teacher misconceptions stem from media portrayals of behavioural genetics or from their own experiences in the teaching profession? Along these lines, the other main avenue for future research would be to begin to explore the feasibility and effectiveness of different CPD methods with regards to behavioural genetics. Here it will be important to remember that CPD should not only be effective but must also appeal to teachers, and acknowledge the existing demands on their time and energy.

Conclusion

In conclusion, this element of the study has provided a new insight into where we currently stand in terms of training and desire for training on behavioural genetics among the UK teaching profession. On the whole, the picture is positive. The majority of participants expressed interest in receiving training on genetics in the future and most have not received anything so far. There is an opportunity for academics to disseminate findings to those 'on the ground'. These findings have also given us a better idea as to how teachers may want to receive this training and what teacher resistance and misconceptions may make this challenging. The next step is to explore further some of reasoning behind the opinions expressed by teachers in this section, as well beginning to work towards developing and evaluating effective training and education for teachers on the topic of behavioural genetics and its implications for education.

9. What do teachers from alternative provision settings believe about the role of genetics in education?

9.1 Introduction

After exploring the perceptions of mainstream teachers, it was decided to go a step further, building on this work by exploring whether teachers working in alternative provision (AP) settings, i.e. special schools and pupil referral units, have similar perceptions and beliefs about genetics applied to education. The interest in exploring this sample originally stemmed from some differences observed when n=5 teachers from special schools in the mainstream study provided data as part of the 'other; category. This sample was far too small for meaningful conclusions to be drawn, and these participants were therefore excluded from analysis, but their responses prompted the decision to dig a little deeper in this area. This decision was supported by the fact that there has been no exploration of how teachers in AP settings perceive behavioural genetics in education and the relevance of its findings to their work.

9.2 Research Questions

This study of AP teachers' beliefs asked:

1. Do the beliefs of AP teachers replicate mainstream findings that teachers see the influence of genes and environment on cognitive ability as roughly equal?
2. Do the beliefs of AP teachers replicate previous research that found the majority of teachers in mainstream schools believed individual differences in behaviour problems are explained more by environmental than genetic factors?
3. Do AP teacher beliefs about, and attitudes towards, genetics vary by factors including gender, age, the age of children they teach, years of experience and school type?

4. Are teachers in special schools and PRUs open to a role for behavioural genetics in education?

5. How do findings from special schools and PRUs differ from to those from mainstream schools?

9.3 Methodology

Participants

After compiling data from various sources, it was estimated that there are 23,112 teachers working across special schools and pupil referral units in England. In order to estimate the sample size needed for the current study the formula for a simple random sample was used. It is acknowledged that the sampling technique employed would not genuinely result in a simple random sample. However, it was decided that this was the best available approach. In this case, for 90% confidence intervals (the lowest level commonly used in social sciences (Albers, 2017) and a margin of error of 5% a sample size of n=266 would be required and a sample of n=103 was recruited. Therefore, the sample size was clearly small and cannot be generalised to the whole population – we cannot be sure it is representative of AP teachers in the UK.

Participants were recruited by emails to special schools and PRUs (AP settings) and by social media. This was deemed appropriate because the study of mainstream teachers had found the two approaches to yield broadly equivalent samples. Initially school receptions or school head teachers were contacted with a request for them to forward the questionnaire link to their full and part time teaching staff. Responses came back to the researchers anonymously. All special schools and pupil referral units in England, i.e. the full population, were contacted in this way and were asked to pass on the questionnaire to their teachers. Some participants were also recruited via social media. Efforts were made to engage relevant associations and unions with the process and, as a result, the NASS (National Association for Independent Schools & Non-Maintained Special Schools) agreed to distribute the questionnaire via their newsletter.

Table 9.1 presents the demographic makeup of the sample. Unfortunately, it was not possible to identify any government statistics that would allow us to check the representativeness of the sample against the UK AP teacher population.

Table 9.1. *Demographic make-up in percentage of alternative provision sample*

Demographic characteristic	**Valid percentage**
Gender	
○ Male	17.5
○ Female	81.5
○ Would rather not say	1
Teacher age	
○ 20-30	13.6
○ 31-40	25.2
○ 41-50	27.2
○ 51-60	21.4
○ 60+	12.6
Years of teaching experience	
○ 1-5	16.5
○ 6-10	17.5
○ 11-15	15.5
○ 16-20	15.5
○ 21-25	13.6
○ 26-30	11.7
○ 31-35	4.9
○ 35+	3.9
Age of children taught	
○ Primary	17.6
○ Secondary	46.1
○ Both	28.4
○ Other (special, EYSF, post 16, ASD school)	7.8
School type	
○ State run special	41.7
○ State run PRU	26.2
○ Independent special	8.7
○ Independent PRU	1.9
○ Other (SEHM school, mental health hospital, one to one)	5.8
○ Specialist provision	15.5

To look at these percentages in comparison to the mainstream study, it can be seen that the AP sample included more female participants. In the mainstream study, 32% of respondents were male and 66% female. In the AP study only 17.5% were male. In both studies, only a tiny percentage of respondents chose not to disclose their gender.

Comparing teacher age in the AP sample to the mainstream sample, teachers over 50 once again made up a moderately large percentage of the sample (34% for AP teachers, compared with 23% for mainstream teachers). Also, similar to the mainstream study, teachers in the youngest age groups had the lowest representation. In terms of teachers in the middle age brackets, in the mainstream study teachers aged 30-50 made up 53.9%, which is very close to findings in the AP study where teachers in the 30-50 age bracket made up 52.4% of the sample.

When we compare years of teaching experience between the studies, it is first worth noting that no participants in the AP study stated that they were NQTs. Moving on to teachers with 1-5 years' worth of experience, in the mainstream study they accounted for 28.5% of the sample and in the AP study they made up a smaller percentage at 16.5%. This is perhaps not surprising as AP teachers are more likely to be specialists, with more experience. In the mainstream study teachers with 6-10 years of experience made up 24.2% of the sample, teachers with 11-15 years made up 18.6%, 16-20 years made up 12.7% and 20+ years represented 29.5% of the sample. In the AP study, the same categories were 17.5%, 15.5%, 15.5% and 34.1%. Overall, the AP study did not differ noticeably in the experience distribution. There were fewer teachers with less experience but this may reflect the nature of alternative provision work, to which more experienced teachers, may be drawn.

Looking at the distribution based on the age of the children taught, in the mainstream study 24.1% of teachers taught in primary schools and 63.3% in secondary schools. In the AP study, 17.6% of teachers were primary school teachers and 46.1% were secondary school teachers. Overall the distribution is similar and the overall lower percentages can be accounted for by the fact that all-through schools are much more common in AP settings meaning that 28.4% of the sample in the AP study were teaching children across primary and secondary school age groups.

When it comes to comparing school type, direct comparisons are difficult to make as the AP sector encompasses a wide range of school types that have no direct comparison in the mainstream sector. However, we can compare the distribution levels of state-run and independent establishments. In the mainstream study, 65.7% of responses came from teachers in state run schools and 32.3% of responses came from teachers working in the independent sector. When this is compared with the AP study, 67.9% of teachers were working in the state sector and only 10.6% in the independent sector (however it is worth noting that some individuals who said they worked in a 'specialist provision' may be doing so within the independent sector). The remaining 21.3% were distributed as follows – 'other'5.8% and specialist provision 15.5%.

Of course, it was not necessarily expected that the figures from each respective study would necessarily be the same, as there are no official figures for alternative provision teachers, but the comparison allows for some contextualisation of the sample.

Measures

Four main variables were focused upon on in this questionnaire study. Perceptions of the aetiology of cognitive ability, perceptions of the aetiology of behaviour problems, openness to behavioural genetics and the role that behavioural genetics does and could play in AP schools. The first measure asked participants about their beliefs regarding the genetic and environmental aetiology of traits. Participants were asked to estimate the relative influence of nature and nurture on cognitive ability – as in the mainstream study (see Chapter 5). However, they were also asked to estimate the relative influence of nature and nurture on a range of behaviour problems using the traits represented in the Strengths and Difficulties Questionnaire (SDQ) developed by Goodman (1997). They were asked to rate relative genetic and environmental influence on anxiety, prosocial behaviour, hyperactivity, conduct problems and peer problems using a 5-point scale ranging from all environment to all genes. Participants were also asked to respond to the Openness to Genetic Research in Education (OGRE) scale, as in the mainstream study. The scale has 5 items and participants use a 5-point scale to indicate level of agreement. Reliability in the current sample was acceptable at $\alpha = .70$. Full details of this measure can be found in Chapter 5.

Finally, participants were asked for their beliefs regarding the role of behavioural genetics in school. Participants were asked if they felt that the science of behavioural genetics already plays a role in their school or classroom and, if so, how? They were also asked whether they would value training on behavioural genetics and its implications for education. Once again, this measure closely mirrored the one used in the mainstream study to allow for direct comparison.

Open Science Framework

Emerging as an important tool for any researcher in psychology, the current study was preregistered with the Centre for Open Science; using the Open Science Framework (https://osf.io/sav8r/). The Open Science Framework (OSF) is described as:

…a tool that promotes open, centralized workflows by enabling capture of different aspects and products of the research lifecycle, including developing a research idea, designing a study, storing and analysing collected data, and writing and publishing reports or papers (Foster, MSLS & Deardorff, MLIS, 2017,p.203).

In summary, it is an online registration site where you submit your research proposal, with a particular focus on precise research questions and planned analysis. Your submission is then reviewed (lightly) and stored on the site for public view. The process aims to improve the transparency of research in psychology and to help improve research credibility and self-reflection within the research community (Klein et al., 2018). Because hypotheses and planned analyses are stated in advance this avoids the temptation to go 'data fishing'.

It is likely that such pre-registration will become the norm to enhance accountability and reduce data fishing in psychological research. It has been a valuable experience to be involved in this process, allowing reflection on the proposed research before commencing data collection. Preregistration of the study ensured that the whole process from start to end was been thoroughly thought through, and that there were clear goals and steps to achieve this already set out and approved by another research body.

Analyses

Descriptive statistics were calculated for all study measures. Correlations, *t*-tests and MANOVA were also used to address the study's research questions.

9.4 Results

9.4.1 Descriptive statistics

Table 9.2 shows means and standard deviations for teachers' perceptions of the relative influence of genes and experience on six traits (1 = all environment; 3 = equal; and 5 = all genes) and the OGRE measure.

