Archer, L., Moote, J., Francis, B., DeWitt, J. & Yeomans, L. (in press). The 'exceptional' physics/ engineering girl: a sociological analysis of longitudinal data from girls aged 10-16 to explore gendered patterns of post-16 participation. *American Educational Research Journal*

Abstract

Female under-representation in post-compulsory Physics is an ongoing issue for science education research, policy and practice. In this paper, we apply Bourdieusian and Butlerian conceptual lenses to qualitative and quantitative data collected as part of a wider longitudinal study of students' science and career aspirations age 10-16. Drawing on survey data from over 13,000 year 11 (age 15/16) students and interviews with 70 students (who had been tracked from age 10-16), we focus in particular on seven girls who aspired to continue with physics post-16, discussing how the cultural arbitrary of Physics requires these girls to be highly 'exceptional', undertaking considerable identity work and deployment of capital in order to 'possibilise' a Physics identity - an endeavour in which some girls are better positioned to be 'successful' than others.

Keywords: Femininity, Identity, Judith Butler, Physics, Science

Introduction

The question of why so many girls do not continue post-16 in the physical sciences and engineering, remains a perennial concern within science education policy and practice. In this paper we bring two distinct theoretical lenses (*Bourdieusian* and *Butlerian* theory) to bear on longitudinal, qualitative data, collected from a sample of girls in England as they progress through schooling from age 10-16, in order to ask, what is it that enables a select few girls to develop and persist with their post-16 Physics aspirations? We explore what understandings girls have developed by age 16 about who Physics is 'for' and we investigate whether there is anything distinctive about the girls who do express Physics

aspirations at age 16, asking how/why are some girls more or less able to make themselves 'possible' as Physicists?

Greater numbers of women are now undertaking science qualifications and careers, compared to four decades ago (e.g. Hill et al. 2010; Harding 1998), yet women still remain woefully under-represented in post-16 science qualifications and careers in the physical sciences and engineering (e.g. Smith 2010a/b, 2011). A considerable body of research has been conducted trying to understand gendered patterns in science participation. This work shows that gendered differences in science interest (Buccheri et al, 2011) and attainment are *not* the issue (Haworth et al 2008; Smith 2011; Tan et al., 2013; Tytler et al 2008). Indeed, despite these minimal gender differences in interest and attainment and despite no differences in girls' and boys' exposure to science at school (with pre-16 science participation being compulsory in most western, developed nations) and a wealth of initiatives being conducted over the years aimed at improving girls' participation and engagement with science, boys still seem to exhibit consistently more positive attitudes to science than girls (Haste 2004; Sjoberg & Schreiner 2005), particularly in relation to the physical sciences (Scantlebury & Baker 2007; Schreiner 2006; Schreiner & Sjoberg 2004) and girls' post-16 subject choices remain stubbornly resistant to change (Darke et al 2002; Jin et al 2011; Leathwood 2007).

The literature paints a picture in which the reasons for gender differences in science participation are, unsurprisingly, complex and multiple (Brotman & Moore 2008; Ceci et al., 2009; Murphy & Whitelegg 2006; Osborne et al., 2003). This combination of factors includes the *culture of science* which is fundamentally aligned with masculinity (Harding 1998, Haraway 1988), which disadvantages women (Blickenstaff 2005). The effects of this culture can be witnessed in the widespread finding that many children come to see science (but particularly physical science) as being 'for boys' (Adamuti-Trache 2008; Baker & Leary 1995; Breakwell et al 2003; Calabrese Barton & Tan 2009; Caleon & Subramaniam 2008; Carlone 2003; Farenga et al 1999; Francis 2000; Jones et al 2000;

Hughes 2001; Greenfield 1996; Mendick 2005; Fennema & Peterson 1985). Relatedly, children still tend to imagine scientists as being male (Baker & Leary 1995; Buck et al 2008; Fadigan & Hammrich 2004).

Issues of the *science curriculum* have also been raised, with arguments made that the mainstream science curriculum tends not to represent the interests and values of girls, and hence holds less relevance for them (e.g. Baker & Leary 1995; Barton & Brickhouse 2006; Barton et al 2008; Haussler & Hoffmann, 2002). Research has also shown how *teachers* play a key role too in the dissuasion of girls from science, for instance, unwittingly reinforcing gender stereotypes (e.g. Kelly 1985), communicating both explicit and implicit lower expectations for girls, and failing to recognise girls' science competence and expertise (Carlone 2004; Warrington & Younger 2000; Tan et al., 2013). This pervasive alignment of science with masculinity, through the myriad culture and practices of science, creates an 'identity gap' that prevents many girls/women, but particularly those from minority ethnic and/or socially disadvantaged backgrounds, from identifying with science (Tan et al., 2013). It also creates formidable barriers and blocks to girls/women's progression through from compulsory to post-compulsory education, higher education (HE) and into scientific workplaces.

These factors, while sharing some commonality across the sciences, are particularly amplified in the case of Physics and Engineering, which record more gender-imbalanced profiles than Biology, Chemistry and Mathematics. Research conducted in the UK by Mujtaba & Reiss (2013) that has focussed specifically on Physics, found that girls and boys who intend to study Physics post-16 tend to express similar views about their Physics teachers and their physics lessons. However, they also found that, compared to boys, girls tend to receive less encouragement from teachers, family and friends to study Physics post-16. There also seemed to be some distinctive features about those girls who intend to continue with Physics post-16. Compared to their female peers who do not intend to study the subject post-16, girls who do aspire to continue with Physics report higher Physics extrinsic motivation, more positive perceptions of their Physics teachers and lessons, and display greater competitiveness and less extroversion.

Moreover, research has found that women and girls encounter particular identity issues in relation to participation in Physics and Engineering. For instance, Gonsalves (2014) notes the inherent tension between femininity and Physics, such that male and female HE Physics students were found to construct the two as essentially oppositional and incompatible. That is, women struggle to be recognised simultaneously as *both* a competent Physicist *and* a woman. As a result, female Physics students report 'managing' (and rendering 'invisible') their femininity in order to be recognised as an authentic Physicists. Likewise, Faulkner (2007) notes how women experience being positioned as in/visible when they try to claim positions of competence and expertise in relation to engineering. Danielsson (2012) further explores these issues, examining Physics' students' various performances of gender, teasing out how they manage to both 'do Physics' and 'do gender' through complex negotiations of both gender (and gendered) subject norms:

> … not only are the female Physics students relating to masculine norms of the discipline, they may also have to deal with the norms and expectations about how a woman in supposed to be in a physics and engineering context (Danielsson 2012: 36).

The dominant discursive tension between 'femininity' and an 'authentic' Physics identity has also been noted within schools. For instance, Carlone (2003) explored advanced level Physics classrooms in the US and found that teachers produced clearly gendered constructions of advanced level Physics students' attainment and 'ability'. In particular, teachers tended to construct male students as more likely to be 'naturally' good at Physics, having a 'raw talent' for the subject, even in the face of their comparatively lower levels of attainment. In contrast, girls' Physics' attainment was 'explained away' as simply due to hard work and 'diligence'[i].

In sum, the literature shows that, throughout their lives and across different educational levels and settings, physics and engineering are fundamentally constructed as masculine subjects. Boys and girls receive differential pushing/encouragement in relation to these subjects and those girls and women who do continue may not receive the same recognition and validation for their science abilities

and identity. Yet as Danielsson (2012: 15) also argues, 'seldom are the voices of women who have chosen to do Physics heard'. In this paper, we aim to contribute to understanding of what makes some girls/women want to continue with Physics and what enables some of these young women to continue but not others. We ask, in what ways are the young women who aspire to Physics distinctive, or not (compared to other students and also in relation to one another)? How do they enact and manage their performances of gender and subject identities? And what makes some more resilient or 'successful' in their performances and their likely progression, than others?

Theoretical lens

For our analysis we draw on two different conceptual lenses – the work of French sociologist Pierre Bourdieu and the work of US critical feminist theorist, Judith Butler - to produce a rich understanding of why some girls are able to develop and persist with Physics aspirations, while others do not. Bourdieu's theory of social reproduction proposes that it is the interaction of habitus and capital within field that produces practice. Habitus refers to the internalised, socialised internal, interconnecting set of dispositions that a person develops in life. For instance, in our previous work we have utilised habitus as a conceptual tool for helping us to ascertain and understand how and why some children come to see science as being something that is 'for me' or 'not for me' (e.g. Archer et al., 2014; Archer & DeWitt 2016).

While habitus undoubtedly relates to socialised, internal cognitions, it is not limited to the 'mind'. Indeed, Bourdieu regards habitus as connecting cognition and embodiment, being 'written' on the body. He describes the body as:

> 'a socialised body: a structured body, a body which has incorporated the immanent structures of a world or of a particular sector of that world – a field – and which structures the perception of that world as well as action in that world (Bourdieu, 1998c, p. 81).

The expression of habitus through the body is described as *hexis*. Hexis encapsulates the way that bodily practices and enduring embodied ways of being, are produced through processes of socialisation

of the habitus. It refers to how people 'carry themselves' in the world, through their gestures, postures, gait and so on (Jenkins, 2006). In this sense, bodies are social entities, carrying and displaying their social locations and histories – hence in this paper we explore how girls embody (or not) their performances of Physics identity.

