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Brainy, Crazy, Supernatural, Clumsy and Normal: Five profiles of children's stereotypical and non-stereotypical perceptions of scientists in the Draw-A-Scientist-Test

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ABSTRACT

Children's perceptions of scientists have traditionally been explored using the Draw-a-Scientist Test (DAST). However, the DAST method, whereby researchers analyse large numbers of children's drawings according to a checklist, is often criticised for not taking children's voices into account. In this study, to explore children's perceptions of scientists, children in four primary schools ($N = 105$) were asked to 'Draw a Scientist', then describe their drawings in an open-ended qualitative questionnaire. A subsample of 30 participants also participated in semi-structured interviews. Thematic analysis that was conducted on the collected data derived five different profiles of scientists described by children: 1) Brainy Scientist, 2) Crazy Scientist, 3) Supernatural Scientist, 4) Clumsy Scientist, and 5) Normal Scientist. These distinct profiles shift from the typical 'stereotypical' versus 'non-stereotypical stance' often presented, describing novel nuances within stereotypical profiles. This work highlights the importance of employing qualitative participatory research methods and incorporating children's voices. The article concludes with suggestions for several directions for future research.

1. Introduction

1.1. Science & Society

Since the 1960s, the international literature shows a 'swing away' from STEM (Science, Technology, Engineering and Mathematics) disciplines in society (Osborne et al., 2003; Schreiner & Sjøberg, 2010). Only a small proportion of students aspire to become scientists and pursue careers in STEM, despite showing an interest in science (Archer & DeWitt, 2017). Lack of science-related aspirations can also be accompanied by negative attitudes towards science and scientists (Schreiner & Sjøberg, 2010). This is concerning for Western societies with economies heavily reliant on science and technology industries, fuelled by a workforce of highly educated and trained professionals (Government of Ireland & Department of Enterprise, Trade and Employment, 2009; Hickey, 2011; National Science Foundation, 2018). Low uptake of STEM subjects by students (Department of Education, 2020; OECD, 2019; The Stem Education Review Group, 2016) and negative public attitudes towards STEM (Gallup, 2019; Schreiner & Sjøberg, 2010) could pose a severe threat to economic growth and prosperity in countries in the European Union (EU).

Moreover, a positive public view of science and scientists is essential in today's post-modern, post-factual, westernised societies (Gallup, 2019). It is necessary for the EU's prosperity and democracy to be informed and literate in STEM by receiving information on STEM advancements and their impact on the EU's societies, growth and well-being (European Commission, 2015; Thomas & Durant, 1987). Greater STEM literacy enables civic engagement with STEM-related issues and has been recognised as an essential factor for worldwide sustainable development (European Commission, 2015; Gago et al., 2004; National Science Foundation, 2018; Science Foundation Ireland, 2018; United Nations, 2019)

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In general, studies have indicated that the general public – both adults and young people – are interested in STEM and view it to be valuable for society (Archer et al., 2020; Gallup, 2019; Murphy et al., 2012; Science Foundation Ireland, 2020). However, despite this interest, many young people still do not aspire towards science careers or study science beyond the mandatory level (Archer et al., 2020). Multiple factors can affect children's science-related aspirations, such as prevalent stereotypical negative perceptions of STEM scientists (such as 'Scientists are nerds, socially awkward and unpopular'), and persistent attitudes that STEM is 'not for me' or 'only for brainy peers' (Archer & DeWitt, 2017).

Drawing from their large-scale longitudinal work on young peoples' science-related aspirations, Archer et al. (2015) proposed the lens of 'Science Capital', which is a theoretical construct adapted from social and cultural capital theory (e.g. Bourdieu & Passeron, 1977). Science capital describes the encapsulation of science-related resources, dispositions (Archer et al., 2015), processes and factors through which young people inform their science-related aspirations (Archer & DeWitt, 2017). Essentially, those with higher levels of science capital tend to have more science-related aspirations. Middle to high levels of science capital in children positively impact science identity and reported science-related aspirations (Archer & DeWitt, 2017). By contrast, a low level of science capital and the prevalence of stereotypical perceptions of STEM fields and scientists significantly and negatively impact children's career aspirations in STEM (Archer et al., 2015; Archer & DeWitt, 2017).

By examining and understanding young peoples' views of scientists, it may be possible to make recommendations for effective interventions to address and minimise negative stereotypes, increase children's science capital and improve their STEM-related aspirations.

1.2. Stereotypes of science and scientists

Young peoples' perceptions[1] of and attitudes towards science and scientists have been explored since the 1950s. In a pilot study analysing 35,000 high school students' essays, Mead and Métraux (1957) identified positive and negative stereotypes associated with students' perceived image of a scientist. In short, the 'stereotypical view of a scientist was 'male, elderly or middle-aged, wearing a lab coat and glasses, on his own in a laboratory performing experiments with test tubes' (Mead & Métraux, 1957, p. 386-387). In addition, specific character features were associated with either positive or negative perceptions of scientists (Mead & Métraux, 1957).

The scientist is described as a genius who received a long and expensive education in the positive perception. He is tenacious and perseverant; devoted to his work; disinterested and humanitarian; not discouraged by the mistakes he makes; patient and open-minded. One day he will straighten up and shout: 'I've found it' (Mead & Métraux, 1957, p. 387). In the negative perception, a scientist's work is perceived as 'uninteresting, dull, monotonous, tedious, time-consuming' (Mead and Métraux, 1957, p. 387.). He may see no results for ages or fail and is unlikely to receive adequate recognition. Scientists' work may be dangerous, and they may keep dark secrets, be hurt, or accidentally kill someone. They are absorbed in science and ignorant of current affairs, neglect their bodies for their minds, and tend to lose touch with people. As a result, they display decreased social skills and social confidence (Mead and Métraux, 1957).

