The impact of out-of-school science activities for primary school children on science knowledge, interest and later academic choices: An evaluation study

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Abstract

Although a growing number of young people are choosing to undertake non-compulsory education, there is concern that not enough are electing to study STEM subjects. Research has suggested that out-of-school science activities, research participation and a child's family

interest can increase both knowledge and interest in science, resulting in a higher likelihood of studying a STEM subject at an advanced level. However, the majority of research to date has been conducted with secondary school age students. This study investigated the impact of Summer Scientist Week, an annual out-of-school science engagement event for 4 -11-year-olds and their families held at the University of Nottingham, United Kingdom. This event introduces primary school age children to psychology-related research and activities about the mind and brain. Findings from interviews conducted with children and parents at the event, as well as survey data from previous attendees aged 14-17-years, indicated an increase in knowledge and interest in science that was maintained over several years, influencing choices in A level subjects. This is the first study to demonstrate the positive impact of out-of-school science activities in primary school age children and its sustained influence on later academic choices in secondary school.

Keywords: Summer Scientist Week, science engagement, impact evaluation.

Key messages:

- Taking part in out-of-school science activities can increase both knowledge and interest in science in young people. However, little is known about the long-term outcomes of early experiences.
- We used a qualitative approach to gain in-depth insights into the short- and longer-term impact of attending Summer Scientist Week, a long-running annual out-of-school science-related research event for 4-11 year-olds, on children and their families. We studied the short-term impact by interviewing children and parents taking part in an event. We studied the longer-term impact via a survey of previous attendees aged 14 to 17 years.
- Our findings suggest that early engagement in out-of-school science-related research events can lead to increased knowledge and interest in science and understanding of

science in practice in young children as well as influence the likelihood of studying science subjects at an advanced level.

Introduction

The number of young people electing to study Science, Technology, Engineering and Mathematics (STEM) subjects at school level continues to lag behind the number of workers required in the sector (National Audit Office, 2018; Royal Academy of Engineering, 2016; STEM Learning, 2018; The Institution of Engineering and Technology, 2021), a finding of concern to policy makers (HM Government, 2017; Tripney et al., 2010; UK Commission for Employment and Skills [UKCES], 2013). Research and development, an important contributor to economic growth, is reliant on the talent and availability of scientists and engineers (Akcali and Sismanoglu, 2015; Roberts, 2002). There is concern that the UK's investment in science and technology is lacking compared to its competitors and that one of its economic problems is a deficiency of STEM skills in the workforce (National Audit Office, 2018; Tripney et al., 2010; UKCES, 2013). Despite an increase in the number of young people undertaking non-compulsory education, there has been little change in the number choosing to study science subjects (National Audit Office, 2018; Royal Academy of Engineering; 2016; Smith and Gorard, 2011), remaining stable at around 45% of total A level subjects chosen between 2018 - 2022 (www.gov.uk). Understanding and improving the uptake of STEM subjects at school and university, and the subsequent continuation into STEM careers is therefore of great concern to policy makers and employer organisations (e.g. EU Skills Panorama, 2012; HM Government, 2014; 2017; The Institution of Engineering and Technology, 2021).

Given the growing demand for STEM skills in the workforce, researchers are increasingly interested in identifying how young people's motivation to pursue these subjects in secondary and tertiary education, and subsequently in their chosen career path, can be increased. Engaging young people in science-related activities or events has previously been found to influence university and secondary school students' knowledge, understanding, interest, and motivation towards science (e.g. Mathieson and Duca, 2021; McLaughlin et al., 2018; Sadler, 2021). Relatively little is known about science engagement in younger children however. In this paper, we present and evaluate Summer Scientist Week, a science engagement activity that introduces primary school age children to psychology-related research and activities about the mind and brain. We present findings from an impact evaluation study investigating both short-term and longer-term impact of attendance at Summer Scientist Week on 4-11-year-old children and their families.