Habitus interacts with capital (economic, social and cultural resources) and is mutually co-constituting with field (Bourdieu 1990a). That is, dispositions within the habitus find their expression through field – and field determines the value of capital. As Bourdieu explains, field is more than just a physical context or environment, it is a 'structured social space' comprising social relations and relationships of power (Bourdieu 1998: 40). Hence we are interested in how girls form their Physics identities and aspirations within and through different fields. A field, such as Physics, contains it's own logic of practice, such as commonly understood rules, traditions and ways of being, and determines who and what counts as valued, valid or authentic. Within any particular field, some groups or social actors will hold more power and be seen as more legitimate than others. For instance, masculine domination of the field of Physics might be seen as 'natural' due to being the result of men's superior 'ability', 'interest' or 'aptitude' for the subject. We are also interested in how these understandings can solidify over time into *doxa*, in which particular relations of order and ways of thinking/ being (e.g. the notion that 'Physics is for boys') can become 'self-evident' (Bourdieu 1984: 471), rather than being understood as the products of particular sets of social power relations.

Bourdieu suggests that agents are socialised into accepting the legitimacy of the culture and principles of those in power, which Bourdieu terms the '*cultural arbitrary'*. For Bourdieu, education and pedagogy is key to this process – producing embedded and durable dispositions to accept the dominant relations of power and to accept the cultural arbitrary as unquestionable and self-evident:

> In any given social formation the legitimate pedagogic action, i.e. the pedagogic action endowed with the dominant legitimacy, is nothing other than the arbitrary imposition of the dominant cultural arbitrary insofar as it is misrecognized in its objective truth as the dominant pedagogic action and the imposition of the dominant culture. (Bourdieu and Passeron, 1990, p. 22)

In this paper, we apply this notion of the cultural arbitrary to the field of Physics, to assert the inherent arbitrary nature of the cultures constructed by these subject areas, into which young people are socialised and to explore the processes and messages which make up the transmission to girls of what Physics 'is' and who it is 'for'. For instance, as discussed later, we identify a dominant cultural arbitrary within Physics as being the widely taken-for-granted notion that Physics is 'hard'/ 'difficult' and only for the 'brainy'.

Useful as we feel Bourdieu's sociology is for exploring girls' Physics aspirations, for our specific gender analytic lens, we use the work of Judith Butler (e.g. 1990, 1993), who proposes that gender can be theorised as a *performance*. In other words, gender is not the product of biology, it does not result 'naturally' from particular bodies. Rather, Butler sees gender as produced through discursive and bodily 'acts'. She asserts that gender is not what you 'are' (or what sexed body you 'have') but is something that you 'do' (perform) and continually re-do, which generates a powerful 'illusion' (Butler 1990: 185/6). That is:

> the "coherence" and "continuity" of "the person" are not logical or analytic features of personhood, but rather, socially instituted and maintained norms of intelligibility" (Butler 1990: 23).

These repetitive performances are both verbal and embodied, often referred to as 'doing boy'/ 'doing girl', in which gender is produced through repeated bodily and verbal performances, generating the illusion of a 'real' or 'fixed' gender. For Butler, the purpose of this illusion is "the regulation of sexuality within the obligatory frame of reproductive heterosexuality" (Butler 1990: 185-6) – in other words, the maintenance of gender power relations and 'compulsory heterosexuality' (Rich 1986).

We find Butler's notion of 'intelligibility' as a particularly useful tool for understanding the possibilities and limits of girls' performances of both gender and physics identities. It helps attune us to the social pressures that students may experience to conform to particular dominant norms:

> "Intelligible" genders are those which in some sense institute and maintain relations of coherence and continuity among sex, gender, sexual practice, and desire." (Butler 1990: 23).

As Butler argues, some gender performances (i.e. those which are more subversive or counter-hegemonic) become 'unintelligible' within dominant social relations. That is, 'the cultural matrix through which gender identity has become intelligible requires that certain kinds of "identities" cannot "exist"' (Butler 1990: 24).

Methods

The Aspires2 project is part of a ten year longitudinal study funded by the UK's Economic and Social Research Council. The first half of the study ('Aspires'), investigated children's science and career aspirations from age 10-14, with the present data set extending tracking of this cohort from 14-19 years old. The study comprises repeated quantitative online surveys of the cohort over time plus longitudinal interviews with a selected subsample of students and their parents, in order to generate both a breadth and depth of data. This paper reports on data from the second phase of the study, focusing on the survey and interviews that were conducted with students at age 15/16 years old (Year 11, the year they take the national GCSE examinations at the end of compulsory schooling).

The survey collected a range of demographic data (including gender, ethnicity, measures of cultural capital[iii]) and covered topics such as general aspirations, aspirations in science; subject preferences, attitudes towards school science (differentiated for Physics, Biology and Chemistry); post-16 choices, images of scientists, self-concept in science; perceptions of own and others' gender identity; participation in science-related activities outside of school; parental attitudes towards science; peer attitudes towards school and school science; careers education and work experiences.

The survey builds on previous surveys, the development and validation of which have been described elsewhere, along with findings from the first three surveys, conducted when the cohort was aged 10/11, 12/13 and 13/14 (e.g. DeWitt & Archer 2015; DeWitt et al., 2014, 2013, 2011). These publications provide further detail on the reliability and validity of the survey instrument, as well as the

specific items. The majority of questions used a Likert scale to elicit attitudinal responses. Interview topic areas include constructions of self (in and out of school, interests, learner identity, self-efficacy); experiences of school; experiences of and views on school science; teachers and other subjects; aspirations and the future; formation of aspirations; influences on choices; processes of post-16 decision-making; imagined future subject choices; gendered constructions of self and others; extra-curricula activities; images of scientists; achievement and popularity; careers education experiences and views on the usefulness of science.

The survey data reported in this paper was collected from students in Y11 (age 15/16 years). This included a nationally representative survey of schools, completed by 13,421 students in England, who were recruited from 340 secondary schools in England (296 state schools and 44 independent). This sample represented all regions of the country and was roughly proportional to the overall national distribution of schools in England as measured by attainment and proportion of students eligible for free school meals. Of the 13,421 students who completed the survey, 46.7% were male and 53.3% were female. Students were asked to self-categorise their ethnic background on the surveys via a double-level question. Overall, students fell into the following (self-reported) top-level ethnic categories: White, 75.9%, Asian 9.7%, Middle Eastern 9%, Black 3.7%, Chinese/East Asian 1.5%, Mixed/Other, 4.8%. 3.4% of students preferred not to answer.

132 interviews were conducted in this phase with 70 students and 62 parents (all of who had been previously tracked since students were at primary school, age 10/11. Interviews lasted between 30 minutes and 1 hour (for students) and up to 1.5 hours (with parents). Interviews were conducted by the authors, three of whom are white, middle-class female academics (two British and one North American) and one is a white middle-class British female PhD researcher and one a white middle-class female (European) research administrator. The majority of interviews were conducted by the second author. Interviewees were invited to choose their own pseudonyms. Interview topic areas broadly mirrored the survey areas, in order to explore students' meanings, understandings, experiences and

identities in more depth. Interviewers probed responses to encourage participants to explain their views and to reflect on the potential sources or influences on their views. Brief field notes were taken after each interview. A complete copy of the survey and/or interview questions are available on request.

All interviews were digitally audio-recorded and transcribed. In line with the study's conceptual approach outlined previously, data were analysed using a discourse analytic approach (Burman & Parker 1993) that is informed by feminist post-structuralism. Initial coding and sorting of the data (on key topic areas, themes and by responses to particular questions) was undertaken by Author 1 using the NVivo software package, with other authors providing a check on reliability of coded extracts in relation to the specified codes. Seven girls were identified as having aspirations to study post-16 Physics (two of whom planned to subsequently continue into Engineering). The lead author searched the coded extracts to identify discursive gender repertoires and patterns of aspirations/ relationships with science, which were then tested and refined through successive phases of coding and analysis, iteratively testing out emergent themes across the data set to establish "strength" and prevalence (Miles & Huberman 1994). For instance, during this analytic stage we identified different key performances of femininity (e.g. 'girly' versus 'alternative') and a number of themes of commonality and difference between the girls, such as 'academic self-confidence', 'love of theoretical Physics'. These coded themes were then subjected to a more theoretically informed analysis (in line with the stated conceptual framework) to identify (i) interplays of habitus, capital and field and (ii) different interplays of ethnicity, social class and gender within the girls' performances of femininity.

Findings

While the main focus of this paper rests with an analysis of qualitative data from our longitudinally tracked sample of girls, we begin by contextualising our interview data with a brief overview of findings from the surveys that were also conducted as part of the larger project. In line with existing participation figures, the Y11 survey showed a strongly gendered profile among students, with respect to their reported interest, identification with the subject and post-16 plans. For instance, of

those Y11 students choosing physics as their best subject, 61.1% are boys and 38.9% are girls. This compares with students who named biology as their 'best subject', of whom 41.1% are boys and 58.9% are girls. Likewise, of those naming physics as 'the most difficult subject', 36.0% are boys and 64.0% are girls (comparable figures for biology are 56.7% boys and 43.3% girls and for chemistry are 45.1% boys, 54.9% girls). The survey also showed that, across the board, the majority of students agreed that Physics is the hardest and least interesting subject. For instance, 47.3% of students agreed that Physics is the hardest subject (compared with 23.4% agreeing that Biology is hardest) and only 32.6% of students agreed that Physics is the most interesting subject (compared with 55.1% agreeing that Biology is the most interesting subject). The students in our survey who were planning to take Physics post-16 largely mirrored wider patterns of post-compulsory Physics participation, being predominantly White or South Asian, male, from more affluent backgrounds and higher attaining (although we recorded a higher percentage of girls than national figures – of those students in our survey who said that they were planning to take Physics at A level, 64.7% were male and 35.3% female). It was also notable that boys seemed to report more positive views from their Physics teachers, for instance, of the students strongly agreeing that 'My teacher thinks I am good at physics', 61.8% are boys and just 38.2% girls.