Interestingly, similar stereotypical features have persisted in studies on children's perceptions of scientists to date. For example, Archer & DeWitt, (2017) and DeWitt et al. (2013) used longitudinal semi-structured interviews to investigate the science-related perceptions that sixth- and ninth-grade students hold about their peers. Results identified a stereotype termed 'Brainy Scientist', associated with high intelligence and 'cleverness'. 'Science-keen peers' were perceived as nerdy or geeky due to undesirable appearance and characteristics, such as 'being too much into science that makes them sound nerdy' or for 'being perfect' (Archer & DeWitt, 2017, p. 69). As such, 'Brainy' peers were perceived as possessing socially undesirable features, unlike socially popular peers in young people's groups, e.g., athletic peers (Archer and DeWitt, 2017). They were at risk of being labelled 'geeks' and were excluded from their peers' groups. 'Brainy' children were also described as having to work harder and do extra work to hide their geekiness to be popular among peers.

1.3. The 'Draw-a-Scientist' test

Perceptions of scientists among children have traditionally been explored using the 'Draw-a-Scientist Test' (DAST) and its variations (Chambers, 1983; Finson et al., 1995). The DAST involves asking participants to 'draw a picture of a scientist' (Chambers, 1983; Reinisch et al., 2017). Analysis of these drawings involves following a checklist to identify stereotypical indicators, e.g., the commonly used checklist 'DAST-C', developed by Finson et al. (1995), comprises 15 such indicators. This quantitative analytical protocol calculates a stereotype score for each drawing: the higher the score, the more stereotypical the depicted scientist.

Studies that used the DAST-C have consistently identified a stereotypical scientist profile as a middle-aged or elderly Caucasian man, often bearded or balding, working indoors wearing goggles and a white lab coat with STEM objects in the background (Barman, 1999; Farland--Smith, 2012; Farland-Smith et al., 2014; Ferguson & Lezotte, 2020; Mead & Métraux, 1957; Reinisch et al., 2017). Different studies found common themes, such as 'mythic stereotype', 'indications of danger', 'indications of secrecy' and 'presence of lightbulbs' (Ferguson & Lezotte, 2020; Finson, 2002).

However, the accuracy of these findings is often critiqued due to the limitations of the DAST-C method. Despite using a quantitative checklist, the analysis can be skewed by researchers' subjectivity and biases and does not consider children's interpretations of their drawings (Ehrlén, 2009). Although efforts have been made to incorporate children's representation of scientists, for example, by requesting a caption or using alternate drawing depiction categories, the interpretations by analysts are still limited (Reinisch et al., 2017). For example, identifying the depicted scientists' gender is problematic (Reinisch et al., 2017). Losh et al. (2008) proposed that children's drawing ability can limit the intended gender of drawn scientists, and this can force analysts to choose a gender for otherwise ambiguous drawings (the DAST-C does not list 'neutral' options). In addition, the DAST-C assumes that if the skin of a drawn scientist is not coloured in, then they are by default Caucasian. However, this could have more to do with the use of white paper, or the lack of colouring pencils/crayons, than with the child's intended projection (Reinisch et al., 2017). This could artificially inflate the reported number of Caucasian scientists obtained with this technique.

Moreover, the use of the DAST-C does not account for some characteristics that are difficult to draw, like intelligence (Ferguson & Lezotte, 2020). It also only allows to capture one scientist stereotype – the Caucasian, middle-aged/elderly man working dangerously – and does not allow to record children's more modern stereotypical representation, such as a crazy scientist with 'dishevelled hair' or 'scientists being an intelligent loner' or cultural variation of a scientist stereotype (Ferguson & Lezotte 2020, p.61). Overall, DAST studies currently lack children's voices, their explanation of their perceptions, and their meanings to their drawings (e.g., Lundy, 2007; Tindall et al., 2009).

Aside from DAST-C studies, qualitative explorative studies that identify perceptions and stereotypes of 'science people' using in-depth research designs that employ a visual tool are limited in the field to date. Using DAST in qualitative research design, this study explored

[1] In this work, *perception* is defined as an internal 'mental image' (Merriam-Webster Dictionary). For 'stereotype', we use the definition by Newton and Newton (1998): 'standardised image of a type of person'.

children's perceptions of a scientist in Ireland from their authentic perspectives. This study aimed to address these current gaps in the literature on children's views of STEM scientists and provide evidence-based recommendations for interventions to minimise scientist-related misconceptions.

2. Material and Methods

A qualitative child-centred methodological approach was employed. Children's voices and expressions were used to explore their perceptions of scientists, employing DAST as an arts-based data collection scaffold. The DAST method was used both as a prompt to actively involve children in the explored topic and as a visual method aiding the exploration of children's perceptions, explanations, and meanings attached to their drawings of a scientist. The methods are briefly presented below and will be described in detail elsewhere.