Predictors of studying STEM subjects

STEM subjects tend to be viewed as difficult, especially when they reach a non-compulsory level, and as a result, students are rarely motivated to pursue them unless they have had relative success in previous stages (Smith and Gorard, 2011). Interest in the subject and its perceived utility have also been linked to subject choice and career aspirations in young people (Mujtaba et al., 2018; Sheldrake et al., 2017; Tripney et al., 2010).

These findings fit in with expectancy-value theory, a theory of motivation that predicts students' choice in a subject and their performance in it (Wigfield and Eccles, 2000). This states that an individual's identity can be conceptualised as two sets of self-perceptions, i) competencies, characteristics and skills and ii) personal values and goals (Eccles, 2009). Together, these can inform students' expectations of success and the subjective value the student attributes to that value, where value is conceptualised as utility value, interest-

enjoyment value, attainment value, and cost (Bøe et al., 2011; Wang and Degol, 2013). Following this reasoning, students would be more likely to choose a subject if they are confident in their ability to do well in it and they believe it to have a high value (Eccles, 2009).

The theory also makes predictions around how experiences in family contexts can influence motivational beliefs, with research suggesting that parents can affect their children's success and interest in a subject or discipline (Dabney et al., 2013; Wang and Degol, 2013). Parents in particular have the ability to influence subject choice. For example, in a sample of Norwegian university students studying a STEM subject, one third reported that their choice of subject was the result of an influential person in their lives, with an emphasis on parents and teachers (Sjaastad, 2012). Moreover, a study conducted in a rural school in Malaysia, found that children who chose to study pure science subjects at school had parents who supported them and also held academic expectations, suggesting these to be influential factors (Halim et al., 2017). The importance of the role of the family is also seen in 'science capital', a concept proposed by Archer et al. (2015) that is used to provide insight into differences in science engagement. Eight dimensions have been identified to influence this engagement. These include science-related attitudes, values and dispositions, participation in out-of-school learning contexts and family science skills, knowledge and qualifications. Findings from Archer et al. (2015), from a survey conducted with a sample of 3658 students across forty-five secondary schools in England, indicate that science capital is related to outcomes and behaviours, and in particular, to an inclination towards post-compulsory STEM participation.

Engaging children and young people in science through out-of-school learning contexts

Of the aforementioned dimensions, one heavily researched area is participation in out-of-school learning contexts and, in particular, how these can influence knowledge and interest in science. Evidence suggests that out-of-school science activities can increase students' interest in STEM (Blaxland & Baillie, 2021; Young et al., 2016). Gibson and Chase (2002) conducted a longitudinal study on the impact of a 2-week science camp for 12-14-year-olds in the United States of America (USA). Findings showed that individuals who participated in the event showed more positive attitudes towards science and greater interest in science careers. Similarly, in a study involving 16-18 year olds, McLaughlin et al. (2018) demonstrated a positive relationship between attendance at a science engagement activity and increased interest and knowledge in science, as well as subsequent engagement and retention in science subjects. A further study by Tyler-Wood et al. (2011) showed that engagement with an after-school science programme in the USA for 9-11-year-old girls led to higher perceptions of science careers and increased science knowledge in individuals who attended in comparison to control participants.

There is also evidence to suggest that out-of-school science activities can go on to influence young people's career aspirations (Dabney et al., 2011). For example, Kitchen et al. (2018) found that high school students who participated in a USA-based STEM-related program were more likely to want to pursue a career in STEM. Additionally, students who understood the real-world relevance of STEM, were more likely to report aspirations towards a STEM career at the end of high school.

Together, these findings provide clear evidence of the benefits of out-of-school science activities. However, there is a lack of research focusing on younger children and the benefits exhibited in this age group. Past research has suggested that it is important for students to be engaged in science at a young age in order to maintain an interest. Indeed, the majority of

STEM graduate students and scientist participants reported that their interest in science started before middle school (Maltese and Tai, 2010). As Anderhag et al. (2016) suggest, rather than young people losing an interest in science as they get older, it is more likely that the interest is never actually established. Indeed, science achievement gaps in the US are present as early as third grade when the first formal science tests are administered, and are largely explained by knowledge gaps that are present at school entry (Morgan et al., 2016). The early years of primary school are therefore a critical period for getting people engaged with science.