Students' engineering aspirations were also highly gendered, of those aspiring to be an engineer in the future, 75.7% were male and just 24.3% female (82.1% male and 17.9% female for those students who 'strongly agreed' that they would like to be an engineer in the future), with multi-level modelling showing a huge effect size for gender (-.88).

The cultural arbitrary: Physics as 'masculine' and 'hard'

Across both the qualitative and quantitative data, young people reported experiencing and constructing Physics as aligned with masculinity and 'cleverness', due to it being a 'hard' subject. Indeed, students and parents largely talked about Physics as having more of a 'natural fit' with masculinity and that biology is more of a 'natural' fit with femininity.

"I guess cos it [Physics] kind of … has like that connotation of manliness" (Hannah)

> "I think it's just to do with the state of mind. And I think it [Physics] does tend to be kind of more of like a masculine state of mind that does tend to correlate with it […] I guess it kind of is a bit more of a man thing in the sense that like men have more of a science-y state of mind" (Davina)

> "Well I think Physics is quite a hard subject […] I don't know like a stigmatism, it's still of sort of it's kind of a men's thing […] Like female engineers, everyone needs them, um, but like I think there's still that slight stigmatism of 'oh that's a man's job' and I think that's probably why some girls are a bit like 'mm, no'" (Thalia)

The prevalence of this association between Physics and masculinity was found across the range of girls in the study, including the latter three girls, who had all enrolled on Physics A level courses. In other words, it seems that girls who take Physics post-16 also share the view of Physics as 'male' and are not apparently any more 'feminist or 'radical' in their views compared to girls who do not continue with Physics. We interpret this as revealing the power of the cultural arbitrary (in which Physics is aligned with hardness and masculinity), such that most girls appear to reproduce and buy into these naturalised associations (see also Danielsson 2012).

As discussed above, the survey data also suggested that most girls appeared to take up and internalise the notion that 'Physics is not for me', being much more likely than boys to describe Physics as difficult, not interesting, and describe themselves as 'not good at physics'. From a Bourdieusian perspective, we interpret these gendered patterns as illustrating young people's internalization of the principles of the cultural arbitrary of Physics ('Physics is masculine', 'Physics is hard', 'boys are better at hard subjects like Physics'), which can lead to self-censorship and self-exclusion, whereby girls are less likely than boys to choose Physics at A level. In Bourdieusian terms, "all cultures are equally arbitrary" (Jenkins 2006 p105) and indeed as Mujtaba & Reiss (2013) found, despite girls' lower reported confidence in their Physics abilities, there are no gender differences in students' actual Physics competence (e.g. in terms of students' performance on Physics test questions). As Jenkins discusses,

symbolic violence is enacted through the imposition of a cultural arbitrary and we would argue that the dominant alignment of Physics with masculinity constitutes a form of symbolic violence that particularly disadvantages girls. Indeed, as we shall discuss in the following section, for those girls who do continue with Physics, a notion of being 'good at Physics' is crucial to their being able to see themselves as continuing with the subject.

We interpret this prevalent association of Physics with masculinity as being achieved in no small part through 'pedagogic work'. As Bourdieu notes, particular educational outcomes and relations are achieved through pedagogic work that is enacted by the education system. Moreover, Bourdieu points out that the greater the amount of pedagogic work that is undertaken, the less we are able to recognise the habitus as being a product of internalisation of the cultural arbitrary. In other words, we become self-regulating:

> "the long term function or effect of pedagogic work is, at least in part, the production of dispositions which generate 'correct' responses to the symbolic stimuli emanating from agencies endowed with pedagogic authority" (Jenkins 2006, p107).

Hence, the pervasive construction of Physics as 'masculine' and 'hard' becomes internalised by girls/women who come to see Physics as being 'obviously' 'not for me', without realising exactly where this 'knowledge' comes from. Indeed, as Bourdieu tells us, the power of doxa lies in its ability to stay unnoticed, as naturalised or 'self-evident'. For instance, in the interviews, most girls who talked about the gendered nature of Physics and Physics participation but could not actually put their finger on why this relationship exists – the association is just taken as 'natural' or 'the way of the world' ("it just tends to be kind of just the way it is", Davina).

So if, due to the cultural arbitrary of physics (as hard and masculine), most girls/young women come to see physics as 'not for me', how and why do some girls persist in these areas? Looking at our data longitudinally, a striking picture emerges in which, by the time students reach the age of 16, Physics seemed to be haemorrhaging girls. Even science-keen girls like Samantha, who had previously

identified Physics as her 'favourite subject', were now disillusioned with the subject and felt profoundly alienated from it. Indeed, most of our 'science girls' (Archer et al., 2012) – those girls who exhibited strong 'science identities' throughout the project - were planning on dropping Physics at A level, while continuing with Chemistry, Biology and often Mathematics (and even Further Mathematics). By age 16, only seven girls had maintained Physics aspirations (although many more aspired to continue with Biology and/or Chemistry). There is a growing interest in the literature in understanding how girls and women in Physics and/or Engineering perform and negotiate their gender and subject identities (e.g. Danielsson 2012; Gonsalves 2014), hence we now consider what made these girls want to study Physics post-16, what factors they may share in common and what makes these girls 'intelligible' (or not) as Physicists.

We begin by discussing the six girls (Davina, Hannah, Kate, Mienie, Thalia and Victoria) who we classified as succeeding in performing, or 'possibilising', legible Physics subjectivities. We then consider the case of Danielle who, although aspiring to take Physics A level, we interpreted as being different to the 'exceptional girls', performing an 'impossible' (denied) Physics identity.

Possible Physicists/ Engineers? The 'exceptional girls'

> "All the individuals in this universe bring to the competition all the (relative) power at their disposal. It is this power that defines their position in the field and, as a result, their strategies" (Bourdieu 1998b, pp. 40-41).

We identified six girls who were performing potentially 'possible' Physics identities – that is, their goals and aspirations were officially sanctioned and regarded as authentic (e.g. they had already been accepted on to A level Physics courses); they strongly self-identified with these subject areas (e.g. they had expressed clear Physics-related aspirations); and they were recognised by others as being Physics 'people' (e.g. they were described by their parents as having 'realistic' aspirations and goals which they and their schools felt that they were entirely likely to attain). Our analysis of these girls' suggested that the girls were distinctive and we identified a number of commonalities in their identity performances,

capital and social backgrounds. Indeed, as we discuss next, we found their profiles and commonalities to be not only distinctive but also exceptional – these are not 'regular' girls, they are, we suggest, 'exceptional girls' who are exceptions to the norm in relation to both their performances of femininity and their possession and deployment of capital. To use Bourdieu's terminology, they are able to mobilise particular resources to help them achieve a legible Physics identity and to operate strategically within these fields.

The exceptional girls are White or South Asian, middle-class and live in the South / East of England. As discussed next, the girls all shared several key features, namely that they are: (i) proud to be different from other girls; (ii) highly competitive, (iii) attain highly and are secure in their academic abilities/identities; (iv) possess high levels of science capital; (v) have supportive schools (which push girls explicitly into Physics); (vi) prefer the theoretical side of Physics; and (vii) have a strategic approach to their gender distinctiveness in relation to the field of post-16 Physics. However, there is also one key difference between the girls, namely that four of the girls perform 'non girly' femininities, while Victoria (and to a lesser extent, Mienie) engages in performances of 'girly' hetero-femininity.

Proud to be 'different' from other girls ("not like your average person"). The girls described themselves as being different from other girls and were proud of this difference. They conveyed a sense of personal boldness and independence, 'not caring' what others think of them and revelling in "breaking boundaries" and "surprising" others. As Thalia's father put it, "She tends not to conform, because she tends to do her own thing […] she's very independent". Their interest in and aptitude for the 'masculine' and 'hard' areas of Physics (and in addition, Engineering, in the case of Hannah and Victoria) were instrumental aspects of their challenging of 'the norm', setting them apart as not only different from most of their female peers (who "don't like Maths and Science at all", Hannah), but as also exceptional students in general:

> "Maybe not a lot of people are good at Science and maybe that's kind of the *beauty* of being someone that is good at Science, I guess. The fact that maybe you're not like your average person" (Davina, emphasis added)
>
> "But I quite like that – I quite like making … well not making people angry, but making people surprised" (Hannah)

Likewise, Kate explained that she does not like to do what is 'expected' of her and gets 'annoyed' by 'gender roles' and Mienie described herself as 'different' to most other girls at school. Their discourses echoed to some extent the views of Taiwanese women physicists interviewed by Tsai (2004), who positioned themselves as exceptional and different to other women, in that 'normal' women were seen as unable to do Physics.

Highly competitive. In line with findings from the UPMAP project (Mujtaba & Reiss 2013), the girls also described themselves as academically competitive. For instance, Mienie exhibited academic competitiveness both in relation to her peers (wanting to be one of the highest achievers in her class) but also in terms of an inner competitiveness, constantly driving herself to improve on her personal best. As Francis (2000, 2010) writes, competitiveness aligns with constructions of masculinity. Competitiveness might also be regarded as a form of embodied capital that might help produce resilience and success within a 'masculine' field, such as Physics.