2.1. Methodology & theoretical framework

Given the theory-based, exploratory nature of the study, with its focus on children's perceptions, the study was designed within the interpretive paradigm in social research: it sees the individual as an active agent who contributes to knowledge with their everyday lived experiences of social phenomena and with their perceptions and interpretations (Creswell, 2013). Children's experiences and means of expression are thus considered valuable sources of information (James & Prout, 1997). The methodology was developed in line with the child-centred interpretive paradigm to explore children's perceptions of a scientist in a way that gives children the active voice and space to express their experiences (Lundy, 2007).

Several methods of data collection were used: Draw-a-scientist-test (DAST, Finson et al., 1995), qualitative questionnaires and semi-structured interviews. Children thus had different means of expression (drawing, oral, written), and the use of multiple data collection tools allowed for data triangulation.

2.2. Participant details

The fieldwork for this study was conducted in four elementary schools in county Galway between autumn 2019 and spring 2020 (Table 1). Schools were selected out of a range of schools which were offered to take part in a STEM outreach activity. Participants were recruited using convenience sampling from three sixth classes (equivalent to USA 6th grade and UK Year 7) and two fifth classes interested in taking part. Despite using convenience sampling, an effort was made to ensure a mixture of schools, whilst acknowledging that obtaining a representative sample of schools in Ireland was beyond the scope of this study. Schools were from a mixture of rural, suburban and urban areas (Table 1). One of the participating schools had 'DEIS' status (Delivering Equality of opportunity In Schools, Table 1). Schools which have DEIS status have been identified as serving disadvantaged communities and receive additional supports from the Department of Education (Department of Education and Skills, 2017).

Once recruited, the lead researcher visited the classes to meet the children (10–13-year-olds, modal age 12 years old), explained their involvement in the study and distributed the consent forms. Only children who returned positive consent and assent participated (n = 105, Table 1). Out of the 40 children that returned parental consent, 30 were purposively selected[2] to participate in semi-structured interviews (Table 1).

Table 1
School and participant details. All participants (N = 105) completed both the Draw-A-Scientist-Test (DAST) and the associated qualitative questionnaire. A subset of participants (n = 30) was selected to participate in interviews. Mean age of participants was 11.51 years for questionnaires, and 11.40 for interviews. Age range of all participants was 10-13 years old. DEIS = Delivering Equality of opportunity In Schools. F= Female, M = Male.

Metric	School 1	School 2	School 3	School 4
Urban/Suburban/Rural	Urban	Suburban	Rural	Urban
DEIS status	No	No	No	Yes
Language of instruction	Irish	English	English	English
Denomination	Catholic	Catholic	Catholic	Catholic
Class level of participants	6th	6th	6th	5th
Nb questionnaire participants	27 (18F, 9M)	17 (6F, 11M)	25 (15F, 10M)	38 (15F, 23M)
Nb interview participants	5 (3F, 2M)	6 (1F,5M)	8 (5F,3M)	9 (3F,6M)

2.3. Research design and methods of data collection

This study aimed to use a qualitative arts-based approach (Coyne & Carter, 2018) to investigate children's perceptions of scientists. Data collection comprised three methods: children's DAST, a questionnaire with open-ended questions describing the drawing (Supplemental Material 1), and semi-structured interviews (Supplemental Material 2). All data were collected during regular class time in school. On average, the drawings took 20 minutes, questionnaires 15 minutes, and interviews 20 minutes.

2.3.1. Drawings and questionnaires

As a gateway into their projected perceptions of a scientist, children were asked to draw a scientist with the prompt 'Please draw a scientist' and to title their picture. They drew their pictures with any materials available, primarily pencils. Then they answered open-ended questions in an attached questionnaire (Supplemental Material 1), on themes derived from the DAST literature: (1) type of scientist, activity and tools used; (2) scientist's characteristics and appearance; (3) perception of scientist in the scientist's childhood.

2.3.2. Interviews

Thirty children participated in semi-structured interviews in their school one week after DAST drawing. Interviews were guided by the open-ended questions of the questionnaire (Supplemental Material 2), children's written answers, and the DAST drawings. The same questions as in the questionnaire were also used in the interview to allow children more space for freedom of expression and to articulate their viewpoints (Lundy, 2007). This could be particularly important for children who are not comfortable with writing long sentences, or who experienced questionnaire fatigue. Additional prompts were used as they arose organically in the conversation, as per the nature of a semi-structured interview. Moreover, bringing children's questionnaire responses this allowed for their descriptions to be explored in more depth (see Supplemental material 2 for examples of how the questionnaire was used as a scaffold in interview).

2.4. Data analysis

To examine children's perceptions of scientists using their descriptions, questionnaire answers (n = 105) and interviews (n = 30) were transcribed verbatim and imported into NVivo 12 for theory-based thematic analysis (Braun & Clarke, 2006). This method analyses participants' perspectives by identifying patterns of meaning within the data and is suitable for examining the content of responses from qualitative data such as was collected in this study (Braun & Clarke, 2006;

[2] Criteria of selection of children for interviews included 1. Given consent from parents, 2. Purposive sample based on the discussion with teachers on parents' availability for interviews. 3. Balance of gender in research sample.

Creswell, 2013).

2.4.1. Analysis of open-ended questionnaires

Each open-ended questionnaire item (Supplemental Material 1) dealt with a particular aspect of children's drawing interpretations and provided an initial starting point for the analysis. Each question had 105 answers (including 'I don't know' and no answers). The responses to each question were analysed separately, using the first four steps of thematic analysis (Supplementary Figure 1, Braun & Clarke (2006)): First, the data were read and re-read to get familiarised with the entire dataset. Then, the responses were coded to identify elementary units of meaning within the data. Codes were generated as close to the participants' descriptions as possible to preserve the meanings of children's interpretations. Codes were then collated based on similarity and difference to identify broader overarching categories (emergent themes) within each question. Codes were refined and clarified to ensure internal homogeneity and external heterogeneity.