Table 9.2. *Descriptive statistics for main study measures*

	Mean	SD	Measure scale	N
Cognitive ability	2.92	.67	1-5	103
Behaviour – prosocial	2.44	.61	1-5	103
Behaviour - hyperactive	3.05	.83	1-5	103
Behaviour – negative emotions	2.37	.70	1-5	103
Behaviour – conduct problems	2.38	.67	1-5	103
Behaviour – peer problems	2.54	.61	1-5	103
OGRE	4.05	.60	1-5	94

Descriptive statistics suggest that teachers, on average, saw genes and environment as playing a roughly equal role (*M*=2.92) in explaining individual differences in cognitive ability. There was more of a leaning towards environmental explanations for negative emotions (*M*=2.37), conduct problems (*M*=2.38) and prosocial behaviour (*M*=2.44) and a very slight leaning towards genetic explanations for hyperactivity (*M*=3.05). As in the mainstream sample, participants said they were open to a role for genetic research in education (*M*=4.05).

To look at each measure in more detail frequencies were explored. Results are presented in graph format in Figure 9.1. Figure 9.1 shows the distribution of responses to the question about the relative influence of nature and nurture on cognitive ability. It is clear that the majority (55.34%) of teachers said that genes and environment play an equal role in explaining a child's cognitive ability. No respondents went to the extremes saying they felt it was down to either 'all genes' or 'all environment'.

Figure 9.1. Distribution of responses regarding the relative influence of nature and nurture on cognitive ability

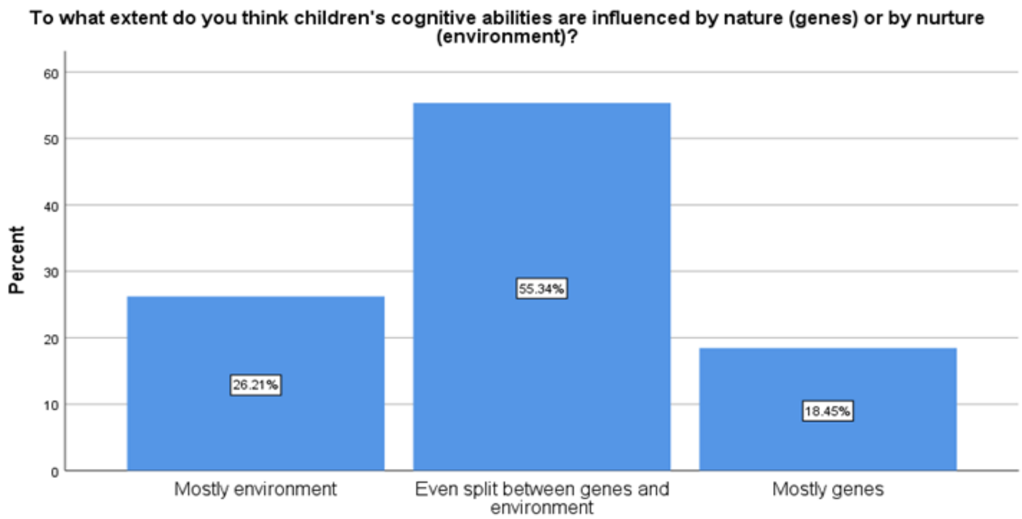


Figure 9.2 shows the distribution of responses to the question regarding the aetiology of children's prosocial behaviour. As shown, a majority (59.22%) felt that this was mostly influenced by environment, with very few advocating genes as the primary influence.

Figure 9.2. Distribution of responses regarding the relative influence of nature and nurture on positive prosocial behaviour.

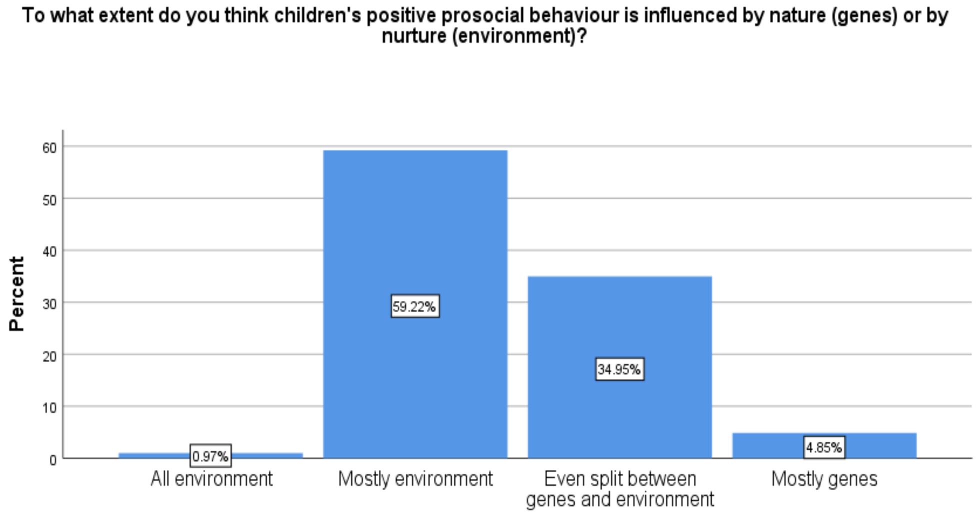


Figure 9.3 shows the distribution of responses to the question regarding the aetiology of hyperactive behaviour. As shown, the distribution of responses is more even here, with the largest proportion (39.81%) suggesting genes and environment play an equal role and the second biggest group (32.04%) favouring genetic explanations. However, both extremes of the spectrum also saw responses.

Figure 9.3. Distribution of responses regarding the relative influence of nature and nurture on hyperactive behaviour.

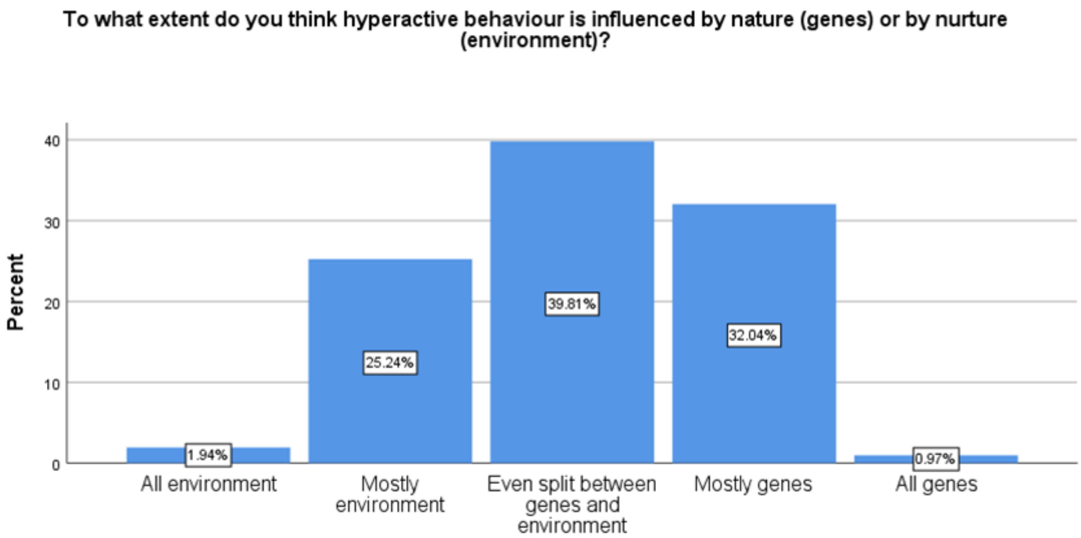


Figure 9.4 shows the distribution of responses to the question regarding teacher perceptions of the aetiology of children's negative emotions. As shown, the largest group of teachers cited mostly environment as the main influence on a child's negative emotions. Much less emphasis was placed on genetic factors.

Figure 9.4. Distribution of responses regarding the relative influence of nature and nurture on negative emotions

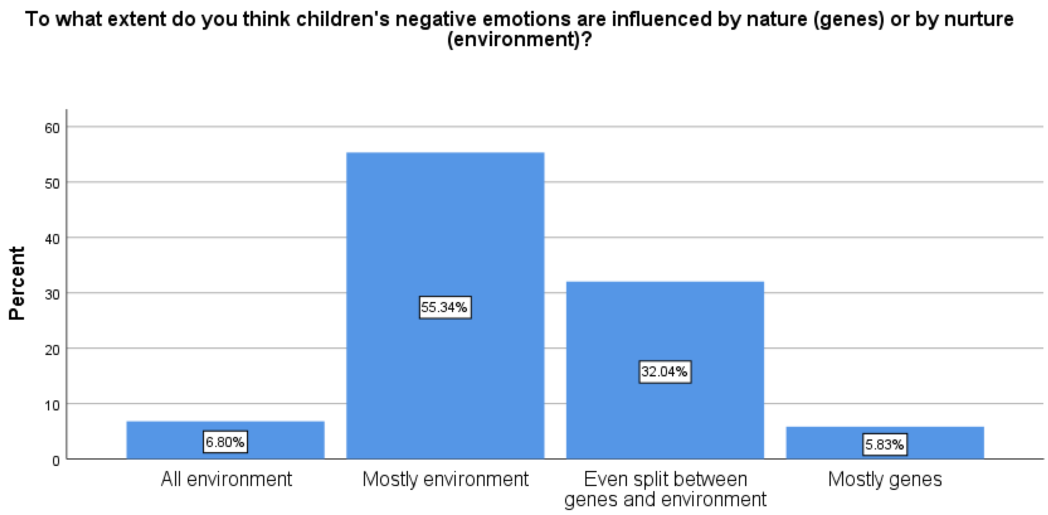


Figure 9.5 shows the distribution of responses when teachers were asked about the aetiology of conduct problems. Here, the majority responded that mostly environment has the biggest influence, with no one suggesting that individual differences in conduct problems are fully explained by genetic effects.