Engaging children and young people in science through research participation

Despite little existing research on out-of-school science activities with primary school age children, there is some existing research into school-based science activities with both preschool and primary aged pupils. These have provided mixed results: The availability of science materials in the classroom was not found to predict later science achievement scores (Saçkes et al., 2011). In contrast, the implementation of inquiry-based science curricula, in which the children are active learners within the research process, have resulted in higher achievement in later science assessments (Akınoğlu & Tandoğan, 2007; Kadavereck et al., 2020), more positive attitudes towards science (Akınoğlu & Tandoğan, 2007), greater motivation for science (Patrick et al., 2009), and greater perceived science competence (Patrick et al., 2009). Similar reports of greater perceived competence have arisen from primary schools taking part in citizen science projects, which involve amateur volunteers (in this case school children) as contributors to real-world science projects (Doyle et al., 2019). These findings suggest that opportunities for children and young people to participate in and learn about real-world science projects are instrumental in enhancing their knowledge, understanding, interest, and motivation towards science.

Psychology, the scientific study of the human mind and its functions, provides an ideal opportunity for young people to participate in, and learn about, scientific methods. Human behaviour is a topic that young people are interested in and experience every day and experiments can be conducted without specialised equipment. Previous research has found that participation in research studies can result in undergraduate students gaining a similar level of knowledge about psychology concepts as they would in a classroom and they can also acquire a greater understanding of the methods involved, as well as a greater interest in science more generally (Bowman and Waite, 2003; Elliot et al. 2010; VanWormer et al. 2014). Psychology suffers as a discipline, however, as many do not consider it a science subject, and further, it is not often listed a recommended or pre-requisite subject for admission to higher education (American Psychological Association [APA], 2010; Russell Group, 2017). For these reasons, schools may feel pressured to direct their students away from it and, as psychology is a non-compulsory subject, many young people may not become exposed to this area of study in primary or secondary education (Banyard and Duffy, 2014).

The current study

Whilst the majority of previous research has looked at the benefits of engaging secondary school age children in out-of-school science activities, and the benefits for undergraduates participating in research, there is a lack of literature investigating the benefits of these activities for primary school age children. Moreover, given the importance of the family in motivating children in engaging with science, we also sought to investigate the benefits gained for parents. In order to do this, we examined the impact of Summer Scientist Week, a science engagement activity developed by researchers at the University of Nottingham, United Kingdom, on the 4-11-year-old children and their parents who attend. We also

examined the longer-term impact of attending the event via a survey of previous attendees aged 14 to 17 years. We defined impact as a change in knowledge, interest, or behaviour.

Summer Scientist Week is an annual 5-day science engagement event for 4-11-year-olds held at the University of Nottingham, UK. Over 3,500 children have attended since the event began in 2007, with many returning to attend in subsequent years. Families attend for a 3 hour session and take part in a range of different activities: Children have the opportunity to participate in a range of gamified research studies, exposing them to the scientific methods used to study cognitive processes such as attention, memory, language, spatial, motor and social skills. These games change each year and have included activities such as navigating a virtual maze (Buckley et al., 2022), deciding what a toy on a table would look like from a different point of view (Pearson et al., 2016), choosing which side of a computer screen displays the most dots (Gilmore et al., 2013) and using clues to identify a series of targets in computerised displays while ignoring distractions (Hayre et al., 2022). Children are rewarded for playing a game with a token that they can then spend on a variety of funfair activities designed to illustrate a key concept of how the human brain works, e.g. hook a duck is used to explain motor control, 'splat the rat' is used to explain reaction times and a beanbag toss game with special goggles is used to explain prism adaptation. Children can also earn tokens by learning fun facts about the human mind and brain which are displayed on posters around the funfair. At the end of the 3 hour session children receive a small gift for taking part and a booklet of further activities to try at home.