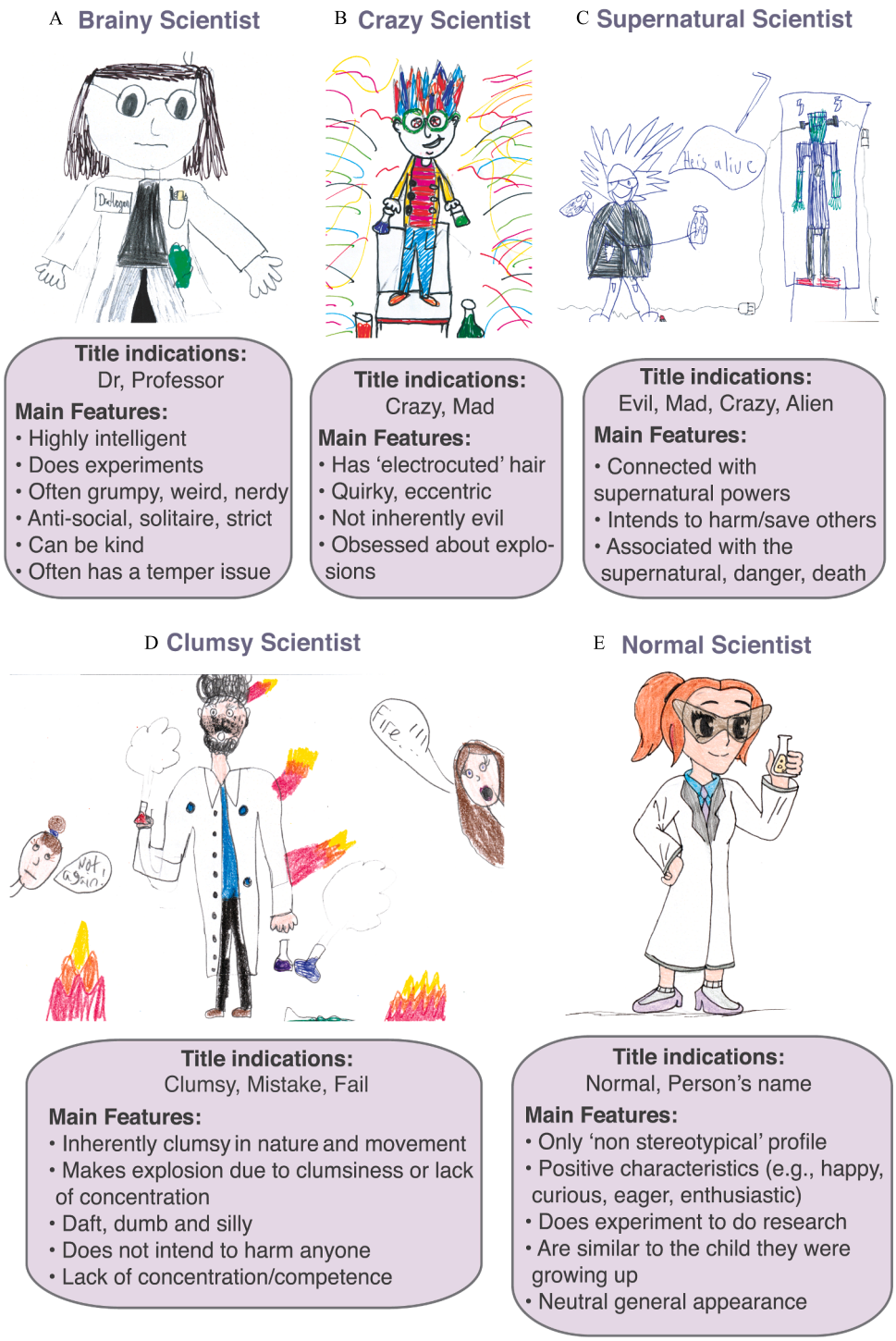

Fig. 1. Summary of the five scientist profiles described by children. This summary is derived from the thematic analysis detailed in supplemental Tables 1-3. Four profiles (A–D) contain features of traditional scientist stereotypes (Brainy, Crazy, Supernatural, Clumsy), and one (E) represents a Normal Scientist. Each profile is illustrated by a child's drawing that approximately represents it.

2.4.2. Analysis of the interviews

The thematic analysis of the 30 interviews followed a similar iterative process of data coding (generating open codes from the children's responses as close to the original text as possible), aggregation of codes into emergent themes, clarification and re-coding (see Supplementary Figure 1; Braun and Clarke,2006).

2.4.3. Thematic integration

The emergent themes that resulted from both questionnaires and interviews analyses were iteratively compared, contrasted, refined and consolidated into the final set of common themes guided by the research question whereby the stereotypes could be distinguished (Supplementary Figure 1). The existing literature further contextualised these themes on children's perceptions of scientists. Finally, the entire dataset was then re-read against these five themes to identify relevant information that might have been missed in the initial coding cycles, establish correspondence between the themes and the wider dataset, and internal coherence.