Figure 9.5. Distribution of responses regarding the relative influence of nature and nurture on conduct problems

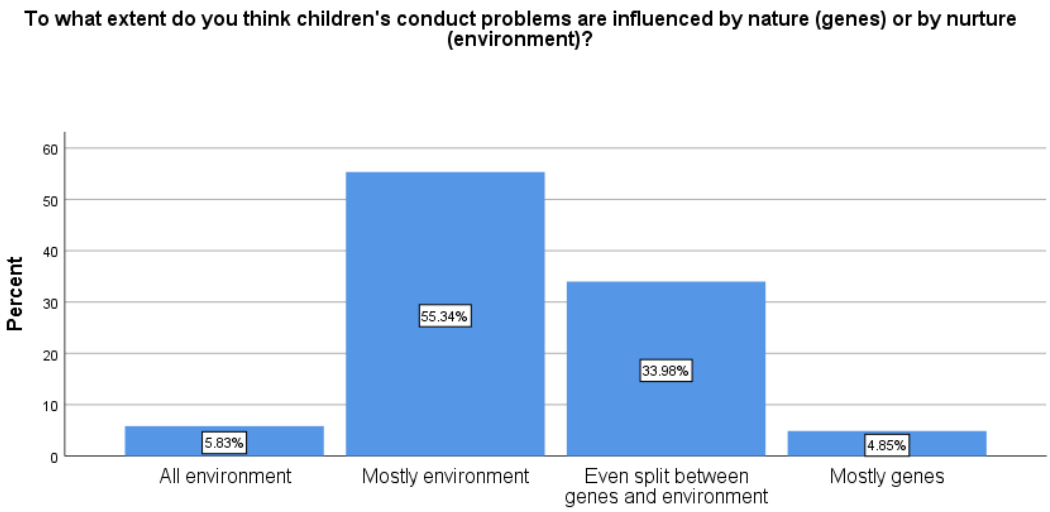


Figure 9.6 shows how teachers responded when asked about the balance between genes and environment when thinking about children's peer problems. As shown, most teachers perceived either an even split or favoured a largely environmental explanation, with no teachers saying all genes had the biggest influence.

Figure 9.6. Distribution of responses regarding the relative influence of nature and nurture on peer problems

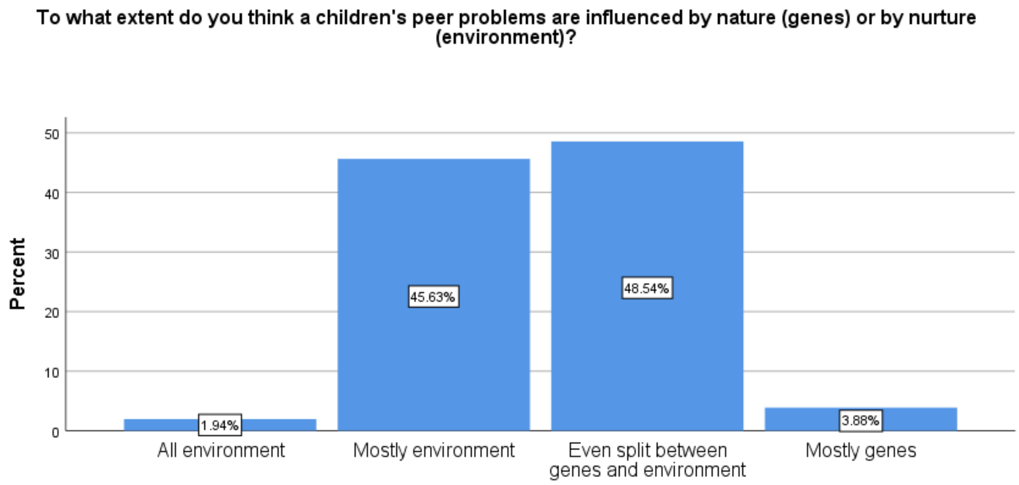
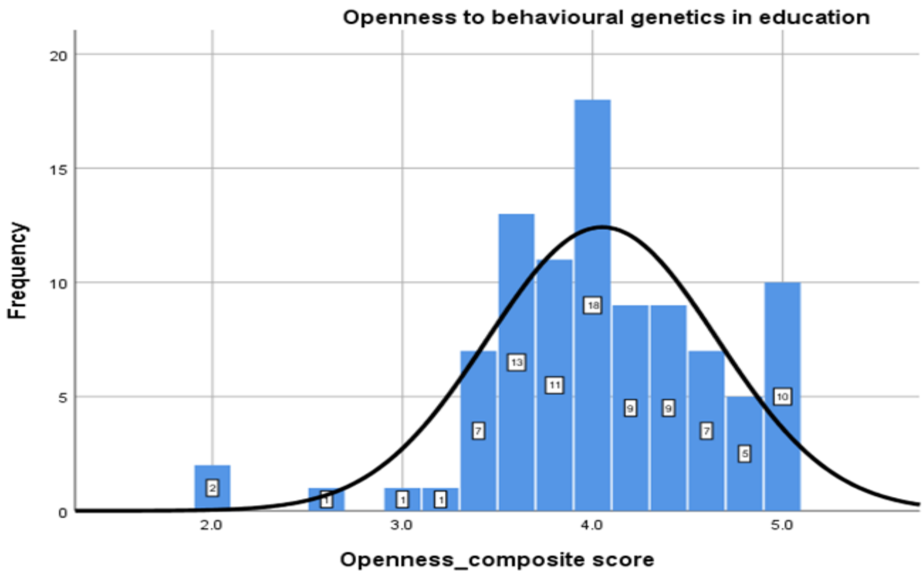


Figure 9.7 shows the distribution of responses to OGRE. As can been seen in the histogram, most participants scored around the 4 mark suggesting they were quite open to a role for behavioural genetic research in education (scale, 1=not at all open and 5=very open), with no respondents emerging as not at all open to behavioural genetics.

Figure 9.7. A graph to show the OGRE composite scores



In terms of how teachers in AP schools felt behavioural genetics already played a role in their school, 38% said they felt it did whilst 62% felt that is didn't. When asked how they felt it already played a role in their school answered centred around the following themes as shown in table 9.3.

Table 9.3 *Thematic analysis of qualitative responses to item: how behavioural genetics already plays a role in the classroom*

Theme/category	Example(s)	N
Awareness of specific genetic conditions (particularly autism)	'Pupils with genetic syndromes that have behavioural characteristics.' 'autism is probably genetic causes and we have many pupils with syndromes/ genetic reasons etc so therefore any indications of likely trends, behaviours and issues are important to know. '	7
Awareness of family history	'Background information - including information about the parents - is collected on entry.' 'Understanding the parental SEND needs and how they over map onto their children and similarities in behaviours/choices'	5
Awareness of impact from environmental factors	'Children significantly affected on day to day basis by impacts from events at home, negative events…' 'High numbers of our pupils have experienced trauma, abuse and attachment difficulties in their early years, this impacts on all areas of their decvelpoment'	4
Brain development	'Leaners with ASD traits & feature have different brain processing structures…' 'Neurodevelopmental cases we have.'	3
Professional assessments and professional decisions in the classroom	'It influences my response to young people's behaviour' 'Students with special educational needs are given specific environments or other differences to the norm wich helps them to access education.'	10

When teachers were asked if they would value further training on behavioural genetics and its implications for education; 90.6% said yes and 9.4% said no. When asked why they would not want further training, responses from the 9.4% centred on the following themes as shown in table 9.4.

Table 9.4. *Qualitative responses as to why participants did not want to receive additional training on behavioural genetics.*

Theme/category	Example(s)	N
Desire to treat pupils individually regardless of cause	'Each pupil is individual and I treat each child according to the behaviours they present - I do not feel I need to know the whys and wherefores.'	2
Environment and society seen as a bigger problem	'I don't think this is the main issue for our young people. Environment and society is a bigger influence'	1
Too busy	'We deal with issues every day'	1
About to retire	'It is interesting but I am just about at the end of my formal teaching career.'	2

9.4.2 Comparative analyses

Comparing variables

The study explored whether there were any overall significant mean differences between the behavioural focused questions and the question on cognitive ability. Following a Spearman's rho test on each behaviour measure compared to the cognitive ability measure, only one emerged as significantly correlated – hyperactive behaviour. A Spearman's rank-order correlation was run to determine the relationship between teacher beliefs about hyperactive behaviour and cognitive ability. There was a weak positive correlation, which was statistically significant (r_s = .201, p = .042). This correlation means that the teachers, who expressed that cognitive ability was more down to genetic factors, expressed a similar belief about the aetiology of hyperactivity, and vice versa for those who favoured environment.

Comparing samples

The four measures used in both the mainstream and the AP study were the cognitive ability measure, the OGRE measure, behavioural genetics already playing a role and would participants value further training. Results from all were compared between the two datasets to see whether means differed significantly. Using a *t*-test for independent samples, no significant difference was found between the two samples (mainstream and AP) in their perceptions of the aetiology of cognitive ability, their OGRE or whether they would value further training. However, significant differences were found between the two study samples with regards to their response to whether they felt that behavioural genetics already played a role in their classroom (t=4.34, df=125.2, p< . 000). Overall, teachers from AP settings were significantly more likely to say that genetics already played a role in their classroom than those teaching in mainstream schools.

9.4.3 Differences based on demographic characteristics

The next element of the research was to examine whether participants in this AP study varied in their responses based on demographic characteristics or background factors. One-way MANOVAs were conducted to explore whether each demographic factor had an overall effect on the main study variables. No differences based on demographic factors were found in the study. Results from the one-way MANOVA can be seen below in Table 9.5.

Table 9.5. *Multivariate Effects on the overall model (significant at p<.05 level)*

Variable(s)	Wilks' Lambda	*F*	*df*	Error *df*	Partial η2
Gender	.750	.597	7	18	.189
Teacher age	.580	.929	28	19.5	.535
Years of experience	.151	1.4	56	32.24	.613
Age of children taught	.905	.540	21	14.91	.418
School type	.426	1.08	35	23.46	.555

As shown in Table 9.5 there were no significant effects on the overall model based on any of the demographic variables. Overall the effect size for each variable was low or moderate.

9.5 Discussion

Overall, the picture that is emerging from this research into beliefs about the relevance of findings from behavioural genetics among teachers in alternative provision settings is similar to what was found amongst teachers in the mainstream. However, some new findings can help to build on the limited extant research in this area.

Teachers from across a range of special schools and PRUs (AP settings) in England in both the state and independent sectors offer us an insight into how these teachers perceive behavioural genetics in relation to both cognitive ability and behaviour problems.

In terms of cognitive ability, teachers generally saw environmental and genetic factors as exerting roughly equal influence on individual differences. This finding was in line with what was found in the mainstream study and aligns with findings from earlier research which places the heritability of cognitive ability at around 50% (Polderman et al., 2015). No differences were found based on demographic characteristics. This finding suggests that teachers working with children who are more likely to include those with known genetic conditions – including learning disabilities and cognitive impairments - do not see cognitive ability as being more innate than teachers of children educated in mainstream settings.