High attainment and strong academic self-confidence/ 'brainy' identity. All the girls recognised themselves, and were recognised by others, as being 'brainy' and high attaining. The girls were confident in their own academic abilities and knew that they were recognised in this way by others. For instance, Victoria described how she was always being singled out for awards at school. Indeed, being 'good at Physics' provided a way of performing 'intelligence', given the dominant construction of Physics as a high status ('masculine'), 'difficult' subject:

> "Like certainly from having just spoken to people I tend to think like there is a trend that actually the more intelligent people do do more Science. I mean obviously if you're doing

> English you're not stupid, obviously that's not what I mean, but like I think there is like a general trend with people who do, let's say Physics, and like loads of Maths and like Further Maths, [they] tend to be extremely intelligent people […] I guess it's kind of just about a certain way of thinking which maybe I associate with intelligence" (Davina)

In other words, if Physics is positioned as a 'difficult' subject that consequently demands 'intelligence', then performing 'being good at Physics' becomes synonymous with 'performing intelligence', or 'brainy' identity (although as we discuss further below, this can be disrupted by gender).

Some parents also recognised the allure of Physics as a vehicle for performing 'braininess', for instance Gertrude (mother) described her older daughter, who is taking all the sciences at A level, saying:

> "And I do think actually she gets kudos from it. … she's got used to the script of saying 'I'm doing Maths, Physics, Chemistry, Biology' and everyone going 'Ooh …' […] she's always been 'clever girl'.

High family science capital. In line with our previous findings that students with higher levels of science capital are more likely to aspire to continue with science post-16 and exhibit a 'science identity' (Archer et al., 2015), the girls largely possessed high levels of, not only family capital, but specifically, family science capital (overall, Victoria was categorised as having medium levels of science capital due to her parents not holding STEM degrees – although other dimensions of science capital were high, e.g. her father strongly valued and prioritised science and maths, had strong science-related social capital and explicitly motivated Victoria to take these subjects). Their parents tended to have STEM backgrounds, degree-level STEM qualifications and cultivated a science-rich family habitus in which post-16 science (but particularly the physical sciences) were strongly valued and encouraged. The families also enjoyed a range of middle-class resources (e.g. economic, cultural and social) to promote their daughter's interests (see also Archer et al., 2012), such as scientific kits, books, magazines, outings and so on. As Davina put it, "Yeah my house is just like … science is just where it's at, basically". Her

father, Dawkins, concurred ("yeah, so we're a scientific household and probably a bit too … too much … we are firmly rooted in science").

This powerful, pervasive fostering of science within her life meant that it had become the only conceivable future career for Davina ("Well I can't see myself doing anything else!"). We suggest that the girls' strongly nurturing home and school contexts (which recognised particular ways in which female bodies could be potentially commensurate with Physics identity), combined with their high levels of capital, helped render their Physics identities 'possible'. That is, their families construct and enact a discursive context within which the girls' physics performances can be 'legible'. From a Bourdieusian perspective, the girls also enjoyed access to some formidable social capital, which could help inform and realise their aspirations. For instance, Victoria described a high ranking military engineering specialist that she knew through her father.

The girls' science capital had brought particular career routes to their attention – as Hannah explained in the case of her engineering aspirations – providing both cultural capital (knowledge about the route), motivation and encouragement to continue and social capital in the form of an attractive 'role model':

> "Well my mum thought it [Engineering] was a good idea. So … actually she was suggesting it to me and I didn't really want to look into it, because I was very fixated on Medicine. And then I applied to a summer school and one of the courses that they're trying out is Engineering. Yeah, and I read a little bit about it, and I thought this is actually quite cool […] My brother is a nuclear engineer […] his girlfriend …she's a physicist as well. …So I talked to her quite a lot […] I mean my mum was very keen about Engineering. I can't think of … they liked Engineering and Medicine actually, they liked those two […] I was quite impressed with my brother's girlfriend cos she did quite like … well I don't know she just seemed quite cool, cos her job was cool … I wouldn't mind doing that" (Hannah)

Kate also described how her brother's girlfriend is currently studying engineering at university and Thalia described the strong support she received from her father:

> "Um, my dad wanted me to take Physics. I'm not sure why, but he wanted me to take Physics […] Like one of my friends got to go with her dad and he, and she got to see like Engineering and everything and she wants to be an engineer and that was great for her" (Thalia)

Girls also described their personal engagement with science-related practices in their leisure time, such as consuming science-related media and social media, which can also be ways of performing science identity and generating science capital (Archer et al, 2015). For instance, Hannah talked about how she loves to follow new discoveries and theories via social media (on the iflscience.com site). Thalia also talked about watching "science-y" and engineering focussed documentaries with her grandparents.

The girls articulated particular attitudes and dispositions in relation to science which we have previously identified as dimensions of science capital that have symbolic (often high exchange) value, such seeing Physics as present 'everywhere' in everyday life and as an enabling subject (useful for opening up career options) (see Archer et al., 2015):

> "Physics is probably the best [subject], because like physics is just around you […] like with Physics I guess it's kind of like well it's just kind of everywhere" (Davina)

> "Science is quite an opening subject" (Thalia)

In Bourdieusian terms, we might explain this gradual process of alignment (between the girls' identities and Physics) as produced through the interaction of science capital with family habitus, which in turn produces hexis (particular embodied ways of being). The internalisation processes depend on particular conditions to produce this particular layering of dispositions in which A level Physics become a (or even *the*?) 'natural' choice for these girls. Indeed, it was notable that Davina and Hannah even seemed a bit bemused as to why most of their female peers do not share her interest in physics. Jenkins (2006) reminds us that collective social identities (e.g. a Physics identity) and a shared belief in the logic of the field (e.g. that Physics is 'hard', 'masculine') are more likely to occur among those who are closest,

socially, to the fields in question. Moreover, as habitus and field are co-constituting, certain types of habitus will become normalised and privileged within any given field. In this respect, we see the girls not only as already close to the field of Physics, by dint of their middle-class, science-orientated family habitus and capital, but also becoming ever closer, through this layering of dispositions and development of a 'Physics girl' hexis over time.

Strong school science ethos and explicit pushing of girls into Physics. Two of the girls attended single-sex schools and all six reported that their schools either had an explicit science or engineering specialism or had Physics teachers who strongly and explicitly motivated and recruited girls into A level Physics:

> "Well my school is actually very supportive of girls doing Science. Well both my Science teachers at the moment are women, and so they're like 'Oh who's taking Physics? How many girls are taking Physics for A Level?' – and getting really excited, because they want girls doing Physics. …And they've also … like it was external to the school, but there was a trip to get more girls into Physics. Which I was going to go on, but I was on holiday so I couldn't go… And also the class … cos normally like there's no girls doing Physics and I don't think … I don't think I'd want to take Physics if I was the only girl in a class full of boys" (Hannah)
>
> "I was talking to my Physics teacher about Physics, because I really like Physics and he said he did think I'd do fine, because I didn't think I'd do well in Physics, but he kind of was like no, you'll do all right […] I think having a [school] Science specialism does sort of kind of push it, because I feel like the school spends a lot of time in the Science and like kind of working the Science and making sure the Science is good, because that's the specialism […] I think it definitely does help push Science" (Thalia)

As Mujtaba & Reiss (2013) discuss, one of the key factors that relates to whether a student chooses to study physics post-16 is whether they have received sustained motivation over time from a key adult (usually a teacher or parent) to continue with the subject. We interpret the impact of this sustained

encouragement as a form of work upon the habitus, produced through the field and enabled by the presence and deployment of capital. Moreover, bringing in a Butlerian lens, we would also interpret this promotion of equal opportunities discourse, and the linked practice of encouraging girls to take Physics, within the girls' schools as creating a discursive context within which the girls' performances of physics identity become (relatively) legible.

Preference for theoretical Physics. The girls shared a preference for theoretical, over practical, aspects of Physics, For instance, when asked what she liked most about Physics, Davina replied "theory, definitely". This preference for theoretical Physics was described as relating to the girls' interest in understanding and engaging with 'big' Physics questions, to help understand the Universe and 'how everything works' in the physical world:

> 'For example like with theoretical Physics you can go like really complicated and just like you know mind blowing, but you can't necessarily do a physical experiment on it. … And also I think I'm more of a mind person than like an actual 'Let's put it together and like prove it'!" (Davina)

> "I probably prefer the theoretical side slightly more, but Physics practicals aren't as bad [as chemistry] … I really like thinking about like or like the universe and I want to know how it works and I'm just, I just want to know how everything works" (Thalia).

> "I do enjoy Physics. I just like knowing how things work, what's going on out there in space and everything. I like knowing why things do what they do" (Victoria)

The girls' preference for theoretical Physics could also be interpreted as underscoring their relationship with Physics as a 'difficult' (intellectually challenging and hence intellectually engaging) subject.

Strategic view of gender distinctiveness re: careers: The girls were all well aware that post-16 Physics and Engineering are currently male-dominated areas and that pursuing these subjects to degree level would mean that they would be outnumbered by men in the classroom and the laboratory.

However, they also expressed the view that their gender distinctiveness, within a predominantly male field, could potentially provide them with a competitive 'advantage'. That is, as Hannah explained, when applying for an engineering course it "could make me stand out". She felt similarly about Physics:

> "Like I know that there's not very many women in Physics. So you'd probably … I don't want to say like advantage, but it would probably make you stand out" (Hannah)

Although Davina had considered but then decided against Engineering as a potential aspiration, she also reflected on the potential advantage that being 'distinctive' might engender:

> "I did consider it [Engineering], cos I sort of thought oh yeah not many girls do Engineering, so I think it's good to get more women into that sort of thing. But then I sort of thought like it's not really for me. […] I'm more a kind of Physics-y person than a Maths person […] I think … well in a sense that [being in a gender minority] would motivate me more because I think well actually in a way it'd be … okay this is a bit cheeky but I guess it would be easier to get into universities, because they're like 'We need to get the numbers proportionate to like society' basically. They'd be like 'Oh wow, this person is a good candidate' whatever, let's let them in - because like you know they are girls".