Parents have the opportunity to learn about research by observing their child(ren) completing the research studies and reading about the study aims and applications via posters placed around the funfair activities. They are provided with leaflets summarising an area of child development research (e.g., learning maths) as well as newsletters presenting research findings from previous years.

The focus of the current study was to investigate the impact that Summer Scientist Week events have on children and family members attending. We employed a range of methods to collect evidence of impact, in the form of a) semi-structured interviews with children and parents who attended at least one previous Summer Scientist Week event, on the day of the event, and b) a survey distributed to secondary school students, aged 14-17, who previously participated in at least one Summer Scientist Week event in order to investigate potential longer-term impact of engagement.

Method

The study received ethical approval from the University of Nottingham School of Psychology Research Ethics Committee (Ref. F1016).

Interviews with children and parents

Participants

Semi-structured interviews were conducted over two Summer Scientist Week events. Parents and children attending the event were invited to take part in the interviews, resulting in a convenience sample of 39 children and 38 parents attendees being interviewed. The child participants were aged 4-11-years (M = 7.95; SD = 2.21) and from a predominantly White (76%) middle class (68% with IMD centile >5) background. 86% spoke English at home. All participants had attended at least one previous event with the exception of one child. Interviews were conducted in a quiet location during the course of the event by the first and second authors. All the interviews were audio recorded and then transcribed verbatim. Parental or carer consent was sought for children's participation in the interview; assent was also obtained from children. All participants were provided with details of the nature and purpose of the interview. Parents or carers also provided written informed consent to be

interviewed themselves. As part of the consent procedure participants were informed of the voluntary nature of the study.

Interview schedule

The interview schedule for parents focused on the perceived impact of the event for their families. Example questions included ‘What do you think is the main benefit of Summer Scientist Week for your family?’ and ‘Do you feel that you or your child have applied any of the knowledge gained from Summer Scientist Week in everyday life?’ The children's interview schedule focussed on what they liked about the event, if they had learnt something new (e.g., ‘What have you learned from taking part in Summer Scientist Week?’), and whether they had discussed the event or the activities outside of Summer Scientist Week. Overall, parent interviews lasted up to 15 minutes, and children’s interviews were shorter, taking into consideration the age of children taking part.

Survey

Participants

Twenty-three 14-17-year-old secondary school pupils (M = 15.02, SD = 0.94, 12 females, 11 males) who had previously attended at least one Summer Scientist Week event took part in an online survey, delivered with Qualtrics software. Participants were recruited via emails to parents/carers who had previously attended a Summer Scientist Week event and had given consent to be contacted about future research studies. Parents were provided with a link to an online information sheet and consent form (created in Qualtrics) and the questionnaire for their children to fill in at home. The email was sent by the database administrator on behalf of the project team. Ninety-one percent of participants identified as White and 9% of multiple/mixed ethnic backgrounds. Parental consent was obtained for pupils to take part in the study; assent was also obtained from the young people before participation in the study.

The survey took approximately 20 minutes to complete. Participants were offered a voucher for participation in the study.

Measures

Participants were asked a series of demographic questions, including age, gender, postcode of permanent residence, and whether any of their parents/carers either had a degree in a science-related subject or worked as a scientist. The latter question offers insights into participants' environment and exposure to science. To investigate the long-term impact of attending a Summer Scientist Week event while at primary school, we asked a series of closed- and open-ended questions focusing on participants' experience of Summer Scientist Week, including what they felt they had learnt and whether participation had any impact on their decision-making, interests, or future plans. We also asked participants what choices they had or would be making for GCSE and A-level subjects.