With regard to behaviour problems, and with the exception of hyperactivity, teachers in AP provision placed more emphasis on the role of environment than on the role of genes. This finding is in line with the limited previous research with mainstream teachers (Walker and Plomin, 2005). Teachers seem, on the whole, to feel that the way a child behaves is not innate and that the world around that child is a more significant influence. This is despite research in the area consistently showing an overall picture of substantial (40-70%) heritability estimates for behaviour problems as measured by the SDQ. However, AP teachers did, in line with research, see hyperactivity as slightly more influenced by genetics than other behaviour problems (Saudino, Ronald and Plomin, 2005). No differences were found based on demographic characteristics. So why do teachers feel that behaviour problems are more strongly influenced by environmental factors than cognitive ability is? Perhaps the idea that students should be able to 'control' their behaviour comes into play. We discipline students for bad behaviour but do not take a disciplinary approach to low academic achievement. Culturally and in the media, behaviour is seen and portrayed as something caused by a child's environment, particularly parenting, with teaching bodies saying that poor parenting is leading to declining behavioural standards (Paton, 2013).

As to why more genetic influence was acknowledged for hyperactivity, this is perhaps due to its links with ADHD. Once again teachers are relatively accurate with empirical findings suggesting that hyperactivity is indeed more heritable than other behaviour problems (Saudino, Ronald and Plomin, 2005). It is possible that teachers felt that owing to the fact that hyperactivity can be perceived as 'medical', they were more willing to perceive it as something more genetically influenced? A greater belief in the role of genetics for hyperactivity was found to be positively correlated with increased perceptions of cognitive ability being influenced by genes; this may strengthen this idea that teachers see hyperactivity as a more innate trait perhaps linked to a condition. However, this is speculation and further qualitative research would be needed to truly understand these nuances.

Looking at responses to OGRE among teachers in AP provision, there is a clear finding of openness amongst teachers. This was an expected finding as it seems more likely that teachers in AP provisions would see the applicability of behavioural genetics to some elements of their profession than teachers in mainstream settings, who were also very open. They teach a range of children with various needs and can likely see for themselves the role both environment and genes have to play. From this, it is positive to see that they feel that behavioural genetic findings and the insights they may offer may enhance their work with children with additional needs. In comparison to mainstream teachers, the mean openness score was almost identical, once again reinforcing the picture that teachers from both mainstream and AP are similar in their views. One thing worth noting is that no individuals in the AP study were not at all open to behavioural genetics in education, whereas a small minority in the mainstream study were. This perhaps suggests that through their slightly differing professional experience, they place more value on the role behavioural genetics could play than a minority of mainstream teachers. It could, of course, also be a simple artefact of having a smaller sample.

Where the two studies did significantly differ was in the teachers' perceptions of whether or not behavioural genetics already played a role in their classroom. Some teachers from AP backgrounds clearly felt that behavioural genetics already played a role in their classroom, significantly more teachers than in the mainstream study. Although not a majority, these teachers cited reasons such as witnessing traits running in families and the knowledge of specific genetic conditions/interactions and the role they play in a child's development and achievement at school. However, once again there were some misconceptions and confusion with teachers talking about the role of negative events such as trauma on their pupils, which is clearly more environmental. Regardless, it is indeed likely that these teachers may have a greater insight into the role genetics play in the children they teach due to their professional background, training and experience; this is reflected in individuals making mention of genetically influenced conditions such as Autism Spectrum Disorder (Sandin et al., 2017). However, as with teachers in the mainstream study, misunderstanding of what behavioural genetics actually is was still clearly present. AP teachers mentioned things such as brain development, which belong to the related but different fields of neurology and neuroscience. Here, we see that across all elements of teaching, a better understanding of what behavioural genetics is would be meaningful to teachers.

The final question asked of AP teachers was whether or not they would value further training about behavioural genetics. The picture here was positive with the majority of teachers saying they would value further training. It seems that despite working with children with a variety of complex needs, AP teachers still feel that knowing more about behavioural genetics would be of use to them. For the minority (a smaller percentage than in the mainstream) that said they would not value further training and reasons for this were similar to those in the mainstream study (see Chapter 8). AP teachers made mention of things such as the desire to treat pupils individually and being too busy or about to retire. One slightly different reason that emerged was the belief that a child's environment and society are a bigger problem. Here we can speculate that these teachers may have had experience of just how badly some children can become disengaged and led astray by the situation around them.

Overall, for any training that may be devised in the future; it is likely that teachers in both the mainstream and in AP would benefit from similar input.

Conclusion and limitations

As we begin to build a picture of teacher beliefs about the relevance of findings from behavioural genetics to education, we can see that overall teachers in different teaching environments are similar in their outlooks. They see a child's cognitive ability as something equally influenced by genetics and the environment. When it comes to behaviour, teachers in alternative provision settings lean slightly more towards the environment as having greater influence, with hyperactivity proving the one exception to this. It is likely that mainstream teachers would, had they been asked, have reported a similar point of view as they did in Walker & Plomin (2005). In terms of their openness, teachers in both the mainstream and in alternative provision settings are open to the role of behavioural genetic research in education and would value future training with most saying that behavioural genetics does not currently play a role in their professional practice. What this means moving forward is that there is much work to be done in terms of beginning to build this relationship between research and teachers, drawing on the evidence presented in Chapter 8. With behavioural genetics advancing at an unprecedented pace it is vital teachers are given the opportunity to be informed and to keep pace.

There are a number of limitations to this study, similar to those found in the mainstream study, which should be addressed. Firstly, the sample was self-selecting and small. AP teachers could choose whether or not to take part and as such we may not have garnered opinions from teachers not interested in the topic. Moreover, the receptionist was relied upon in most cases to pass on the email; so some teachers, although included in our sampling strategy, may never have had chance to respond. Moreover, it is difficult to know if the sample truly reflected the demographic make-up of teachers teaching in alternative provisions. No exact statistics exist to which the sample could have been compared, therefore it is hard to generalise any findings to the whole population

10. General Discussion

10.1 Introduction

The importance of developing a constructive conversation between teachers and behavioural geneticists is increasingly pressing, as behavioural genetic research is advancing more rapidly than many anticipated, and may have real-world implications before long. Findings from this study offer insight into how this conversation might work, and how it could be nurtured. These findings also advance our understanding of what teachers, and the general public, think about genetic research being applied to education, and offer some suggestions as to why they may feel the way that they do.

The main aim of the research presented in this thesis was to build a comprehensive picture of teachers' beliefs about the genetics of intelligence, including their knowledge of the subject, their openness towards findings from behavioural genetics being applied in their classrooms and their attitudes towards further training on the subject. Teachers were sampled from across the UK and the views of teachers in mainstream and alternative provision (AP) settings were compared. Prior to focusing on teacher beliefs, a study of how the general public perceive genetics in relation to education was conducted. In this chapter the main findings from the three studies presented in this thesis will be summarised and discussed, and what they might mean for teachers, education and the general public will be explored.

10.2 Research questions

A number of research questions were posed throughout this thesis, and the findings will be summarised in this chapter. Most centred on the following areas:

- Establishing what perceptions and attitudes exist towards genetics, both amongst the general public and the teaching population.
- Exploring how knowledgeable the general public and teachers are about behavioural genetics, as well as building an understanding of where misconceptions and hesitancies might lie.

- Asking how much teachers differ in their perceptions, mindset, openness and knowledge of behavioural genetics, comparing groups based on whether they teach in mainstream or alternative provision schools, and on various demographic factors.

- The position of teachers now and whether they feel behavioural genetics has already begun to influence their classroom practice.

- How open teachers are towards behavioural genetics and how, moving forward, training and dissemination on the subject might look.

10.3 Perceptions of genetics

For the general public, discussion of genetics in education evokes a disproportionate amount of debate. In the context of a content analysis, focusing on online open comments under an article about genetics in education reported in Chapter 4, the topic was found to spark strong reactions and disagreements between commenters. The article under which the comments were analysed reported Dominic Cummings, Special Advisor to the then Education Secretary Michael Gove, as having said that SureStart (a programme aimed at pre-school children) was a waste of time; Higher Education and teaching lacked quality and, most importantly for this study, that genetics outweighs teaching when it comes to children's performance in school. Despite the article comprehensively covering a range of topics, and a range of controversial views, most comments focused on what Cummings said about genetics.

This study suggested that the general public perceives genetics in education as something worthy of heated debate. The article also demonstrated that when an unpopular public figure, in this case Dominic Cummings is involved; perceptions can be blurred by the political opposition of those reading the article. This has occurred more than once, with a similar political debate erupting following a more recent article in the *New Statesman* – responses were split along political lines between supporters of the author, science writer Phillip Ball on 'the left' and right wing commentator Toby Young (Ball, 2018). Overall, the perceptions of the public suggested that they strongly opposed the suggestion that genetics may outweigh an environmental factor such as teaching quality. However, in the Guardian article, despite other topics being discussed in the article, Cummings also received the most support for his comments on genetics as opposed to any other of the topics. Perceptions of genetics in the general population are not clear cut; the topic causes a great amount of debate and discussion, and the public are clearly engaged with it, expressing very strong views in both directions.

However, it must be remembered that those commenting beneath the *Guardian* article (and also the more recent *New Statesman* article) are self-selecting individuals that read the left wing press and choose to comment, so are unlikely to be representative of the general public.

For teachers sampled in the main studies presented in this thesis, perceptions of behavioural genetics in education were hesitant in places. This hesitancy from teachers perhaps reflects the controversy of the topic as seen in the content analysis of the *Guardian* article. Across both mainstream and alternative provision settings teachers reported the relative influence of nature (genes) and nurture (environment) on cognitive ability as being a roughly equal split. Teachers here tended to 'sit on the fence' as found in a previous study (Walker and Plomin, 2005) with teachers perceiving nature and nurture (rather accurately) as playing a roughly equal role in explaining individual differences in cognitive ability. Very few teachers placed themselves at either extreme, with no AP teachers at all placing themselves in 'all genes' or 'all environment' categories. A more growth mindset was the only factor linked to a different response to the nature-nurture on cognitive ability – a more growth mindset was correlated with greater environmental emphasis being placed on cognitive ability. This finding strengthens what we know already about teacher perceptions of the aetiology of cognitive ability and suggests that this view has remained stable over the past 13 years, in spite of major advances in the field. It is not clear to what extent teachers are aware of the advances that have been made, including developments in genomewide polygenic score (GPS) research (e.g. Selzam et al, 2017).