The girls' ability to view the field in such a strategic way might be interpreted as largely facilitated by their high levels of science capital. Indeed, parents who themselves worked in elite/middle class STEM fields, were often among the most likely to recognise the strategic potential in such positionings. Moreover, the combination of the girls' 'alternative' gender identifications and performances and their ability to re-frame the issue of women's under-representation in Physics (and Engineering) into a form of potential personal strategic advantage within the field, helps to explain why they might not be as daunted or put off the subjects post-16 (by issues of gender imbalance) as compared to other girls.

'Girly' or 'Not girly'? The exceptional girls' negotiations of femininity

Four of the 'exceptional girls' (Davina, Hannah, Kate and Thalia) distanced themselves from femininity, which in turn also contributed to their self-identification as being 'different' and 'going against the grain'. Like the women engineers (Walker 2001) and physicists (Gonsalves 2014) who identify themselves as 'tomboys' in other studies, these girls actively aligned themselves with more 'masculine', but also more 'alternative', forms of dress and taste:

> "So yeah I guess it's a bit weird … there are other people in school that listen to kind of like rock … but like I think no one will go like let's say as heavy as I would – nowhere near. [„] I'm kind of like our year's like 'metal head' effectively […] I guess a lot of my classmates probably think I'm kind of weird or like whatever […] I do have a lot more male friends than most of my friends do, and I'm also probably more science-y than most of my friends are […] I wouldn't say I'm a particularly feminine person at all. I mean you know like I swear quite a lot (laughs) […] I swear like a sailor, it's ridiculous. You know I don't … I don't really dress particularly feminine, like I tend to wear jeans and like band t-shirts and hoodies and stuff, and I wear boys' like skater shoes. So I mean yeah I'm not … I don't have a particularly feminine voice either … and I think well so what? – like there's nothing wrong with that, it's just like that's just what I am." (Davina)

> "I'm not … not particularly feminine […] I'm just more comfortable in jeans […] I mean I wear a skirt to school every day, but that's just because … well I've cut my hair really short … like really, really short, so I don't want to wear trousers. I feel like I'd be too manly. But at home I wear what I like […] So I guess with my friends um … we're all quite … 'nerdy' is quite a good way to put it. We all like you know 'Dr Who' and all that kind of stuff […] I like the alternative [music], like *My Chemical Romance* or that kind of [thing].".(Hannah)
>
> "I used to play rugby […] and I like all the sort of like heavier rock […] I get like, I feel like a lot of peer pressure sometimes, because the stuff I like isn't always like accepted with people like

> […] I'm not really what you'd probably consider girly. I don't particularly care what the gender stereotype roles are. If I do not want to adhere to it I will not adhere to it". (Thalia)

Looking back across their interviews from age 10-16, these identity performances seemed to develop and coalesce over time. For instance, in her earlier years, Davina had positioned herself as more of a 'normal' (in her words), feminine girl (see Archer et al., 2012) but from age 14-16, she increasingly performed a distinctly 'not girly' femininity orientated around 'hard' rock music and a masculine presentation of self, which she felt was exemplified by her style, friendships, voice, speech and her all male role models (scientists Richard Dawkins and Brian Cox and metal band artists). As Gonsalves (2014) found, many women physicists report performing less feminine identities and managing their appearance (to be 'not girly' or less feminine) within Physics settings, either temporarily or as an enduring aspect of their gender identity performances (see also Ong 2005). As Gonsalves (2014) discusses, 'the scientific mind is … regarded to be, simultaneously and contradictorily, disembodied and male' (p.505), hence for women to be authentic physicists, they may downplay or resist performances of femininity (perhaps 'neutralising' their feminine bodies?).

Indeed, as Gonsalves explains, women may find that in order to be recognised as 'hard working' ('brainy') and hence authentic/competent physics students, they need to perform 'non girly' gender identities. Gonsalves notes that 'this practice of regulating appearance to demonstrate commitment to study is a form of gender policing that appears to be prevalent in the physics community' (p.513), although as she also remarks, the practice seems to be only found among women, not men. In this respect, our girls might be seen as performing identities in line with this dominant discourse of physics identity as 'not girly' – although as we discuss below in relation to Victoria (and to a lesser extent, Mienie), a small number of girls may be able to overcome this to make possible a seemingly impossible identification.

The girls who performed 'non girly' femininity/ masculinity recognised that their 'non-conventional' performances of gender meant that they were not the 'coolest' or 'most popular' students

– although they navigated this through valuing and identification with a performance of 'geek chic', which a number of students and parents in the wider sample recognised and felt provided a contemporary 'socially acceptable' way of performing 'being good at science':

In line with their performances of 'not girly' femininity, the girls all suggested that they were comfortable in male company and did not anticipate being 'put off' by a male-dominated Physics or Engineering environment in HE.

> "I don't care what gender other people are there, it's kind of about what's good for me as an individual and what I think is like the best thing for me to do". (Davina)

> "I don't really mind [being the only girl on an Engineering course], but I'd imagine that other people wouldn't like that […] No I don't think it would [matter]. I'd quite enjoy it because … like breaking boundaries whatever". (Hannah)

Notably, the girls did not seem to adopt any explicitly feminist politics with which to argue for their 'authenticity' as young women in relation to the 'masculine' worlds of Physics and Engineering. Indeed, they described their 'alternative' performances of femininity in quite essentialised terms (e.g. '[it's] just what I am', Thalia/ Davina). This may in part, relate with their constructions of the 'Physics brain' – which locates an authentic (masculinised) Physics identity as an essentialised cognitive quality, which can exist independently of a male body. Their disassociation from femininity and investment in more 'masculine' and/or non-conformist performances of self work to produce a more congruent embodied performance of the 'Physics brain'.

Bourdieu suggests that the cultural arbitrary is both sustained through, and results in, *hexis* (bodily practices and enduring embodied ways of being). Indeed, we note from the longitudinal data that the girls' development of a 'strong' (consistent performance) of a Physics identity seems to go incrementally hand in hand with their productions of 'alternative' identities and gender performances. We interpret the alignment between the two as enabling the girls to perform possible Physics

subjectivities. That is, their 'natural' bodily ways of 'carrying themselves' in the world (e.g. as 'masculine' performances of scientist 'geek chic'), become ever more congruent with the cultural arbitrary of Physics, as e.g. 'hard', 'masculine'). This resonates with findings from Ong's (2005) research with women scientists in HE, who described moderating their dress and appearance (performing less hetero-feminine identities) in order to be taken 'seriously' as 'authentic' scientists.

However, it was also notable that one of the 'exceptional girls', Victoria, did perform an explicitly 'girly' identity. Mienie also identified herself as 'girly' in some ways (e.g. she likes to wear glittery hairbands and do her nails), although she also talked about being a 'geek' and not a very popular or sociable student (preferring to concentrate on her work). In contrast to the other girls, Victoria had not always been into science. At age 10/11, she aspired to be a dress designer. At age 12/13, she had 'no idea' of her future aspirations, although she toyed with the ideas of science, research and accountancy/banking. At age 13/14, she wanted to be a banker (or possibly a scientist) and at age 16 she had firmly decided on becoming a helicopter pilot (inspired by a trip she had been on to an air base overseas with her Air Cadets group). To achieve this, she was planning to study aeronautical engineering at University, and had chosen maths and physics A levels and was applying to a military college for sixth form.

Victoria described herself as a 'girly girl'. She talked about how she enjoyed wearing make-up and going shopping. However, she also seemed very adept at balancing her gendered identity performances, and seemed to engage in heteroglossic performances of gender (see Francis 2012), describing herself as also fitting in and relating to a wide range of students ("I feel like I've got like a bit of everyone in me […] I can relate to all of them"). For instance, she describes how she is not always girly, is a member of the air cadets, which sets her apart from most of her female peers and which she describes as having "like a tomboy sort of aspect to it". She talked about being "very conscious of how I come across to other people" and seems to be careful and deliberate in her presentations of self, ensuring that they are appropriate to different contexts.

Despite her current successful negotiation of managing to 'do' both physics identity and hetero-femininity, Victoria also hinted at potential risks and future struggles in these continued identity negotiations. For instance, she recounted her mother's fears that her femininity might 'change' and be 'spoiled' by pursuing an engineering degree and career:

> "The image that they'd get [is putting girls off engineering]. Like my mum said, OK you can go off to the RAF but don't come really butch with no personality and a monotone voice. I think that is more the image of engineer rather than science".

Moreover, despite her own balancing of 'girly' femininity and her aspiration to study physics, Victoria also "definitely" agreed that girly girls are much less likely to go into Physics. In this respect, it would be interesting to see whether Victoria might engage in increasingly selective performances of femininity as she progresses through the physics and engineering 'pipelines', akin to one of Gonsalves' women HE physics students, Laura, who regulated when and where she performed 'girly' femininity, and 'struggled with finding spaces for appropriate performances of gender, while still being recognised as a member of the physics community' (p513).