Data analysis

Interview data and participant responses from the survey's open-ended questions were analysed separately by means of qualitative content analysis. We took an inductive approach to the analysis (Elo and Kyngas, 2008) to identify patterns in the data. For both sets of data, the analysis comprised three phases:

1. *Preparation phase:* This involved repeatedly reading through the transcripts as a way of familiarising ourselves with the data and to identify any initial ideas that were related to our research question. This phase was completed by the second author.
2. *Organising phase:* This involved a process of coding data extracts which were relevant to our research question. We adopted a realist/essentialist epistemological standpoint, where the focus of the analysis is on participants' experiences and the

meanings associated with these experiences. Manifest coding was used, where codes reflected a short summary of the semantic meaning in participants' responses. Conceptually similar codes were grouped into categories. Categories were reviewed and refined to ensure that each category was conceptually distinct with no overlap in ideas, and that the resulting categories captured the ideas in the coded extracts in relation to our research question. Coding of the data was completed by the second author. Development of categories were undertaken by the first and second authors. Resulting categories were named and relevant extracts from participants' responses were selected from the dataset to illustrate how the ideas expressed within each category were represented in the data. This step was conducted by the third author.

3. *Reporting phase:* Narratives were developed for each category. These, together with selected quotations from the interview transcripts and survey data are presented below.

Results

Interview data

Two content categories were identified capturing the impact of attending a science engagement event on children and families: 1) Knowledge and understanding in science and science practice and 2) Interest in science and application of scientific knowledge. These are described below, together with selected quotations from participants responses.

Knowledge and understanding in science and science in practice

This theme captures the increase in knowledge and understanding in children and families on science and the role of scientists or researchers. When children were asked on what they had learnt as a result of taking part in the activities, comments included learning new facts about

the brain and brain anatomy. For example, one participant commented, *"the neuro system has like a never-ending amount of lightnings that that go from one neuron to a another which sends messages"* (Child Participant C7). This was often knowledge above and beyond what was covered in the school curriculum. As one participant mentioned *"... find things out that you might not … find out maybe in a science lesson at school"* (Child Participant C1). Children also commented that through taking part in various studies and activities they acquired new facts about body and performance, such as the significance of our eyes in helping to provide balance (e.g., "*I've learned more about your eyes … how you need them for balance"*, Child participant, A9), concentration and coordination to complete tasks ("*if you're better at learning at remembering rhythm of beats it can help you with like reading and writing and things in school*", Child Participant C3).

Engaging with research studies and funfair activities at Summer Scientist Week has helped children acquire knowledge on science in practice, and in particular the importance of research in science for the advancement of scientific knowledge and the scientific process. Children spoke about the role of psychologists in studying the brain and acquiring knowledge on behaviour. For example, comments from participants included "[psychologists] *research the brain and you try and figure out what the different parts do*" (Participant C15) and *"study the brain and how people react and how they do stuff"* (Participant C23). Responses also demonstrate that children often associate the discipline of psychology with science, research, and university (e.g., "*Research; science research … university",* Child participant A9), with some commenting specifically on aspects of the research process. For example, one participant mentioned the use of technology in capturing peoples' responses (e.g., "*... if you use computers ... they can help like ... taking information*" (Child participant, A5). Children also commented that in addition to conducting research psychologists are also education providers (e.g., "*teach students*", Participant 16; "*you teach other people about science"*,

Child participant, A7).

Attending the event in a university setting and engaging with the activities and resources available at the event, provided a deeper understanding of the research process in the field of developmental psychology. This was evident in how parents spoke about an increase in their knowledge as well as their children's knowledge. From a parent perspective, attending the event has led to increased understanding of research processes with children. For example, comments from parents included *'...I guess before I hadn't really thought that big groups of children were actually involved in the research that you carried out ... now I can see that so many children are here and that the research that you do actually gets quite tangible benefits to them...'* (Parent participant B16) and *"I've learnt how well tailored the trials are really to the children..."* (Parent participant B4).