In terms of AP teachers' perceptions of the aetiology of behaviour problems (not assessed in mainstream teachers), beliefs followed a similar pattern. For the five behavioural measures: prosocial behaviour, hyperactivity, negative emotions, conduct problems and peer problems, most teachers sat almost in the middle with a slight emphasis on the role of the environment. The one exception to this was hyperactivity, for which greater emphasis was placed on the role of genes. Perceptions of the aetiology of hyperactivity tended slightly more towards the role of genetics than it did for cognitive ability amongst AP teachers – which in itself is an interesting finding worthy of further exploration.

These perceptions show us that teachers do not perceive their role as one outweighed by genetics as suggested in the *Guardian* article. Rather, they are willing to accept that genetics plays a role in explaining individual differences in all traits they experience as teachers in the children they teach. Yet, their perceptions also emphasise that they see the raft of environmental factors at play (including themselves as teachers) as being equally important.

Seemingly, since the Walker and Plomin paper in 2005, no one has made attempts to establish how teachers perceive the role of behavioural genetics in education. This is despite – as demonstrated in Chapter 4 (also, Crosswaite & Asbury, 2016) – the topic being the source of much debate and resistance for complex historic and social reasons. Now we have begun to ask teachers in both the mainstream and in alternative provision settings, we can see overall that both groups of teachers are very similar and match our expectations in terms of their perceptions, which are broadly in line with scientific findings. Teachers are not hostile towards genetics, hesitant maybe, but overall they are open to the role of behavioural genetics in education. Their perceptions of the relative influence of nature and nurture show a balanced opinion; in which they see the role of both play out every day in their classrooms. For the general public, the politicisation of findings from behavioural genetics likely mars their perceptions. In the article that formed the basis of the content analysis in Chapter 4 we see a right wing advisor's views being reported by a left wing newspaper (The Guardian), meaning that for some who commented they may have opposed the opinions of Cummings simply because of their political opposition to him. Teachers' perceptions then could be said to be based on a clearer view and greater individual experience.

In terms of teacher mindset, we have replicated previous findings that show teachers on a whole hold a growth mindset (Jones et al., 2012; Gutshall, 2014). Mindset was deemed important to this study as it was felt likely that those teachers with a growth mindset would also hold a more environmental view of the nature-nurture questions. Mindset did prove to be an important variable with three interesting findings: teachers from state schools had significantly higher growth mindset than teachers from independent schools; perceiving genes as playing a bigger role was correlated with a more fixed mindset; and a higher score on the knowledge test score was correlated slightly with a more fixed mindset. Further investigation is warranted, but these preliminary findings not only contribute to the mindset research field but also help build insight into a wider teacher profile type i.e. growth minded individuals who favour the environment or those with a more fixed mindset who perceive a greater role for genes and have a better understanding of behavioural genetics. It is worth nothing that if we did progress forward with further education for teachers on behavioural genetics we may well see the casual correlation between increased knowledge and a more fixed mindset result in unintended consequences. We want teachers to have a better understanding of behavioural genetics but not for that to result in teachers becoming more deterministic and fixed in their visions of what children can achieve. Behavioural genetics shows us that not all children have the same cognitive abilities (comparable to intelligence in mindset lexicon) but we know that it is still important for teachers and children to believe their efforts will, and do, have some impact. Any future teacher education programme would do well to monito this initial correlation found in this study. We can now begin to build a picture of the way teachers perceive multiple aspects of psychology, which could prove valuable moving forward with dissemination.

10.4 Knowledge of the role of the genetics of intelligence

The next aspect to explore is how accurate teachers are in their knowledge of behavioural genetics and what the picture looks like overall in terms of the public and teacher knowledge of behavioural genetics. The issues that may be contributing to misconceptions and lack of knowledge will also be discussed.

A lack of knowledge and understanding was clearly a factor contributing to the hostilities found in the content analysis. A complex subject like genetics is easily misunderstood and misconceptions can be rife (Tabery 2015). This was reflected in the occurrence of Nazi related comments from the public – here behavioural genetics and eugenics were worryingly conflated. The difference is stark – eugenics is based around controlling reproduction to achieve an increase in perceived desirable heritable characteristics (Rivard, 2014). In comparison, behavioural genetics comes with no agenda; rather it is research field which aims to establish the extent to which a human trait is explained by nature (genes) and nurture (environment). For many, the suggestion that teachers and schools may not influence individual differences is a hard concept to swallow. Interpreted in the wrong way and with a lack of true understanding of the topic (findings from behavioural genetics) members of the public may interpret it as suggesting we have little control over our destinies and that we are unable to influence the future of society's children through education. Education is society's most expensive intervention and is often used as a measure of how well a country is doing globally. Therefore, it is no wonder that the public are quick to jump to wrong conclusions if they do not understand fully understand the role genetics could play in education, and the fact that heritability does not imply immutability.

The over-simplified and misleading reporting of Cummings' message is likely to have exacerbated this misconception and generated further hostility. This highlights the need to ensure that researchers communicate their own findings accurately and appropriately, and it is not the message portrayed by the media that 'shouts the loudest'. In addition, we see the issues that can arise with the politicisation of findings from behavioural genetics, which is becoming an increasing problem (Ball, 2018). Here we run the risk of allowing behavioural genetics to become a 'political football' and for worthwhile findings to become marred by politics, potentially putting off the public and teachers from engaging with findings. Scientists need to address this problem and identify strategies to help.

Despite working in education, it was not assumed that teachers would have a high knowledge of behavioural genetics and this indeed was what was found. Teachers lacked knowledge and were potentially even misinformed about behavioural genetics (with most scoring below chance on our knowledge test). With no training in this somewhat specialist area it is not at all surprising that knowledge is low. However, teachers having knowledge of behavioural genetics could give them power; power to use the findings as appropriate in their classroom should they wish (if practical applications become available at some point), but maybe more importantly it could give them the power to challenge any politicisation or commercialisation of behavioural genetics that may occur in the future. Teachers should be informed so they can make a professional decision and be in a position to speak out about how they'd like the future of genetics in education to look, even if what they want is to resist its encroachment into education.

However, in terms of how accurate teachers are in terms of estimating the relative influence of nature and nurture on cognitive ability, based on current twin studies, they are relatively accurate. Research estimates the heritability of cognitive ability is approximately 50%-70% on average (Polderman et al., 2015). So, despite maybe not fully understanding the methods and details of behavioural genetics, teachers are able to make a relatively accurate and informed judgement of how much influence genetics has on educationally relevant traits.

With regard to perceptions of the aetiology of behaviour problems, AP teachers offered an initial insight into their knowledge and understanding of the aetiology of behaviour problems. Overall, their judgement that most behavioural problems are more environmentally influenced was a little less accurate than findings surrounding cognitive ability. Research shows that most behaviour problems, as with cognitive ability, actually show substantial heritability (Scourfield, Van den Bree, Martin & McGuffin, 2004; Lewis, Haworth & Plomin, 2014; Lewis & Plomin, 2015). However, the picture is more nuanced with behaviour problems. Some aspects of some of the behaviour traits show lower heritability estimates – for example, anxiety and depression at 40% heritable (Cheeseman et al., 2017). To truly pick apart how much teachers know, further research would be required. Perhaps here we have highlighted a misunderstanding that teachers see behaviour problems as something more malleable and as something that children have more control over. Perhaps they see it as something more caused by a challenging home environment or difficulties with peers. The findings that behaviour is seen as more environmentally influenced than cognitive ability, despite this not necessarily being the case for a number of the behaviour measures, was also mirrored in the only similar study by Walker and Plomin (2005). In fact, the findings of this study largely reinforce those found by Walker and Plomin (2005); suggesting teacher perceptions and knowledge have remained largely stable in the past 10 years despite advances in behavioural genetics and increasing publicity of behavioural genetics (Plomin, DeFries, Knopik & Neiderhiser, 2016; Ball, 2018).

10.5 Similarities and differences in the teaching population

Overall, UK teachers as a population emerged as relatively homogenous in their views. Studies of teachers in both mainstream and alternative provision settings delivered similar results. It was hypothesised that teachers from alternative provision settings may see genetics as having a greater influence on cognitive ability and that they may be more open to the role of genetics in education, because of their experience with children with certain disabilities which are known to have a clear, simple genetic basis. However, overall means for the relative influence of nature and nurture across both groups were very similar, with both groups reporting almost identical openness to behavioural genetics and reporting similar views regarding the role of behavioural genetics and training on the subject.

This finding is perhaps slightly surprising as teachers from AP reported that behavioural genetics already played more of a role in their classroom. Despite these perceptions, a knock on effect from this was not seen– such as the perception of a greater role of genetics on some of the traits. The fact that AP teachers were significantly more likely to think that behavioural genetics already played a role in their classroom was expected and makes sense in comparison to the mainstream. Teachers in AP provisions are more likely to have come across pupils with specific genetic conditions and this may have led them to alter their professional practice – it is this that they most likely feel means that behavioural genetics already plays a role in their classroom. Now, whether they are misinformed is difficult to tell, it is unlikely that they are using ACE models and heritability statistics to inform practice (there is no clear application of such models). Therefore, here we see perhaps a slightly erroneous finding with AP teachers saying they have some understanding of *molecular* genetics and *medical* genetics, which they are wrongly conflating with behavioural genetics. It is likely that in reality mainstream and AP provision schools are similar – in other words behavioural genetics does not play a role in the vast majority of classrooms across both sectors. It was not expected that it would play a role as there are yet to be clear practical applications based on research findings.

The hesitations and concerns towards behavioural genetics in education expressed through the qualitative elements of the study reveal some broadly similar themes. Understandably, as with the general public, some of the teachers across all of the sectors expressed concerns around genetic technology potentially resulting in discrimination towards individual children. Teachers also raised concerns over how applicable genetics is to their practice. These concerns, although limited to a minority, are obviously something that needs exploring further. As discussed in the content analysis study, it is possible that political marring of the topic and over-simplified media coverage may be partly the cause of such hesitation. But equally, these teachers could be incredibly well read on the topic and still have concerns, as do some of the scientists involved (e.g. Turkheimer, 2000; Panofsky, 2015). Across both AP and mainstream, less complex reasons for not wanting training in behavioural genetics included being about to retire and being too busy. With teacher workload higher than ever before (Adams, 2018) this is understandable and as addressed in the CPD chapter (Chapter 8), careful consideration would need to be taken when deciding how best to provide training and CPD that was doable for teachers.