'Immunity' and resilience

We suggest that the above analyses point to the massive amount of identity work and resource mobilisation that the girls and their supporters (e.g. their families and schools) are deploying and undertaking in order to produce the girls as potentially possible (viable) physics subjects. This industriousness seemed to generate a facilitative discursive environment or habitus which motivated, enabled and supported the girls to pursue their Physics aspirations. We suggest that this resilience might even be conceptualised as a form of 'immunity', providing the girls with an embodied, durable 'defence' that inoculated them against the myriad of factors which work in subtle, and not-so-subtle, everyday ways to exclude and prevent girls from continuing with Physics. That is, we do not see the girls as somehow 'outside' society or as not subject to the same pressures, barriers, dissuaders and gendered norms and messages that their female peers are subject to. Rather, their 'immunity' enables

them to better navigate, resist and repel these factors. For instance, as discussed earlier, the issue of 'teacher quality' was often named by girls and their parents as a factor that puts off many students (but particularly girls) from Physics. The 'exceptional girls' were no exception (e.g. Victoria described the 'rubbish teacher' she had and Hannah recounted how "I had a teacher and she wasn't very good, like we were very confused a lot of the time"), but their combination of capital, habitus and hexis enabled them to persist and access alternative forms of support when necessary (e.g. private tutoring). Likewise, the exceptional girls also recounted the issue of "boring" and "dry" Physics content within the compulsory curriculum. As Hannah explained

> "Well it does get boring at times. Cos like you're not doing like really cool experiments that you get to do in uni".

However, as Hannah hints at in her quote, they were able to maintain a motivation to continue, fuelled by the anticipation of there being more exciting Physics awaiting in the future. That is, they were driven by a 'longer term' goal that helped them to weather smaller storms and challenges along the way.

The girls acknowledged that their 'unusual' aspirations and interest in Physics (and for a couple, also Engineering) marked them out as different and could even result in explicit peer resistance and disapproval. For instance, Hannah recounted:

> "I told my friend I was thinking of Engineering, they were like 'Ooh, why would you do that? … they thought it was all confusing and gross"'.

For some, like Thalia, having like-minded friends was important and she recognised that without support, many girls might be put off Physics ("I think if they're in a social group that's all like mm, no Science is weird then they'll think oh no Science is weird"). Victoria also recounted how she had originally enrolled on GCSE Engineering but had ended up dropping out of the course because she was the only girl and had struggled with the boys' sexist and exclusionary practices:

> "I was the only girl … in the whole year to take engineering, [..] all the boys were like, this is so funny […] I'd just be over there in the corner making the power points […] and I just found it really boring."

But as Victoria also explained, her strong STEM capital and encouragement enabled her to strategically return to the subject ("everybody told me I could still pick it up later").

As discussed earlier, the girls were also very aware that dominant public discourses and stereotypes frame Physics as male (for instance, through the popular US TV show *The Big Bang Theory*). Yet their distinctive combinations of identity and cultural resources meant that while they recognised these discourses (and even as discussed earlier, reproduce them to some extent) they are not personally put off from continuing with Physics. As Thalia explained:

> "I think it depends on what you see in the media, because I watch a lot of programmes where there's all the really like cool scientists or the cute scientists or the really smart guys that everyone loves, but then like you've also got the sort of image of it's something you don't really want to do, and it's like quite tiresome and everything" (Thalia).

Thalia's comments point to a critical literacy that may facilitate her apparent 'immunity' to wider public stereotypes/ discourses and which, we might suggest, is fostered by the industrious identity work and resource deployment that she and her significant others are undertaking to produce her possibility as a physicist. However, we might suggest that the existence and prevalence of these wider stereotypical discourses also require Thalia, and the other girls, to constantly defend and assert their own 'possibility' – as wider societal discourses still (constantly?) position femininity and physics as incompatible (impossible).

'Exceptional-girl *denied*': Danielle

So far we have discussed the six girls who were performing 'intelligible' Physics subjectivities. We now turn our attention to a seventh girl, Danielle, who held Physics aspirations, but who was

arguably less intelligible as a Physics subject. Danielle is a white, working-class girl who lives in a city in Central England. She held a number of factors in common to the other 'exceptional girls', for instance, she absolutely loves Physics and really wants to study it at A level:

> "I love Physics […] if you were sitting a Physics exam you can look at the … question… do the equations and work it out, even if you knew nothing about what it was about. That's what I like about Physics. It's kind of like common sense"

She describes herself as being good at the subject ("I'm really good at Physics") and competitive ("Yeah, I am competitive […] I'd like to be the top of the top set" [laughs]). She also has a preference for theoretical/conceptual Physics:

> "I don't like visual science [e.g. demonstrations]. I'm a bit of a boff. I'd rather sit and read an article and write about like… I just like doing like the coursework side of science"

She values Physics as useful for all aspects of life:

> "Even if I decided I wanted to be an English teacher I wouldn't mind doing a Science next year because I do enjoy it. I do enjoy Science […] I think Science does fit into everything. Like there's science in everything, isn't there?"

Danielle "definitely" likes the idea of becoming a scientist, has friends who also enjoy Science; ("Quite a lot of my friends really love Science. Like most of my friends quite like Science") and is in the top set for science at school. She is also confident to assert her love of Physics in defiance of peer pressure, saying "I'm not embarrassed to say Science is my favourite subject".

However, Danielle also differs from the other Physics 'exceptional girls' in some key ways. For instance, she has comparatively much lower science capital than the other girls (although her dad is a non-graduate level mechanical engineer). She is taking Double Science at school and her overall levels of attainment are good rather than exceptional (e.g. she is predicted eight or nine GCSEs A*-C grade but mostly at 'B' or C grade level). As we discuss further below, Danielle also has an ambivalent

identification with 'cleverness' and she performs popular 'glamorous' femininity. As a result, we suggest that despite her love of Physics and her desire to take the subject at A level, her ongoing Physics trajectory is far from certain. Indeed, at the time of interview, Danielle seemed somewhat resigned to the likely possibility that she would not be accepted on to Physics A level, not least given that this was the only one of her subject options that had not been confirmed already by the school and had been left as dependent upon her achieved GCSE grades.

> "I'm taking English language, Media, Heath & Social Care and Psychology, I think. I was going to take Physics but I've got to wait to get my results from my exams back, because if I don't get a B, I can't do Physics"

Moreover, despite recounting her overwhelming love of science and how it is her 'favourite subject' in each of her various interviews, from the age of 10 and all through her early secondary years, by the time of her Year 11 interview, aged 16, Danielle appears to have changed her favourite subject, which she now identifies as being English (with Science a second or potentially equal favourite). Moreover, she aspires to be an adult education teacher, probably teaching English, anticipating that she will go to university "then build up to being a teacher".

We suggest that three key, inter-related themes are particularly important as working against Danielle's post-16 Physics, all of which are strongly shaped/inflected by her subject position as a working-class girl. The first is her performance of working-class, 'popular' femininity, and the second is her troubled/troubling relationship with 'cleverness'. The third is her (classed, gendered) comparative lack of (and/or under-activation of) (science) capital.

Danielle's performance of popular hetero-femininity (the 'wrong body' for Physics?). Danielle described at length at various points in her interview how she performed a version of popular hetero-femininity, characterised by a groomed, 'glamorous' hyper-feminine style, epitomised by her love of make-up and hair extensions, which she wears both in and out of school. In this respect, her performances of girly femininity are more monoglossic (Francis 2015) than Victoria's. Crucially, they

are also differently classed: whereas Victoria performs a 'demure' and 'tasteful' middle-class girly femininity, Danielle performs a working-class girly femininity which dominant society often denigrates as 'vulgar', 'excessive' (e.g. Skeggs 1997, 2004) and 'not clever' (Bourdieu 2010)

At a personal level, Danielle is entirely comfortable with, and takes a pride in, her performances of femininity, although she is acutely aware that these jar against the middle-class habitus of the school and the notion of what a 'good schoolgirl' should look like (i.e. as asexual and 'demure', see Walkerdine 1990) and in particular, what an authentic science/ Physics student should look like. In particular, Danielle worries that her performance of working-class femininity is interpreted by others as evidence of her lack of intellect:

> "I'm a bit of a party girl … I like make-up and hair and stuff like that, but then I do like the kind of school side. Like everyone thinks I'm really dumb, but I'm not. I seem quite dumb I suppose… because like I do all my make-up and hair and just seem a blonde bimbo".

As discussed by feminist theorists such as Walkerdine (1990), Renold & Allan (2006) and Francis et al (2011), research has discussed the (im)possibility of 'feminine cleverness' – that is, cleverness is constructed in masculine terms, such that girls' performances of cleverness are either not recognised as such (e.g. are explained away as due to 'hard work') or are only recognised when they are achieved through performances of masculinity. As this work has also pointed out, 'cleverness' is also classed, such that authentic performances of cleverness are aligned with middle-class identity performances. As a working-class girl, Danielle is concerned and aware that her embodiment conveys "like a vibe that I'm not clever". Although Danielle also contests the 'truth' of this popular association:

> "Like girls who wear a lot of make-up and hair and look fake, they're supposed to be in Set 5 for everything and the girls that wear glasses and have short hair and don't wear any make-up are supposed to be in set 1. […] it's just a load of rubbish, isn't it? Because it doesn't affect your brain"

Danielle attempts to navigate this gendered and classed minefield (to assert her own physics authenticity) by drawing on a discourse of the 'brain' to negotiate the embodied tensions that arise from having the 'wrong' body for performing a recognised Physics identity. The unintelligibility of performances of working-class 'girly' femininity in relation to physics were also foregrounded by several of those exceptional girls who were successfully 'possibilising' their own Physics trajectories. For instance, Davina and Victoria both agreed that 'girly' girls do not take physics, yet Davina seemed perplexed by this and ruminated that she could not work out the reason for this "correlation" (as she termed it). Likewise, Victoria talked disdainfully of how a number of girls who she knows to be "smart" have ended up "morphing into other people" and changing their aspirations to more 'feminine' careers, such as hairdressing ("a social job, rather than a job worth doing"). Similarly, Hannah reflected on how 'doing girly' often entails "acting stupid", in order to garner male heterosexual approval:

> "And um … well like some girls in my year they act stupid. Like I don't think they are stupid, but I think they act it… So they think 'Oh I can't do it [Physics], cos I'm stupid' – but they're not at all…[Int: Mmm, why do they do that?] Uh … probably because they're sitting near boys"

Danielle reflects that her performances of femininity are particularly unusual in the top set, where she is positioned, although as she asserts, she feels that this imbalance should not detract from the injustice or inaccuracy of the stereotype:

> "Most set 1 [top set] girls are a little bit like boffiny.. Like there is only like three of us that wear a lot of make-up and do our hair, but it doesn't take away the fact that the stereotype's wrong"

For Danielle, this disjuncture is particularly noticeable within the context of the 'masculine' and 'hard' cultural arbitrary of Physics. She illustrates her frustration through an example from a recent incident at a college careers day, which had greatly offended her:

> "I came in for like my careers day and looked around everywhere and I wanted to be like approached by like Science colleagues and stuff [but a lady came up and said to her] "Well you look like you'd like to do Beauty, young lady". I was like, "I thought you might say that. I don't

> want to do Beauty". Because I know it sounds horrible to everyone who's done beauty, but when I think of Beauty I just think of someone who messed up their GCSEs and had to do that".

As Danielle's extract illustrates, she both resents and resists the alignment of popular working-class hetero-femininity with non-academic routes, yet she also reproduces this discourse ("when I think of Beauty, I just think of someone who messed their GCSEs up and had to do it"). Applying a Bourdieusian lens, we might interpret this as a habitus divided against itself – in order to access a privileged space or identity position, Danielle must also reproduce aspects of the pathologising discourses that she herself is subject to. She wants to be recognised as scientific/ performing science identity by the science staff at the careers day but knows that her performance of femininity is not intelligible as scientific ("I thought you might say that"). In order to assert herself as intelligent, she thus takes up the dominant discourse and derides those who take Beauty as 'not intelligent'.

Danielle's working-class, feminine habitus is expressed through hexis, in her bodily practices and ways of being, but while these have use-value within some (e.g. working-class) fields, they do not carry the same currency (have exchange value) within the academic field, and particularly, not in the masculine field of Physics. Indeed, Danielle indicates that she is aware of the masculine, 'nerdy' performances of masculinity and femininity that are associated with STEM subjects, such as maths:

> "It was like, imagine coming here and seeing someone that like looked really nerdy saying 'you look like you want to do maths' […] they obviously think I look like I couldn't do a teaching job or go to university".

While railing against the alignment of particular subjects with gender, Danielle also reproduces these discourses herself, for instance identifying maths as 'masculine' and English as 'feminine':

> "I think maths is masculine because … it sounds weird but women will argue and men will say their point and leave it. And maths only has one answer. Whereas English is a debate. That's why I think English is a women's subject and maths is a man's. I don't know why"

Interestingly, Danielle constructs Physics as 'both' masculine and feminine, being a bit like both subjects ("I like it because Physics is kind of like Maths *and* English"), which could potentially be interpreted as her trying to subvert dominant constructions of Physics (as masculine) in order to argue for her own legitimacy within it (it is *both* masculine and feminine). However, as discussed above in relation to the girls' use of the 'Physics mind/brain' construction, these discursive manoeuvres can be fragile/ risky, in that they cannot ultimately 'cope' with the problem of the normalised male body underpinning dominant constructions of the authentic Physicist.

Clever/dumb (the 'wrong mind'). Allied to Danielle's troubled negotiation of her own performances of femininity in relation to her desired position as an authentic science/ Physics subject, her interviews were also laced through with a repeated wrestling over her positioning in relation to being 'clever' or 'dumb'. Danielle's own self-identification and self-positioning changed throughout each interview, according to the context and others being invoked at that moment. For instance, in relation to her family, she positions herself as 'clever':

> "All of my family is not clever. Well, my mum has the potential to be really clever .. she went to do [occupational therapy qualification] but she got pregnant with me so she couldn't do it […] Like my dad said to my sisters 'you've got to do something with your hands because you're not clever enough to use your brain'. They're really dumb"

Yet her self-identification (as 'clever') is also challenged by her father, who Danielle accuses of misrecognising her on the same basis that other people do, due to her performance of girly working-class femininity:

> "And my dad turned round to me the other night and went 'you ain't clever enough to go to college'. I went, 'yes I am, shut up'. Like he doesn't know I'm clever. He thinks what everyone else thinks, that I'm not clever because I look like this… But… I'll prove him wrong"

To draw on Sennett & Cobb's (1977) terminology, we would argue that Danielle's talk reveals not only the hidden injuries of class here, but particularly the injuries of working-class femininity. Indeed, it is notable that in the context of (middle-class) school, Danielle feels much more ambivalent and unsure of her 'cleverness' ("I seem quite dumb I suppose"). She had changed school between years 9 and 11. At her old school she had felt 'stupid' in relation to most subjects, but noticeably maths and English. She described the school as "for posh kids", saying "It was for intelligent children and then if you're not as intelligent then they don't really care about you half as much … here I don't feel stupid. I used to feel stupid at [old school], really stupid". Yet, at her old school she had felt that she was comparatively better at science – something that she did not feel was the case at her current school:

> "I've always liked science because it's just I find it fun. The only thing now is, I used to feel really good at science at my old school because no one else was that good at Science and now I feel like I'm not quite as good, because everyone else is better".

As various scholars have noted, notions of 'cleverness' are gendered (e.g. Francis & Skelton, 2005) and classed (Bourdieu, 2010). As Bourdieu explains, notions of competence underpin the structure of class distinction and the preservation of relations of privilege/ domination, such that class power asserts that 'the poor are not just immoral, alcoholic and degenerate, they are stupid, they lack intelligence' (Bourdieu, 2010: 119).

Despite her love of science and her long held secret desire to become a scientist, Danielle took Double Science as her GCSE option, rather than the more prestigious Triple Science route. She reasoned:

> "Triple Science is too hard.. I wouldn't have done it, I'd have failed, so there was no point"

In other words, Danielle has internalised dominant societal messages about the classed nature of 'intelligence' and who Triple Science is 'for'. Moreover, she lacks sufficient cultural capital and elite science capital to know that this 'choice' may preclude her access to A level Physics. This feeling of 'not excelling' sufficiently at Science had spilled over into her aspirations, making her rule out her 'dream job' of becoming a scientists because she does not feel 'good enough'. As Bourdieu explains, a shared belief in the legitimacy of particular power relations provides the basis of symbolic violence against Others. That is, Danielle does not have to be 'told' she cannot become a scientist, she already 'knows' that she is 'not good enough' and rules herself out, thus preserving the elite nature of the field.

The under-activation of capital ('the wrong capital'). Whereas the 'exceptional girls' all possessed high levels of family science capital, Danielle was somewhat different. For instance, she did not have any family members or family friends with A level or degree level STEM qualifications, indeed, as Danielle explained "no one in my family has ever been to University" and there were few science-related resources, interests or practices in her out-of-school life. We identified her as having various forms of use-value capital (or 'funds of knowledge', Moll et al 1992) but these seemed rarely, or only partially, leveraged/ activated. For instance, Danielle's dream to become a marine biologist was originally sparked by a family holiday abroad when she was younger ("I loved like looking at the rocks just like underwater. I just really liked it. I love water, I love science, so it was just like the perfect job"). But this interest and experience was never capitalised upon or activated further. She had never talked to anyone within or outside her family about her aspiration and she did not engage in any out of school science learning enrichment activities. This stood in stark contrast to her more recent aspiration to become a teacher, which she had discussed with a school teacher and received advice about and for which she had also managed to foster and support by drawing on wider family social capital (a relative who is a teacher). Instead, Danielle decided silently and privately that she would 'never' be able to pursue her 'secret' ambition ("No [I never talked to anyone about it], but I'd just assumed you'd have to like get an A* in Science").

In sum, as a white, working-class overtly 'feminine' girl, we contend that Danielle is 'un-intelligible' as an authentic A level physics subject: she troubles the dominant embodiment of 'who does Physics'. Compared to the dominant cultural arbitrary of Physics, her performance of popular working-class hetero-femininity means that she has the 'wrong body' and her performance of 'average' attainment (and her conflicted identification with 'clever'/ 'dumb') means that she has the 'wrong brain'. She also has the 'wrong capital' – that is, she does not possess symbolic forms of science capital nor does she enjoy access to the mechanisms of privilege that might help her to leverage and transform her capital into Physics participation. As such, we fear that the weight of social inequalities resting upon and working against Danielle are such, that we are pessimistic about her likely ongoing participation in Physics post-16.

Discussion

In this paper we have attempted to contribute new insights to the long-standing conundrum of why so few girls persist with Physics post-16. We know that in primary school, boys and girls both report liking science, with little gender difference (Murphy & Beggs 2003; Archer & DeWitt 2016) but by secondary school, strongly gendered patterns of interest are noted between the different sciences, with these patterns following through into patterns of post-compulsory participation in physics. We have highlighted the immense identity work undertaken by girls and their significant others in our study in order to produce themselves as potentially viable/possible Physicists. Yet we have also argued that our data show that agency alone cannot guarantee that these girls are able to successfully pursue their aspirations. Indeed, our data suggest that structural and social class inequalities and the cultural arbitrary of physics not only potentially puts off girls (because they do not offer an attractive and/or achievable vision of who girls can 'be' within these subject areas) but may also actively work against and prevent some girls (notably working-class girls like Danielle) from continuing, even when they want to.