Interest in science and application of scientific knowledge

This theme captures how taking part in Summer Scientist Week has had a positive impact on children's interest in science as well as benefits for children and their families beyond the event, reflecting a change in behaviour.

Children in our sample expressed an interest in finding out more about the brain, findings from the studies they participated in, and how researchers use these findings. For example, one participant commented *"I'd like to know more of ... you take the information like from the tests and what you do"* (Child participant A5). In addition, in their interviews, parents have also commented that engagement with Summer Scientist Week activities has led to an increase in their children's interest in science. Responses include, "*I do feel my daughter's become more interested in science*" (Parent participant, B1) and that the event itself "*it*

stimulates discussion and interest about why things have been done and what some of the studies have been about" (Parent participant A10).

Attending Summer Scientist Week at a higher education setting enhances children's exposure and awareness of universities and this can also facilitate interest towards university. For example, one participant commented *"... it also seems to interest them quite a bit about the university ... because they see ... the inner workings of the university ..."* (Parent participant, B4). For some, this can also serve as a motivating experience, in terms of potentially encouraging children to attend higher education later on. For example, one parent commented on how their child(ren) "... *get the opportunity to see the university ... my boy this morning he was saying that he really wants to go to uni because he really likes university so there's some motivation for them for lifetime"* (Parent participant, A25). Similarly, another parent mentioned *"they've seen ... part of university life which may if they're interested encourage them to go on and do university themselves"* (Parent participant, B11).

Parents also commented how their children have discussed the funfair activities and research studies at the event with family members as well as their friends and teachers at school. For example, one participant mentioned "... *they talk about it a lot, I know my daughter she has a dyslexic teacher at school and she talks to her about it as well and says that she wants to go to university to do what they do and find out about the brain I know she's talked about that and the studies and she likes the idea that you look at lots of different people to see how the brains work and she's quite interested in the mechanics of the studies if that makes sense, so about how they look at lots of different people* (Parent participant B15). This illustrates how taking part in university research activities can contribute towards increased interest and motivation towards STEM in young people. Similarly, one parent commented on how they

have shared knowledge about studies at Summer Scientist Week with their child's school teacher, leading the teacher to embed this information in the classroom, demonstrating impact on teaching and learning beyond the event (e.g., *"I know that they did a project at school … one of the leaflets we'd been given … and I gave it to the teacher and they and [participant's son] ended up teaching a few kids in the class on how to walk in a line or something I can't remember what the study was on I think it was about closing your eyes and turning and brain you know spin and then walking along a line … and, 'oh he did this at summer scientist' and … I ended up giving [the teacher] the leaflet so that she … carried out very similar sort of experiment in the class to show the kids on you know your ears and your balance and things";* Parent participant, B11).

Participants have also commented on applying knowledge acquired through Summer Scientist Week activities in their everyday life as well as changes in behaviour. For example, one child participant mentioned how they applied this knowledge at school, *"I sometimes use the knowledge that I learnt here and used it in science at school"* (Child participant, B7). Parents have also commented how observing and findings out about studies run at Summer Scientist Week had facilitated awareness of behavioural processes in children. Parents expressed how this has had an effect on their way of thinking about their children's behaviour (e.g., *"... when all my children do things to think about it a bit more analytically rather than just what they're doing why they're why they're doing it sometimes"* (Parent participant B14). Comments reflected parents' consideration of aspects of their child(ren)'s development *"I think it makes me look at my kid's behaviour and take an interest in the way they're developing cognitive skills and, you know just at the back of my mind rather than a specific area that I'm looking into I think as a parent you're always looking at how they're changing and developing so I think it does make me look at things in a different light"* (Parent

participant, B6). Similarly, another participant mentioned *"... it makes you think about child development and the age that the child develops these things as well so you know ... you look at other children and in in some way kind of compare the child with your own child's development in a way ..."* (Parent participant, B10). This experience has also led some parents to reflect on their practice (e.g., "*I guess it probably gets me thinking a little bit more about how they approach things and how we approach things as a family as well ... especially in terms of approaching learning"*; Parent participant, B2).