Looking more closely within the teaching population, once again only a few differences emerged based on differing demographic characteristics. The only significant differences emerged within the mainstream sample and were based on the age of children teachers taught and the type of school they taught at (state vs. independent). In terms of the age of children taught the differences lay in openness and knowledge. Teachers who taught younger children were significantly more open to behavioural genetics but at the same time less knowledgeable. This seems like an odd paradox, and we can but speculate as to why this finding emerged. Perhaps teachers of younger children feel that behavioural genetics has more to offer their classroom practice with children being more malleable at a younger age and the heritability of cognitive ability increasing with age (Haworth et al., 2009).

Maybe also that they have more time and freedom to utilise behavioural genetics findings compared to those in the secondary school settings whose focus is more on exams. The lower knowledge levels may be explained by numerous factors. To speculate, maybe there are fewer primary school teachers who are science or psychology specialists who studied those subjects to degree level. Further investigation is needed. What we can take from this is that there may need to be flexibility of approach for primary and secondary schools – a different approach may be necessary for the different stages. Focusing on improving knowledge and building on the openness at primary level; and focusing more on showing secondary school teachers the potential benefits of behavioural genetics (to enhance openness) with some knowledge input. Once again this is an area for further research and investigation.

In terms of school type, teachers from state schools were significantly more growth minded than teachers from independent schools. Once again we can only speculate as to why this is. Perhaps teachers in independent schools - where arguably all the best resources are available and where confidence and mental toughness are prioritised (Trafford, 2017) - see on a daily basis, children who may try hard with all the best resources and still cannot achieve in the same way as some of their peers. Or perhaps the independent sector attracts teachers with certain opinions of what drives success and this could explain the difference seen. This finding is interesting and once again warrants further investigation to establish where this difference may stem from and how best to respond to it as researchers.

Despite findings from previous research (Georgiou, 2008; Hilderbrandt & Eom, 2011; Jonsson et al., 2012) that subject taught and teacher age influenced closely related beliefs such as mindset and theories of intelligence, these demographic aspects yielded no significant differences in this study.

10.6 Moving forward

Moving forward, the most important message to take away is of the importance of cautious but optimistic dissemination of scientific findings to the public and to teachers. We want the general public, but most importantly teachers; to understand and then make an informed decision on what they think of behavioral genetics. For wider society we can offer a warning about scientific information. Ignorance on the topic will likely only lead to misuse and even abuse of what behavioral genetics could offer in the future. What needs to be discouraged and actively avoided by the research community is the politicisation of behavioral genetics, which as mentioned is already beginning to happen. Behavioral genetics in education does not have a right or a left wing agenda; it is and should aim to remain a rational voice in a sea of politicised anecdotal education policy. We risk alienating the general public and more importantly the educational community if we allow behavioral genetics and its findings to become a political football used by politicians as justification for whatever policies they want to push onto schools and teachers for ideological reasons. By equipping teachers first, going to the professionals first, we can at least hope to empower them with the knowledge to use behavioral genetics as a tool in their toolkit when, if and how they see appropriate, and when evaluating the likely impact of interventions. It is the role of behavioural geneticists to ensure that their findings are communicated and interpreted correctly and made available to the educational professionals to use as they see fit.

With that in mind, it is the job of researchers to begin to consider how such dissemination might look. With the finding that teachers are on the whole homogenous in their perceptions of the relative influence of nature-nurture on educationally relevant traits as well, as being similar regarding their openness towards behavioural genetic in education, it seems fair to say that moving forward, any plans for dissemination can be considered suitable for all teachers.

Forming an integral part of this study, it has been established that a large proportion of teachers do want further training in behavioural genetics, and have to date, received very little if any training on the subject. This opens up the opportunity to help inform teachers about behavioural genetics through continued professional development (CPD), and maybe in the future also as part of initial teacher training (ITT).

When questioned as to what advantages they felt behavioural genetics might offer: ability to target specific interventions, early identification of children who may need specific input and increased focus on personalised learning were the most popular choices selected.

When teachers were questioned on their preferred method of training, they cited as their top three training preferences: in-school training day, meeting and talking with behavioural geneticists and visits from external expert to the school.

From all of this, we can arguably begin to see a rough outline of what teachers want from researchers. They want a direct conversation, face-to-face and what they want to know most about is how to help individualise learning to meet the needs of those children most in need. Moving forward, there is a clear demand and a clear need for teacher training in the topic. There is still work to be done to establish exactly how it might look and how well it might be received. Careful consideration needs to be taken to ensure we present teachers with something useful and applicable to their practice, otherwise they are likely to simply say – so what? Their time is more constrained than ever, so it is vital that any dissemination is meaningful, accessible and does not demand too much from teachers who are already under incredible pressure (Howard-Jones & Fenton, 2011). We must also tread carefully in terms of ethics, perhaps before starting a dialogue with teachers it would be worth establishing some ethical boundaries as suggested by Stein (2010), who reminds us that we are not aiming to *design* children but rather to *raise* children (Stein, 2010). We should entrust teachers to make decisions for the children in their classroom as they see fit.

10.7 Reflexive analysis

When approaching this research, I came from a background of beginning to train in the teaching profession. I had seen first-hand the pressure placed upon both teachers and children to reach a certain level of attainment or progress in a narrow set of skills (namely English and Maths) despite their individual differences and talents. Although much of what I saw showed the dedication and commitment of teachers, I also witnessed the negative and damaging consequences of a system placed under extreme pressure to achieve the same level for every child when, for some children, that seemed unreasonable. Much of what I experienced made me consider that our approach, as teachers, was potentially misguided and anecdotally many teachers had expressed the same sentiment to me.

I already had some experience of behavioural genetics having focused upon genetics in education for my undergraduate dissertation. Everything in behavioural genetics and differential psychology tells us that across the population there is a large amount of variance and individual differences can be attributed to differences in our genes and our environments. Findings from behavioural genetics tell us that traits such as reading and maths ability – so highly prized in the education system – are highly heritable and, as such, differences between children are not solely explained by the quality of schooling they have received, or their individual efforts. In many ways then, we are inflicting unwarranted pressure on our schools, teachers and children by trying to enforce a narrow ideal of what it means to be educated.

For me, the main appeal of behavioural genetics was its support for personalised learning, guided by great teaching, and its broad definition of educational success encompassing a wide range of strengths. This belief has simply grown since embarking upon the research.

Having seen that behavioural genetics can offer us a research-grounded alternative approach to education, I have been motivated to share this with the rest of the education profession. Although I did not, and still do not, know exactly how behavioural genetics will fit into education in practice, I wanted to at least start to disseminate these findings to challenge the narrow status quo of success in society that arguably leaves many children behind, disillusioned with education as their personal strengths aren't those rewarded highly in our current system.

I believe that behavioural genetics offers a genuine alternative (based on research over political ideology) to our narrow education system that places too much focus on a narrow range of academic skills at the expense of failing to celebrate and utilise other intrinsic skills within our children. I did not claim to know at the beginning of my research exactly how schools and teachers should use behavioural genetics findings, and although I now have more ideas which have been mentioned in this thesis, I still hold the belief that teachers are best placed to use behavioural genetics research as they see fit. Yet, as I first believed and later went on to find out, teachers have little experience or knowledge of behavioural genetics, so here I hope to begin to contribute to the conversation with education professionals, offering them another perspective on education which I suspect some may appreciate in an education system that I believe fails many of our children.

10.8 Overall limitations and directions for future research

There are a number of limitations to this study that should be addressed. In terms of generalisability of findings, it cannot be claimed that findings can be representative and therefore generalisable to the whole of the UK population. Participants in the content analysis element of the study were self-selecting individuals who chose to comment under an article in a left leaning newspaper. Therefore, they are not representative of the wider general public. Equally the teaching sample was self-selecting, in spite of a careful sampling strategy. Teachers could choose whether or not to take part and as such we may not have garnered opinions from teachers not interested in the topic. Moreover, the receptionist was relied upon in most cases to pass on the email; so some teachers, although included in our sampling strategy, may never have had chance to respond. When the receptionist was not relied upon, convenience sampling through social media also meant that most individuals were self-selecting. Also, despite attempts to boost underrepresented groups we still did not manage to recruit a representative number of teachers from Wales and Northern Ireland, or from state primary schools for the main study. In terms of the alternative provision study, the sample size was relatively small and as such cannot be said to be generalisable to all alternative provision teachers.

The sampling technique also presented some limitations. Due to the nature of stratified sampling, although a representative sample was contacted to take part, we were unable to ensure a representative response. Some school types ended up being overrepresented (independent and secondary) and the reason for this is twofold. Firstly, in the interest of simply getting a large enough sample, all school types were involved in subsequent sampling waves regardless of the rate of responses so far. This meant that some schools that may have only made up a small percentage of UK schools, such as independent schools, may have been contacted at a proportionally higher rate than more mainstream school groups. This was compounded by a potential greater response rate compared to school types who had a low response rate- primary schools for example. Secondly, when attempts were made to bolster those types of schools that were underrepresented (primary schools and schools outside of England) the responses received were insufficient to balance out the skew towards the overrepresented schools, despite our best efforts.

However, overall it is felt that the sampling strategy used was the most robust, objective and representative approach available with limited resources and the need to ensure that teachers remained anonymous.

The element of this study that explored the general public's perceptions of behavioural genetics in the context of education cannot be said to be generalisable to the whole of the UK population. The study serves as a snapshot into how a single, self-selecting group (online commenters on a *Guardian* article) feel about behavioural genetics in education. Although the findings were necessarily limited by being based on a single article in one left-leaning newspaper, with comments from a self-selecting sample, the analysis nonetheless served to provide a glimpse into wider perceptions of behavioural genetics in education, beyond just teachers, set against the context of very little other research in the area. Moreover, even though commentators were self-selecting and commenting under one article, a wide range of opinions, issues and ideologies emerged in the analysis which contributed to our wider understanding of the current perceptions the UK general public (of which teachers are a part) hold on behavioural genetics in education. This initial study helped to set the foundations for a more focused exploration of teacher perceptions. It was valuable to understand what the general feeling towards behavioural genetics in education was in the UK so this could be compared to how teachers reacted to the idea of behavioural genetics playing a role in education. This allowed us to establish whether any hesitations teachers had, were specific to their profession or more widely felt amongst those not necessarily from the profession.

In terms of the study measures, a couple of new measures were used throughout this study. Although one (OGRE) has since been used successfully in another study – therefore enhancing its validity – overall it cannot be claimed that all measures have been tested and used enough to ensure validity.