As a result, five overarching themes emerged from this analysis and resulted in five profiles of a DAST scientist as described in children's perceptions. These profiles were named according to the children's expressions used in descriptions of their drawings: Brainy scientist, Crazy scientist, Supernatural scientist, Clumsy scientist and Normal scientist.

The characteristics of these identified profiles of scientists are presented in the results below. Data characterising the thematic categories of each profile are summarised and presented in Supplemental Tables 1-3. The DAST drawings were not analysed but used to support the interview and illustrate the representative findings (Figs. 1 to 6).

3. Results

3.1. Five profiles of scientists emerged from children's descriptions of their DAST scientist

The thematic analysis of the aggregated questionnaire and interview data indicated that children's perceptions of scientists could be categorised into five distinct profiles (Fig. 1): 'Brainy Scientist' (A), 'Crazy Scientist' (B), 'Supernatural Scientist' (C), 'Clumsy Scientist' (D) and 'Normal Scientist' (E).

Among these identified profiles, the first four include features that would be regarded as 'stereotypical', e.g., being very intelligent, having a dishevelled or eccentric appearance, or causing explosions or fires (Fig. 1A–D; Finson, 2003, Ferguson & Lezotte, 2020). The last profile, 'Normal Scientist,' has no negative stereotypical indicators (Fig. 1E).

The questions used to explore the children's drawings allowed nuances between the five profiles, especially the four stereotypical ones (see Supplemental Tables 1-3). For example, three of these (Crazy, Supernatural and Clumsy) feature allusions to the negative stereotype of scientists being somehow 'crazy' (Supplemental Table 2), but they show differences in perceived levels or style of 'craziness'. Crazy Scientists are perceived as such due to their mad love of and crazy excitement towards explosions (Supplemental Material Table 2). They do not intend harm but are crazy in an eccentric way. Conversely, Supernatural Scientists are mad in an evil way, or they fight malevolent powers. They create explosions or dangerous tools to harm others or to save others from evil powers, akin to typical representations of a 'Supernatural Scientist' (Supplemental Table 2). Clumsy Scientists often make explosions, but unlike the Crazy or Supernatural Scientists, these result from his inherent clumsiness or lack of knowledge in science (Supplemental Table 2). The 'Crazy' nature of Clumsy Scientists is caused by clumsiness rather than insanity.

Each scientist profile is described in further detail below, whilst referring to nine common questions on what the scientist does ('Title, activity, type of scientist and tools' in Supplemental Table 1), how the scientist looks ('Characteristics and appearance' in Supplemental Table 2), and the type of child that the scientist had been ('Scientist as a child' in Supplemental Table 3), as described by children.

3.2. Brainy Scientist

The Brainy Scientist has high intelligence, often indicated in the title of the drawing. This profile may feature references to academic standing, e.g., ' Prof. Prestonerfuffle' (Fig. 2A) or 'Dr. Docter' (Fig. 2B), or to famous brilliant scientists in history, such as Isaac Newton, Albert Einstein or Marie Skłodowska Curie.

Brainy Scientists are not represented as partaking in a specific activity (Supplemental Table 1). They can be male or female (see quotes below). Their key characteristic is high intelligence: children said they are 'very intelligent' and 'a good scientist who knows his stuff'. This is often combined with various socially unfavourable characteristics; for instance, children describe them as 'grumpy' and 'weird' (Supplemental Table 1).

These negative social characteristics are further highlighted by children's descriptions of other aspects of their personality: 'very strict', 'perfectionist', 'judgey'. They are often perceived generally as 'boring'. Although Brainy Scientists can be 'kind', they are reported to have 'issues to regulate anger', suggesting a temper (Supplemental Table 2). Brainy Scientists are self-absorbed and solitary, perceived as 'a bit

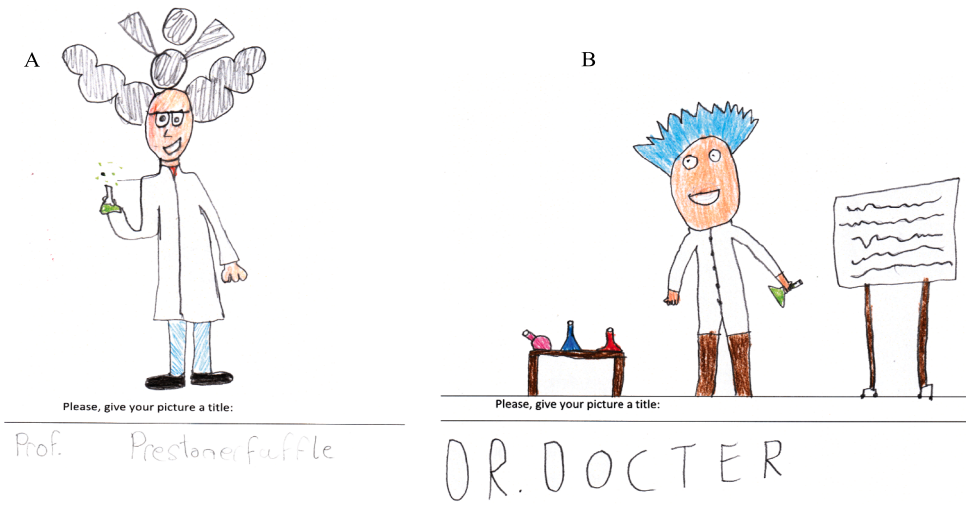

Fig. 2. Example drawings of a Brainy Scientist, containing characteristics of that profile. The identifying characteristic includes the presence of an academic title in the drawing title for example in (A) Prof. Prestonerfuffle or in (B) Dr. Doctor.