Our analyses tried to delineate the cultural arbitrary of Physics, in which Physics is dominantly constructed as being both 'masculine' and 'hard'. We noted that this construction was evidenced not

only among those girls who do not plan to continue with Physics, but also among those who do. We suggest that the multiple and repeated ways in which pedagogic action was played out in our data, producing a layering of dispositions within students' habitus, can both naturalise the cultural arbitrary (as 'real', 'natural' and 'the way things are') and produce patterns of conformity – that is, predictable patterns in terms of who 'chooses' to take Physics post-16, and who does not. In other words, it produces a self-regulating system. As Jenkins writes, "The legitimate culture becomes experiences as an axiom, a *fait accompli*: Children all too soon stop asking 'Why?' Exclusion works most powerfully as self-exclusion" (Jenkins 2006 p107).

We investigated in detail those girls in our sample who were intending to continue with Physics post-16 and found that, due to the dominant construction of physics as 'masculine', in order to produce themselves as viable physicists, the girls (and their supporters, such as family/schools) were engaging in extensive identity work and needed to deploy significant amounts of capital to make possible an 'impossible' subject position. This suggests that a physics identity may be particularly hard for working-class girls to attain. Moreover, we argued that the girls who did manage to possibilise themselves were not 'usual' – we identify them as 'exceptional' in multiple ways: in the sense of being highly academic, in their disassociation from femininity, and investment in 'alternative' identities (e.g. being proud to be 'different' to other girls), attending schools which explicitly encourage and push girls into A level Physics and having high levels of financial, cultural and science capital.

We suggest that particular (masculine, middle-class) ways of being may be more intelligible and congruent with the cultural arbitrary of Physics and that these were socialised/ internalised by girls in our sample and then played out through their bodily performances and ways of being. Hence, most of the girls who aspired to continue with physics engaged in 'non-girly' performances of gender that aligned with cultural arbitrary, which sees femininity as incompatible with authentic performances of Physics identity. Victoria and Danielle, in particular, trouble these dominant versions through their performances of more 'girly' femininity. However, we also wonder how sustainable these performances

are and what extraordinary efforts might be required to maintain performances of both 'doing heterofemininity' and 'doing physics', which, as discussed earlier, can be policed and derided as inauthentic not only by males but also their female peers. This issue is exemplified by a recent media frenzy around the sexist comments made by Nobel prize winning English biochemist Professor Tim Hunt. Hunt's allegedly 'humorous' call for gender-segregated labs - because women are too heterosexually distracting and too emotional ('they fall in love with you and when you criticise them, they cry'"[iii]) was met by a Twitter storm of (far wittier) responses by women scientists who posted up images of just how 'un-sexy' they are at work[iv]. While these responses can be read as a heartening re-claiming of voice and visibility by women scientists (and were indeed powerful, contributing to Hunt's later resignation[v]), it is also notable that their claims to scientific authenticity were largely predicated upon conformity to the cultural arbitrary of science as 'not feminine'. Indeed, it might be suggested that part of the strength of feeling behind their responses lie in Hunt's dismissal of their authenticity through an accusation of 'girliness'.

In this respect, we might interpret Victoria and Danielle's performances as not only troubling the cultural arbitrary of physics, but also as potentially offering much more radical and subversive challenges to the dominant power relations[vi]. However, while Victoria is, for now, engaging in heteroglossic performances of gender (both middle-class 'girly' femininity and performances of masculinity, e.g. via air cadets), Gonsalves' (2014) study suggests that she may find this increasingly difficult to manage, both at a personal level but also because it can be policed not only by men but by other women. For instance, Gonsalves discusses the example of Ruby, a woman physicist who is troubled and 'bothered' by women who transgress gendered norms in the lab by performing girly femininity and hence derides/ resists their 'possibility' as Physicists.

Danielle and Victoria's performances of girly femininity also point to the silent, yet equally pernicious, role of class inequalities within the cultural arbitrary. We suggest that Danielle's performances of working-class girly femininity remain particularly unintelligible in relation to the

cultural arbitrary of physics, which, we argued positions Danielle as possessing the 'wrong' body, mind and capital for participation in post-16 physics.

A bleak outlook? It is often claimed that getting more women into Physics will change the culture. However, our analyses suggest that it might not be that simple. Moreover, as we have discussed, 'more women' does not necessarily equate to 'more working-class women' – and we suggest that greater recognition needs to be given to the intersection of gender and class within women's exclusion from Physics.

Jenkins (2006) reminds us that collective social identities (e.g. a Physics identity) and a shared belief in the logic of the field (e.g. that Physics is 'hard', 'masculine') are more likely to occur among those who are closest, socially, to the fields in question. As habitus and field are co-constituting, certain types of habitus will become normalised and privileged within any given field. The six girls who look to be the most likely to pursue their physics aspirations all came from middle-class backgrounds and shared a common view of Physics as 'masculine' and 'hard'. That is, they positioned themselves as aligned with and embodying these values (e.g brainy, non-feminine, 'hard') through their performances of masculinity (and negation of femininity) and ownership of the 'physics brain'. They found it hard to 'understand' other girls' resistance to physics outside of these terms. Hence, we hypothesise that they are unlikely to substantially trouble or disrupt the cultural arbitrary and are unlikely to contribute to any radical revision of the field through their participation. We also hypothesise that Victoria will have to engage in substantial identity work to maintain her possibility as an engineering subject and may need to compromise aspects of herself if she is to comfortably continue. The problem, as we see it, remains that if the only women who can 'make it' into post-compulsory physics are essentially 'clones' of the current cultural arbitrary, then in seems unlikely that the culture of Physics will change dramatically and the mere presence of more women in these fields may not necessarily really widen participation in any meaningful way.

In sum, we suggest that unless we change the cultural arbitrary of Physics (and allied, similarly male-dominated subjects, such as engineering), then there will be little change in the profile of those who continue in these fields. 'Girly', but particular working-class, young women like Danielle, may passionately 'love' the subjects but they may be unable to complete the classed and gendered identity work necessary to become intelligible as physicists. Depressingly, for feminists and science educators, our analyses do not point to a simple or single course of action that might be undertaken to ameliorate the gendered and classed inequalities surrounding participation in physics. However, we suggest that an increased focus on the intersection of both gender and class within discussions of post-16 physics participation is a useful step. We also suggest that a potentially fruitful avenue of inquiry may be to focus on what might be done to change the cultural arbitrary of physics and the conditions within which students make their subject 'choices', rather than attempting to change the attitudes and aspirations of girls themselves. Changing the cultural arbitrary would, of course, be no mean feat, however, we suggest that it might best be attempted through sustained partnership working between professional societies, teachers, curriculum developers, awarding bodies, universities, the media and grassroots youth organisations to convey a coherent, more inclusive vision of Physics and to ensure that different sections of the 'physics ecosystem' are not reinforcing the cultural arbitrary. For instance, in the UK the Institute of Physics (2015) published a position piece in which it calls for schools to challenge the popular view that 'physics is hard', instead actively promoting all subjects as equally challenging. We see this as a highly useful first step – and suggest that it could be further strengthened not only through buy-in from teachers and students, but also through the actions of, for instance, awarding bodies who will need to redress the grade severity that currently occurs (research show that A level Physics is marked more harshly than other subject areas, Thompson 2016) and, for instance, the media (which continues to portray physicists as brainy men). In other words, we believe there is scope, and need, to address the cultural arbitrary on many different fronts.

Moreover, while based on a small and un-representative sample, our findings raise questions as to whether there is a latent 'pool' of girls/women who are simply waiting to be 'turned on' to physics

(as per the assumptions underlying a number of gender and science initiatives). Our analyses suggest that the conditions required to 'possibilise' a female physics identity may be highly rareified and elite - and the necessary identity work and resource deployment to be extreme. Finally, we would emphasise that although we have focussed on issues of post-16 progression within this paper, the 'pipeline' is not our driving concern. We consider the exclusion of girls/women from physics to be a social injustice that needs to be challenged, both for the good of under-represented groups but also in the interests of creating socially just science – to this end, we advocate for change within the culture of physics, so that it might become a tool for social justice rather than a proponent of inequality. A key part of this, we propose, will be to engender a broader acceptance of who can legitimately 'do' physics (e.g. challenging current doxa around high attainment) – without this, current trends in participation look set to stay.

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[i] This finding has been noted previously, whereby girls' attainment is explained away as due to their 'plodding diligence' as compared to the 'natural', 'effortless brilliance' of boys (see Francis & Skelton, 2005).

[ii] Cultural capital was determined by responses to items such as parental university attendance (and leaving school before age 16), approximate number of books in the home and frequency of museum visitation. These items were used to provide an overall indication of level of cultural capital.

[iii] E.g. see http://www.theguardian.com/uk-news/2015/jun/10/nobel-scientist-tim-hunt-female-scientists-cause-trouble-for-men-in-labs (accessed 14/9/15).

[iv] E.g. see http://www.bbc.co.uk/news/blogs-trending-33099289 (accessed 14/9/15)

[v] http://www.independent.co.uk/news/uk/home-news/distractinglysexy-female-scientists-mock-sir-tim-hunts-sexist-remarks-on-twitter-10313435.html (accessed 14/9/15)

[vi] It is interesting to see similar themes playing out in relation to women engineer's self representations – see http://www.theguardian.com/technology/2015/aug/05/engineers-twitter-ilooklikeanengineer (accessed 16/9/15).