It is also worth acknowledging that further exploration is needed as to exactly what teachers were thinking when they selected the middle option on the nature-nurture question indicating an even split between the influence of nature and nurture on cognitive ability. It is possible that some teachers selected this option because they simply were not sure and no 'don't know' category was available to them. It was intentionally decided to exclude the 'don't know' category as we wanted to nudge teachers into properly considering the question and trying to make a decision, not just simply selecting 'don't know' and then moving on. However, this does leave some doubt as to teachers' intentions.

Further qualitative research would need to be conducted to establish what teachers' thought processes were when responding to this question. Here there is clearly an important avenue for further research. One option would be to use a 'think aloud' task, sitting with teachers while they complete the questionnaire and asking them to talk through their decisions. This would reassure us as to the reliability and validity of the measure.

In terms of future research directions, this study has laid foundations for further research using both quantitative and qualitative methodologies. Further quantitative research could look into diversity of opinions in other teaching demographics such as nationality or religious views. It would be interesting to explore some cross-cultural comparisons and perhaps look more deeply into why such cultural differences may exist. In an ever-increasing global world, education is now compared globally; therefore, any underlying cultural differences could prove increasingly important. Further research might also explore how a working relationship between scientists in the field and teachers in the profession could look. There is also potential to see how teachers view the heritability of other educationally relevant traits such as effort and motivation. A particularly relevant trait would be school achievement which has been found to be even more heritable than cognitive ability (Kovas et al., 2013; Krapohl, 2014).

In terms of qualitative research, it would be interesting and valuable to further investigate the demographic differences that emerged (primary vs. secondary and state vs. independent) to try and better understand the driving forces behind these differences. Theoretically, it is hard to decipher if individuals come to teaching holding similar opinions towards behavioural genetics from the outset, or if a career in teaching moulds them into similar beliefs. Moreover, is there an underlying reason why teachers from independent schools had a less growth mindset? Again, is it that private schools attract individuals with certain opinions or does working in a private school mould individual's beliefs? Moreover, are individuals who choose to go into teaching different in any way to the general public or indeed parents in terms of their beliefs about behavioural genetics? Or do they just act as a microcosm of the general public who share their political ideals or education perhaps? Although likely hard to untangle, this would be an interesting avenue to explore.

There is also arguably a need to better explore the driving force behind some of the presented findings, which would likely require future qualitative investigation. For example, when it came to the nature-nurture question, did the majority of teachers 'sit on the fence' by saying cognitive ability was an even split between genes and environment because they were unsure of the answer or because this was their actual considered judgement? We simply cannot know from the current data so this would warrant future investigation.

11.Conclusion

In conclusion, as rapidly as behavioural genetics has progressed, research into how it is being received by the education sector has not. This thesis set out to address a number of research questions that centred around teacher, and public, perceptions of behavioural genetics with a specific focus on cognitive ability. Overall, what was found suggests that despite an overall open attitude towards the potential role of behavioural genetics in education, knowledge of the subject was universally low. Teachers, who on the whole held a growth mindset, were fairly accurate in their judgements of the relative influence of nature and nurture, with this reflecting past findings. The overall picture suggested homogeneity amongst the teaching population, regardless of whether they taught in mainstream or alternative provisions.

Tentative steps have also been made to build a picture of how we can begin the conversation with teachers. It's beyond the boundaries of this thesis to begin to suggest exactly what we should tell the teaching community, but it's important to acknowledge that a conversation with teachers regarding the potential impact of behavioural genetics needs to happen soon and is likely to be welcomed. Teachers want training on the topic and it's vital we do not miss the opportunity to share with them important and meaningful findings from behavioural genetics.

For behavioural genetics researchers it is fundamentally important to share findings and to better understand how they are perceived and received by those who will likely be impacted by them. Research being conducted solely for the sake of another publication does not fulfil its duty to enhance knowledge. The knowledge we are enhancing should belong to everyone. Yet how can we seek to share knowledge with the educational community if so little is known about the status quo?

It was the purpose of this study to begin to address this question and to build a better understanding and knowledge base in our research community regarding how teachers perceive behavioural genetics. Headway has been made and it would be fair to say that this study has bettered our understanding in the UK as to how knowledgeable and open teachers are towards behavioural genetics. But of course, there are a wealth of further research directions to be taken and it is important to acknowledge the limitations of this thesis.

It is hoped that this thesis has contributed to our understanding of teacher beliefs about the aetiology of individual differences in educationally relevant traits, and the relevance of behavioural genetics to education.

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13.List of abbreviations and definitions

Educational abbreviations:

AP….alternative provision (any education provision outside the mainstream)
PRU….pupil referral unit
CPD….continued professional development (learning and training in a professional context)
ITT….initial teacher training (teacher training before employment)
SENCO….special educational needs coordinator (in-school role)
SEND….special educational needs and disability

Behavioural Genetics terms:

- Heritability…. the proportion of the variance in a trait in a population that is attributable to genetic variation (differences in genotype).
- Shared environment (c2)…. events that happen to both twins, affecting them in the same way
- Non-shared environment (e2)…. events that occur to one twin but not the other, or events that affect either twin in a different way.
- ACE…. typically the above three components are called A (additive genetics/heritability) C (common environment/shared environment) and E (unique environment/non-shared environment).
- ACE model…. The ACE model indicates what proportion of variance in a trait is heritable, versus the proportion due to shared environment or non-shared environment.
- Genotype…. the genetic makeup of an organism or group of organisms with reference to a single trait, set of traits, or an entire complex of traits.
- GWAS….genome wide association studies

14. Appendix

14.1 Copy of email sent to schools

THE UNIVERSITY of York

Email: mc855@york.ac.uk

[Date] 2016/2017

Dear [head teacher's name]

We would like to invite you and your teaching staff to take part in a study of teachers' beliefs about, and knowledge of, the influence of genes on learning and educational achievement. This study has been designed to enhance understanding of what teachers believe and know about genetics, and to identify areas in which further information or training might be welcomed by the profession.

Participation will involve completing a questionnaire which should take no longer than 10 minutes. The link to the questionnaire is here - https://york.qualtrics.com/SE/?SID=SV_6yRWHVpJu4NQoJL - and full information about the study's aims is also provided here. We would be very grateful if you would consider completing the questionnaire and circulating the link to all of your teaching staff (full and part-time) with a request to do the same. Your support for this research would be greatly appreciated.

Scientists are making progress in understanding how genes and experiences are relevant to the classroom and it is crucial that teachers' voices are heard and taken into account as this research progresses. Our study aims to ensure that teachers' perspectives are heard and understood by scientists. The study will be carried out as a PhD project by Madeline Crosswaite and will be published by a small team at the University of York.

We would like to assure you that all responses are completely anonymous (we do not ask for names or individual school details) so there will be no identifying information in any publication arising from this research.

We really hope you will want to take part and thank you, and your staff, in advance for your time and insight.

Questionnaire link - https://york.qualtrics.com/SE/?SID=SV_6yRWHVpJu4NQoJL

Yours sincerely,

Madeline Crosswaite and Dr Kathryn Asbury

Psychology in Education Research Centre, Department of Education, University of York

14.2 Mainstream teacher questionnaire

Teacher Beliefs about Genetics and its Relevance to Education

It is anticipated that this questionnaire will take you about 10 minutes to complete.
Behavioural genetics is a relatively young science, which is developing at a fast rate. The main focus of behavioural genetics is to explore the role of genetic and environmental influences on human behaviour. It is an interdisciplinary field combining genetics and psychology and covers a wide range of human behaviour from cognitive ability to personality disorders. This questionnaire will ask you about your personal knowledge and opinions of behavioural genetics as it relates to education.
The data will be shared between myself (mc855@york.ac.uk) and my supervisor Dr Kathryn Asbury (Kathryn.asbury@york.ac.uk). All responses are anonymous and untraceable back to individuals or their schools. Data will be stored securely on a password protected computer for approximately three years until study completion and publication. Data may be used in publications and presentations, but will not be traceable to you. You are able to decline to answer any question individually or to withdraw from the questionnaire any time.
Participation in the questionnaire will be taken as confirmation of informed consent. Any queries, comments, concerns or complaints should be directed to the researchers (Madeline Crosswaite, mc855@york.ac.uk and kathryn.asbury@york.ac.uk) or to the University of York Education Ethics Committee (via education-research-administrator@york.ac.uk). **Please click on the arrows to proceed to the short questionnaire - thank you in advance for your time.**

Q1 Please indicate your gender.

○ Male (1)

○ Female (2)

○ Would rather not say (3)

Q2 Please indicate your age.

○ 20-25 (1)

○ 26-30 (2)

○ 31-35 (3)

○ 36-40 (4)

○ 41-45 (5)

○ 46-50 (6)

○ 50 and above (7)

Q3 How many years have you been employed as a teacher?

- ◯ Currently in NQT year (1)
- ◯ 1-5 (2)
- ◯ 6-10 (3)
- ◯ 11-15 (4)
- ◯ 16-20 (5)
- ◯ 20+ (6)

Q4 Do you teach children of primary or secondary school age?

- ◯ Early Years (1)
- ◯ Primary (2)
- ◯ Secondary (3)
- ◯ Sixth form (years 12 and 13) (4)
- ◯ Other (please specify) (5) ____________________

Q6 Which of the following options best describes the type of school you currently work in?

- State school/academy (no religious affiliation) (1)
- State school/academy with a religious affiliation (2)
- Free school (3)
- Independent/private school (4)
- Independent/private school with religious affiliation (5)
- Special school (6)
- Other (7) ____

Q7 How would you describe your school's location?

- Urban (1)
- Semi-rural (2)
- Rural (3)

Q8 In which geographical area within the UK is your school located?

- England (South) (1)
- England (North) (2)
- Wales (3)
- Scotland (4)
- Northern Ireland (5)

Q9 What is the subject you teach for the majority of your teaching time? (primary school teachers of multiple subjects should select the first box)

- ◯ Primary teacher (multiple subjects) (1)
- ◯ English/Literacy (2)
- ◯ Maths/Numeracy (3)
- ◯ Science - combined (4)
- ◯ Science - biology (5)
- ◯ Science - chemistry (6)
- ◯ Science - physics (7)
- ◯ History (8)
- ◯ Geography (9)
- ◯ Languages (10)
- ◯ Art (11)
- ◯ Music (12)
- ◯ Sport/physical education (13)
- ◯ ICT (14)
- ◯ Technology subject (15)
- ◯ Drama/performing arts (16)
- ◯ Religious Education (17)
- ◯ Other (please state) (18) ____

Q9a Do you hold a SENCO role within your school?