Fig. 3. Examples of Crazy Scientist representations in children's drawings, containing characteristics of that profile: for example, in (A) presence of explosions, crazy hair, mention of 'crazy' or 'mad' in title or in (B) crazy hair, explosion happening ('Bang!'), figure appears excited about the explosion.

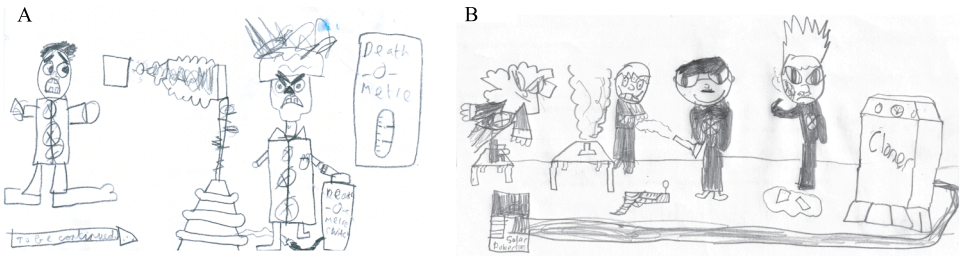

Fig. 4. Example drawings of a Supernatural Scientist, containing identifying characteristics of that profile: for example, in (A) extra-terrestrial (alien) features of the scientist and the presence of 'alien' in title or in (B) supernatural ability indicated in title ('The Scientist who doesn't live') and a strange-looking experiment set up in background.

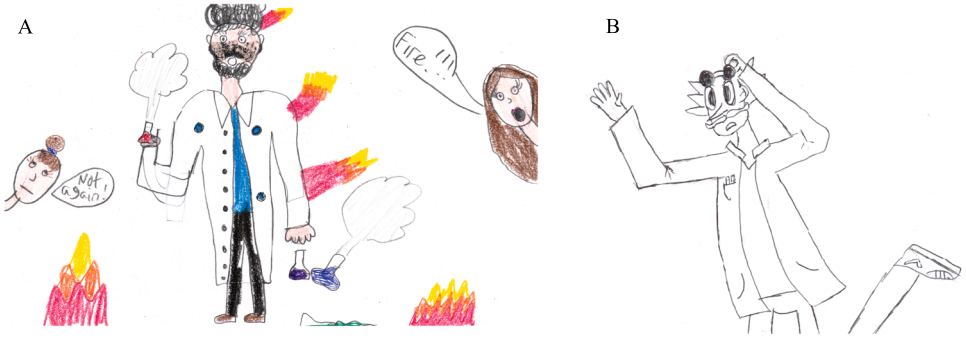

Fig. 5. Example drawings of a Clumsy Scientist, containing identifying characteristics of that profile: for example, in (A) accidental explosions (note bystander saying, 'Not again'), dishevelled appearance indicated by burn holes on lab coat and smoke on face, and shocked expression on face or in (B) clumsy movement of the scientist, here he is tripping over.

weird' because they spend most of their time alone in the lab. Often perceived as geniuses, Brainy Scientists are also described as 'nerdy', and 'crazy about their work', which nobody else understands:

> *Like, he would be like always talking about all this kind of like tech stuff, and he keeps talking about maths, and every single minute he always talks about science stuff and he's being really weird all the time as well. (Scott, Child no. 12)*

When in contact with people, Brainy Scientists are described as being 'shy, nervous, quiet and not very talkative' (Supplemental Table 2):

> *More solitary or just enjoy working on their own, as opposed to in groups and as opposed to dealing with maybe a lot of the public. (Anna, Child no. 11)*
>
> *Yeah, he doesn't like being with a lot of people. (Nick, Child no. 15)*

Their likes and interests highlight that they are perfectionists, very 'clean', 'organised' and 'tidy':

> *Yeah … so he tries to keep everything really clean. So his house and stuff, he'd make sure it's spotless.*
>
> *[Interviewer:] And why does he do that?*
>
> *Because he just doesn't like it being messy or untidy. (Rachel, Child no. 5)*

Fig. 6. Example drawings of a Normal Scientist, containing identifying characteristics of that profile: for example, in (A) smile, general neutral appearance, scientific lab in background, and title 'ANY one can be a scientist!' or in (B) smile, general neutral appearance, and using science to find 'solutions' as indicated by speech bubbles or also in (C) smile, general neutral appearance, and use of regular laboratory equipment.

Brainy Scientists like reading, studying, and exploring in their free time. They dislike noisy things and, due to their perfectionism, failing and mistakes. They know they are perceived as different due to their nature, and they dislike this (Supplemental Table 2). They dislike being directed by other people or told what to do, like at school. Their high intelligence is connected to reasoning. Consequently, Brainy Scientists do not like fantasy or fiction, as it makes no sense to them.

They don't like being smart. [survey answer]

She hates being told what to do. [survey answer]

She likes science, she doesn't like…fictional stories. [survey answer]

[Interviewer] Why does she not like fictional stories?

Because she thinks they are nonsense. (Amanda, Child no. 10)

When asked to describe Brainy Scientists as children (Supplemental Table 3), the children said they were 'organised but crazy', and already 'smart and bossy', like their adult selves. They were recognised as 'being in his own world', 'a bit weird', 'nervous, shy and quiet'. They were highly intelligent children: 'sciency' and 'smart'. They liked science from an early age and practised it in their free time. They had many achievements as children, such as science awards or playing 'extreme chess'. They seem to have been born as brainy child-scientists already and all the characteristics they would have at a later age existed already in childhood.