Findings from the interviews also demonstrate behavioural changes in parents' behaviour, reflecting knowledge and information obtained at the Summer Scientist Week event. This includes application the knowledge gained at home with their children (e.g., *"... an insight into how like the research boards that you put up just different things that you never even thought about and think well actually I could apply that at home as a you know understand that not all children are the same..."*, Parent participant, B11).

Attending the event had also led to an increased interest in learning more about psychology (e.g., *"I felt like I wanted to understand more about psychology personally as a result of having been to summer scientist week so she recommended some books to me and ... I've done a bit of reading"*, Parent participant, B9) as well as interest in taking part in further research studies conducted at the university, beyond the Summer Scientist Week event. For example, one parent commented, *"there have been opportunities I think that have come out of taking part in the summer scientist week ... they have taken part in other studies beyond summer scientist week ..."* (Parent participant, B7).

Survey data

Analysis of the open-ended questions resulted in the development of a single theme 'Long-lasting interest and engagement in science', capturing how young people who had previously attended SSW have benefitted more longer-term from this experience.

Participants spoke about how engagement with research at the event has helped to develop their knowledge and understanding of science and the scientific process. Responses include *"I learnt a lot about the different parts of the brain , and what they did, and how we could use tests to find out how the brain changes throughout life"* (Participant 10) and *"[I learnt] there a different parts of the brain that stimulate different responses"* (Participant 6). This has also led to positive attitudes and increased interest in science and psychology specifically. For example, one participant reported *"I feel that I have become more interested in science and have also become more curious and intrigued by the human mind"* (Participant 13).

Engagement in this science event has provided insights into a future in science as well as sparked interest in engaging with science further. One participant wrote *"it showed me the opportunities available if i took psychology…"* (Participant 24), whilst another commented *"[As a result of attending SSW] I have learnt about careers within science"* (Participant 11) illustrating the benefits of engaging with research in psychology at a younger age in terms of increasing awareness of research as a career path in the field. For some participants this has led to increased motivation to pursue science further in secondary education (e.g., *"It's had a positive impact on my school subjects, as Triple Science is one of my GCSE options. I would also like to take psychology as an A-Level"*, Participant 10; *"it made me want to do trilogy science at college"*, Participant 19). These findings illustrate how engaging with science at a younger age can impact young people's choices academically.

Discussion

This was the first study to investigate both short- and longer-term impact of a science-related research engagement event on primary school age and their families. The findings provide evidence of impact in three key areas across our two groups of participants: increase in scientific knowledge, enhanced interest in science, and changes in behaviour, with findings from our survey data demonstrating that attending science out-of-school activities in primary school leads to increased motivation to pursue science subjects later in secondary education. These findings are discussed below, together with implications for practice.

Increase in knowledge

Our findings highlight that attendance at Summer Scientist Week contributes to improved knowledge in science. This was evident in interviews with children and survey responses in the previous attendees. Participants spoke about how taking part in the research studies and funfair activities at the event enabled them to gain further knowledge on aspects of the brain and brain anatomy, and processes involved in behaviour, often beyond what was covered in the school curriculum. Whilst previous research demonstrates that out-of-school science engagement leads to enhanced scientific knowledge in secondary school pupils (Braund and Reiss, 2006; Tyler-Wood et al., 2011), this is the first study to demonstrate this effect in younger children.

Participating in the research process directly allowed Summer Scientist Week attendees to experience the role of a psychologist first-hand. This resulted in an increase in knowledge about science in practice and the role of a psychologist in studying the brain and behaviour. Participants often associated psychology with science, showing an awareness of psychology as a scientific discipline. An understanding of this at an early age is key as many outside academia do not consider it a science subject.