- Yes (1)
- No (2)

Other This part of the questionnaire has been designed to gather information about your ideas about intelligence. Please answer as honestly as possible.

Q11 Please tell us to what extent you agree or disagree with the following statements.

	Strongly disagree (1)	Disagree (2)	Mostly disagree (3)	Mostly agree (4)	Agree (5)	Strongly agree (6)
You have a certain amount of intelligence, and you can't really do much to change it. (1)	o	o	o	o	o	o
Your intelligence is something about you that you can't change very much. (2)	o	o	o	o	o	o
No matter who you are, you can significantly change your intelligence level. (3)	o	o	o	o	o	o
To be honest, you can't really change how intelligent you are. (4)	o	o	o	o	o	o
You can always substantially change how intelligent you are. (5)	o	o	o	o	o	o
You can learn new things, but you can't really change your basic intelligence. (6)	o	o	o	o	o	o

Q12 To what extent do you think a child's cognitive ability is influenced by nature (genes) or by nurture (environment)?

- ○ All environment (1)
- ○ Mostly environment (2)
- ○ Even split between genes and environment (3)
- ○ Mostly genes (4)
- ○ All genes (5)

This section aims to establish how much you know about behavioural genetics at the moment.

Q15 Please indicate whether you think each statement is true (factually correct) or false (not factually correct)

<u>Clarification of terms used:</u>
Heritable = the extent to which differences between people (e.g. in their ability or personality) can be explained by differences in their genes.
Trait = a distinguishing quality or characteristic in an individual.

	Definitely true (1)	Probably true (2)	Neither true nor false (3)	Probably false (4)	Definitely false (5)
All psychological traits show substantial genetic influence. (1)	○	○	○	○	○
No psychological traits are 100% heritable. (2)	○	○	○	○	○
The heritability of traits and behaviour is caused by many genes each with a very small effect. (3)	○	○	○	○	○
Some traits and behaviours are linked to each other for genetic reasons e.g. IQ is related to school test results because the same genes influence both. (4)	○	○	○	○	○
There is likely to be a single gene that is responsible for the differences between people in intelligence. It is just a matter of time before it is identified. (5)	○	○	○	○	○
Our intelligence becomes more heritable as we get older. (6)	○	○	○	○	○

The neighbourhood we live in and the parenting we experience are influenced by our genes. (7)	○	○	○	○	○
Behaviour problems are usually explained by parenting. (8)	○	○	○	○	○
Most psychological disorders (e.g. ADHD, anxiety) are the extremes of normal behaviour, rather than genetically distinct disorders. (9)	○	○	○	○	○
Most mild to moderate leaning disorders (e.g. dyslexia) are the extremes of normal behaviour, rather than genetically distinct disorders. (10)	○	○	○	○	○

This section aims to gain an insight into your views about the role of behavioural genetics in education.

Q15 Please indicate the extent to which you agree or disagree with each statement.

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
Research that explains genetics and environmental influences on cognitive ability could be useful to teachers. (1)	o	o	o	o	o
Overall, I feel that the science of behavioural genetics has a role to play in education. (2)	o	o	o	o	o
I do not think that findings from behavioural genetics should be used to inform future educational directions. (3)	o	o	o	o	o
Personally, I would not like to see findings from behavioural genetics influencing my day-to-day classroom decisions. (4)	o	o	o	o	o
I would like to know more about behavioural genetics and its implications for child development. (5)	o	o	o	o	o

Q17 Here is a list of potential advantages some researchers believe an increased knowledge of the genes associated with cognitive ability might bring to schools.
Please select as many as you feel would be beneficial to your professional practice, if they were possible.

- ▢ Ability to target interventions more specifically to certain children. (1)
- ▢ Ability to decide on setting/streaming of children more precisely. (2)
- ▢ Earlier identification of individual children who may need specific input. (3)
- ▢ Increased focus on personalised learning. (4)
- ▢ Ability of parents to request specific educational focus based on child's genetic data. (5)
- ▢ Ability to provide earlier and more tailored careers advice. (6)
- ▢ Individualisation of extra-curricular input based on identified genetic strengths. (7)

Q18 Do you feel that the science of behavioural genetics already plays a role in your school or classroom? If yes, please explain how below.

- ○ Yes (1)
- ○ No (2)

Q19 If yes, please elaborate.

- ○ Please explain how (1) ____

The final section aims to establish your opinion regarding future training on behavioural genetics.

Q20 Did you ever receive any formal training on behavioural genetics as part of your teacher training provision?

- Yes (1)
- No (2)

Q21 Have you ever received any formal training on behavioural genetics during your time as a fully qualified teacher? (e.g. CPD)

- Yes (1)
- No (2)

Q22 Would you value further training in the future on behavioural genetics and its implications for education?

- Yes (1)
- No, why not? (2) ____

Q23 If you answered yes to question 22, which of the following methods of training delivery would you most prefer, please select up to three.

- Online training course (1)
- Meeting and talking with behavioural geneticists (2)
- In-school training day (3)
- Training conference (4)
- Visit from external expert to the school (5)
- Peer training (6)
- Documentation and resource packs (7)
- Video training (8)
- Other (9) ____

14.3 Alternative provision teacher questionnaire

Alternative Provision Teachers Beliefs' about Genetics and its Relevance to Education

It is anticipated that this questionnaire will take you about 10 minutes to complete. The questionnaire has been designed to explore some of your beliefs about genetics. Please note: If you have already received this questionnaire through your school and responded, please do not respond again. Behavioural genetics is a relatively young science, which is developing at a fast rate. The main focus of behavioural genetics is to understand the influence of genetic and environmental influences on human behaviour. It is an interdisciplinary field combining genetics and psychology, and covers a wide range of human behaviour from cognitive abilities through to personality disorders. This questionnaire will ask you about your opinion about whether behavioural genetics is relevant to education, thinking particularly of education in special schools and Pupil Referral Units. All responses are collected anonymously and are therefore untraceable back to you or your school. You are able to withdraw from the study at any time until you have submitted your responses. After this it will no longer be possible to identify which responses are yours. The data will be shared only between myself, Madeline Crosswaite, and my PhD supervisor Dr Kathryn Asbury. Data will be stored securely on a password protected computer for approximately three years until the study has been completed and results have been published.

Completion of the questionnaire will be understood as confirmation of your informed consent to take part in the study. If you have any queries or concerns please contact me (mc855@york.ac.uk) or the Chair of the Education Department's Ethics Committee (education-research-administrator@york.ac.uk). **Please click on the arrows to proceed to the short questionnaire - thank you in advance for your time**

Q1 Please indicate your gender.

- ◯ Male (1)
- ◯ Female (2)
- ◯ Would rather not say (3)

Q2 Please indicate your age in years.

____

Q3 How many years have you been employed as a teacher? Please give you answer to the nearest year.

____

Q4 Do you teach children of primary or secondary school age?

- ◯ Primary (2)
- ◯ Secondary (3)
- ◯ Both (4)
- ◯ Other (please specify) (5) ____

Q6 Which of the following options best describes the type of school you currently work in?

- ◯ State run special school (1)
- ◯ State run pupil referral unit (2)
- ◯ Independent/private special school (3)
- ◯ Independent/private pupil referral unit (4)
- ◯ Specialist provision e.g. specialist autism school (8)
- ◯ Other (7) ____

This part of the questionnaire has been designed to gather information about your ideas about intelligence and behaviour. Please answer as honestly as possible.

Q7 To what extent do you think children's cognitive abilities are influenced by nature (genes) or by nurture (environment)?

- ○ All environment (1)
- ○ Mostly environment (2)
- ○ Even split between genes and environment (3)
- ○ Mostly genes (4)
- ○ All genes (5)

Q9 To what extent do you think children's positive prosocial behaviour is influenced by nature (genes) or by nurture (environment)?
A child's positive prosocial behaviour includes behaviour such as their ability to consider others' feelings, sharing, being kind to younger children and volunteering to help out.

- ○ All environment (1)
- ○ Mostly environment (2)
- ○ Even split between genes and environment (3)
- ○ Mostly genes (4)
- ○ All genes (5)

Q10 To what extent do you think hyperactive behaviour is influenced by nature (genes) or by nurture (environment)?

Hyperactive behaviour includes restlessness, constant fidgeting, being easily distracted and struggling to finish tasks.

- All environment (1)
- Mostly environment (2)
- Even split between genes and environment (3)
- Mostly genes (4)
- All genes (5)

Q11 To what extent do you think children's negative emotions are influenced by nature (genes) or by nurture (environment)?

Negative emotions include worrying a lot, often being unhappy, being nervous and having many fears.

- All environment (1)
- Mostly environment (2)
- Even split between genes and environment (3)
- Mostly genes (4)
- All genes (5)

Q12 To what extent do you think children's conduct problems are influenced by nature (genes) or by nurture (environment)?

Conduct problems include behaviour such as easily getting angry, fighting, frequently lying and taking/stealing things.

- All environment (1)
- Mostly environment (2)
- Even split between genes and environment (3)
- Mostly genes (4)
- All genes (5)

Q13 To what extent do you think a children's peer problems are influenced by nature (genes) or by nurture (environment)?

Peer problems include struggling to make friends, preferring to spend time alone, being a bully/victim of bullying and preferring to spend time with adults.

- All environment (1)
- Mostly environment (2)
- Even split between genes and environment (3)
- Mostly genes (4)
- All genes (5)

This section aims to gain an insight into your views about the role of behavioural genetics in education.

Q14 Please indicate the extent to which you agree or disagree with each of the following statements.

	Stronly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
Research that explains genetics and environmental influences on cognitive ability could be useful to teachers. (1)	○	○	○	○	○
Overall, I feel that the science of behavioural genetics has a role to play in education. (2)	○	○	○	○	○
I do not think that findings from behavioural genetics should be used to inform future educational directions. (3)	○	○	○	○	○
Personally, I would not like to see findings from behavioural genetics influencing my day-to-day classroom decisions. (4)	○	○	○	○	○

I would like to know more about behavioural genetics and its implications for child development. (5)	○	○	○	○	○

Q15 Do you feel that the science of behavioural genetics already plays a role in your school or classroom? If yes, please explain how below.

○ Yes (1)

○ No (2)

Q16 If yes, please elaborate.

○ Please explain how (1) ____

Q17 Would you value further training in the future on behavioural genetics and its implications for education?

○ Yes (1)

○ No, why not? (2) ____