3.3. Crazy Scientist

Crazy Scientists are generally described as doing experiments involving explosions (Fig. 1B; Supplemental Table 1), e.g., they are 'making explosions' or 'mixing chemicals that explode'. References to explosions or fire appear in the title or the drawings, e.g., expressions such as 'Kaboom', 'Explosion', 'Fire' or 'Bang' (Fig. 3).

Crazy Scientists are overly excited about both making explosions (Fig. 3B) and the explosions themselves. Explosions are the main interest of their work, and their excitement and obsession about explosions makes them inherently 'crazy' as scientists:

… he is very happy… because he likes to make explosions and he is making one right there. (Paul, Child no. 8)

Unlike Brainy Scientists, Crazy Scientists are often described as kind and likable (Supplemental Table 2). They are not evil and do not intend to cause any harm:

[Interviewer] So, in describing him here, you said he is very kind but crazy kind [question based on survey answer]. What does that mean?

Like, he is very kind, but he is kind of a bit, not odd but kind of like not normal either. (Paul, Child no. 8)

Crazy Scientists are eccentric. They have a generally unkempt appearance and are recognised by the stereotypical 'Crazy hair' that looks like they have just been electrocuted in an experiment (Figs. 1B and 3).

Well, it's just the scientist with his crazy hair, and he's in like a town or something, and he has like his lab coat and he has his goggles on, and he's just crazy with his hands up in the air.

[Interviewer] What is crazy about him?

He looks like he got electrocuted or something. (Scott, Child no. 12)

When asked to describe the Crazy Scientist as a child, children often

mentioned sets of contradicting characteristics. For instance, they were 'crazy but likeable' or 'nice but had dark secrets'. As children, Crazy Scientists already enjoyed explosions and dangerous activities as much as they do in adulthood (Supplemental Table 2).

3.4. Supernatural Scientist

The Supernatural Scientist representations have references to 'Mad' or 'Evil' in the titles or the drawings (Fig. 1C, Supplemental Table 1). They can also be called 'crazy', but while Crazy Scientists are seen as eccentric, Supernatural Scientists are perceived as 'crazy' on a more malevolent scale. They are associated with being unnatural, supernatural, evil or in the company of creatures. These creatures' names are often mentioned in the titles, e.g., 'Alien sci' or 'Frankenstein', and are indicators of the scientist's evil and dangerous nature (e.g., 'Scientist taking over the world'). Titles might also refer to the scientist's superpowers (e.g., 'Fighting with Alien's disease' or 'The scientist who doesn't live').

Children often depict Supernatural Scientists making something unnatural, such as aliens or clones, or being supernatural themselves (Fig. 4). Themes of evil, danger and potential death are implied in their activities. Their appearance often includes supernatural features, such as 'tentacles'. Interestingly, they think they are a scientist because they like science, but they are not necessarily a human scientist e.g. they can be a creature.

Supernatural Scientists often have supernatural powers and an evil nature – planning world domination, for example. They are perceived as evil because they intend to harm people or want to do dangerous things and activities that could hurt people:

What kind of scientist is it? [survey question]

Kind that wants to make poison. [survey answer]

[interviewer] And his personality is evil? [question based on survey answer]

Yeah.

[interviewer]What does that mean?

That he likes making bad stuff that maybe hurt people or something. (Nick, Child no. 15)

Alternatively, the Supernatural Scientists are described as fighting dangerous and evil supernatural creatures that could harm humans. This is the only time they are not described as evil: instead, they are saving the world from evil creatures who threaten human lives or want to take over the world (Supplemental Table 2). In this version, they still have a strong connection to supernatural creatures and engage in deadly activities such as 'killing zombies', 'aliens' or other creatures. As such, Supernatural Scientists always have a supernatural power in an interplay in their activities.

In all variations of this profile, they are described as evil or fighting with evil while conducting forbidden 'mad' science experiments they like to do (e.g., creating 'new species', 'clones'), or while using superpowers. Thus, the tools they use are hazardous, powerful, and often illegal or forbidden (e.g., 'Death-O-Meter' in Fig. 4A or 'the cloner' to make a human in Fig. 4B). They dislike animals and various things related to creatures and supernatural or unnatural things, though they always seem to deal with them. In addition, they like doing unnatural things that would kill ordinary people, such as 'Eating chemicals'.

As children, Supernatural Scientists were 'mad and mean'. They had 'mad sciencey interests' related to creatures and the scientist's dangerous nature, similar to the adult character (Supplemental Table 3). They could be unnaturally old, such as '100000000' years old. Sometimes children reported that this scientist 'was never my age', suggesting they were never a child – again indicating their supernatural features. When imagined as a child, their interests were connected to 'making dangerous, mad, evil plans for the future'. Thus, Supernatural Scientists aspired to become evil scientists from childhood.

3.5. Clumsy Scientist

Titles associated with the Clumsy Scientist drawings highlight scientific incompetence, e.g., 'mistake', 'failure' or 'clumsiness' (Fig. 1D, Supplemental Table 1). Clumsy Scientists are described as 'crazy' and slightly dangerous, but they do not mean to harm people. Clumsy Scientists are dangerous because of scientific incompetence and lack of scientific knowledge necessary for conducting their experiments. They are particularly described as a 'clumsy' and 'not very good' kind of scientist (Supplemental Table 2), and are portrayed as 'Failing the experiment', setting everything around them on fire and putting everyone at risk through their mistakes (Fig. 5).