This knowledge was reflected in the comments from the children attending the event but was also maintained by previous attendees who were aware of the opportunities and careers available through studying psychology. An awareness and understanding of the applications of a discipline, and its perceived utility, have been found to have a strong link to the take-up of STEM subjects at advanced levels as well as career aspirations (Mujtaba et al., 2018; Sheldrake, Mujtaba and Reiss, 2017; Tripney et al., 2010). This is consistent with the expectancy-value theory of motivation that has been used to predict students' subject choice (Eccles, 2009; Wigfield and Eccles, 2000). This was reflected in our survey of previous attendees at 14-17 years who indicated that attending Summer Scientist Week had encouraged them to take up Science subjects, including Psychology, at A level.

Increase in interest

Children who attended Summer Scientist Week reported greater interest in psychology, in particular an interest and curiosity in finding out more about the brain as well as the outcomes of the research studies that they took part in. Similar to this, Copley (2018) found that engagement with research raised awareness of their insights but also led to increased inspiration and curiosity about research. Parents also reported that their children showed a greater interest in science after attending the event. This enhanced interest in science was maintained over several years, as evidenced by our survey results from 14-17-year-old previous attendees. These observations are consistent with previous research demonstrating that out-of-school science activities promote an interest in science (McLaughlin et al., 2018; Young et al., 2016), and extend these findings to a younger age group. According to the expectancy-value theory (Bøe et al., 2001; Eccles, 2009; Wang and Degol, 2013; Wigfield and Eccles, 2000), enhanced interest and enjoyment of science and psychology as a result of attending Summer Scientist Week may be another contributing factor as to why previous

attendees reported that attending the event encouraged them to take up Science subjects at A level.

In addition to influencing uptake of science and psychology subjects beyond non-compulsory education, Summer Scientist Week also appeared to influence education aspirations more generally. Parents commented that attending the university campus, provoked their child's interest in attending university later in life. This suggests that the location of out-of-school science activities may also have an impact on later subject and career choices, in addition to the material covered.

Change in perceptions and behaviour

A key aspect of impact involves influence beyond the event itself. For children, this took the form of discussions with non-attendees, such as friends and teachers, and applying their knowledge at school. In one case, resources from Summer Scientist Week were taken into the child's classroom and this led to the teacher adopting the activity featured in the resource in their science curriculum. This demonstrates impact on a broader range of children beyond the Summer Scientist Week attendees. Survey findings also indicate that attendance at Summer Science Week also influences behaviour in terms of subject choice at A level, with some participants reporting a desire or uptake of psychology and other science subjects at A level as a result of attending Summer Scientist Week.

Parents who attended the event also reported a change in perceptions and behaviour around child development. Some parents mentioned how the experience encouraged them to reflect on their children's behaviour, taking into account their child's perspective, their stage of child development and the understanding that all children develop differently. For some, this also led to a desire to find out more about psychology either through further reading or taking part in further research studies at the university.

Parents play an important role in promoting children's interest in science, in terms of fostering an early interest in the subject and influencing subject choice in their children (Dabney et al., 2013; Sjaastad, 2012). The role of the family is also important in science capital, a concept proposed by Archer et al. (2015) that has been used to predict a higher engagement in science. In particular, an inclination towards studying STEM subjects at an advanced level. By engaging parents as well as children with science Summer Scientist Week may provide additional impact on children beyond engaging them alone.

Conclusion

This study sought to investigate the impact of attending an out-of-school science engagement event on children's knowledge, interest and behaviour relating to science. Whilst prior research has looked at the influence of science engagement in secondary school age individuals, this was the first study to demonstrate short- and longer-term impact in younger children. Our findings show that attending Summer Scientist Week leads to enhanced scientific knowledge and understanding of science in practice. Engagement also led to an increased interest in science which was maintained over several years, influencing choices in A level subjects. Participating in Summer Scientist Week led to changes in perceptions and behaviour both in attendees and their families. These findings illustrate that early engagement in out-of-school research-related science activities can positively contribute towards enhanced science understanding and the uptake of STEM subjects beyond compulsory education.

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