Clumsy Scientists use dangerous tools or liquids that they have often dropped, 'failed' or 'set in a fire' and created a dangerous explosion:

[Interviewer] Can you tell me more about it? How do we know he's clumsy?

Because he's setting everything on fire, and they say that he's done this before … he's trying to like make something new … and then it's failing. Like he did it wrong, and that's why everything is exploding everywhere. (Mia, Child no. 25)

[Interviewer] And tell me more about silly and daft.

Kind of like, that's what I meant by very clumsy—and always doing silly things when they're not working.

[Interviewer] Like what?

Like … tripping over stuff maybe, or like putting water with their cereal instead of milk. (David, Child no. 16)

They are unkempt, with a dishevelled appearance, or with stained or outsized clothes:

[Interviewer] What would be clumsy about him?

One foot is bigger than his other. And he has tiny arms.

[Interviewer] So that would be clumsy about him?

Yeah. And I think he always wears lab coats too big for his size. Because it kind of acts as pants as well. (David, Child no. 16)

The Clumsy Scientists' dishevelled appearance is also due to clumsiness, e.g. they may have burn marks on their lab coat due to accidental fire (Fig. 5). Descriptions of the Clumsy Scientists as children comprise mostly negative characteristics related to their clumsiness, such as being 'dull, stupid, daft', 'silly', 'messy', 'annoying'. They are described as being 'troubling but nice' and 'funny'. Participants never mentioned special interests during their childhood (Supplemental Table 3). 'Clumsiness' is the most predominant feature associated with this scientist across children's descriptions.

3.6. Normal Scientist

The last scientist profile that emerged from the analysis was the 'Normal' scientist (Fig. 1E). Title indicators of this profile include expressions associated with 'science', 'scientist', or 'research'. Titles may include names of everyday people, e.g., 'Joe the Scientist' or emphasise that 'Anyone can be a scientist' (Fig. 6A).

These scientists engage in activities that suit real-life STEM scientists and are congruent with the actual daily work of a STEM researcher. For example, the scientists drawn are 'doing experiment or research' (Fig. 6B), 'making medicine', 'observing', 'writing the results down, or 'reporting', or they are doing laboratory work such as 'holding the bottle' (Fig. 6C), 'reaching for a test tube', etc. This was the only profile where scientists were described as doing activities other than running an

experiment in a lab: Normal Scientists could also teach or have a profession unconnected to science while doing science as a hobby. As such, they can be described as 'science enthusiasts' rather than STEM professionals (Supplemental Table 1):

> *She's very enthusiastic… she likes to fill peoples' minds with facts and help them learn*
>
> (Hannah, Child 1)

When children were asked, 'What kind of scientist is it?', they responded with various STEM professions, such as 'medical doctor', 'health scientist', 'biologist' or 'chemist'. Interestingly, children also used the expression 'Normal' in contradiction to 'Crazy' or 'Mad' kind of a scientist in their descriptions when asked in the questionnaire 'What kind of scientist is it?' (Supplemental Table 1) distinguishing the 'normality' of this scientist as his essential feature.

The character of a Normal Scientist is described as an ordinary 'average Joe' who likes to do science, research, or experiments (Supplemental Table 2). Normal Scientists are interested in nature but also in things that anyone may be interested in. It is the only profile associated with positive, socially desirable characteristics such as 'creative', ~~'funny'~~, 'curious', 'bubbly' or 'fun to be around' (Supplemental Table 2) – characteristics often highlighted by drawing the scientists with smiling facial expressions (Fig. 6):

> *She loves adventures, trying new things and making a mess! She daydreams a lot too. Very independent. [survey answer]*
>
> *He/she is very creative and loves mechanics [survey answer]*

It should also be noted that both the Normal Scientist and the Clumsy Scientist are associated with the characteristics 'Funny'. It is possible that this may be interpreted differently by the children: the 'Funny' nature of the Clumsy Scienitst may be due to his 'Silly' and 'Daft' nature, whereas when it is associated with the Normal Scientist it is seen more as a positive social trait:

> *He is an optimistic funny guy. (Adam, Child no. 9)*

There were no likes or interests specifically associated with Normal Scientists (Supplemental Table 2), but they dislike various things that children probably dislike (e.g., eating spinach). They are described as having a neutral appearance that anyone could have, e.g., 'Tall, brown hair, blue eyes' (Adam, Child no. 9).

These scientists as children were described as the 'same as now'. Interestingly, children used words that may indicate their experience of how adults describe them, such as 'hyper', 'giddy', 'fun' or 'normal kid' (Supplemental Table 3). Unlike the other types of scientists, who always wanted to be a scientist, Normal Scientists were normal children, not predestined for science but who decided to become a scientist based on their growing interest:

> *'He was just a normal kid, and then one day he wanted to become a scientist because he saw everyone [doing science] and he really liked science. So, he just wanted to become one. (Ulrich, Child no. 14)*
>
> *She probably didn't like science back then, because people change as they grow older. She probably was like every other child her age. A typical child … probably in university or end of secondary school, around that time she probably would have started [liking science]. (Junan, Child no. 20)*

4. Discussion

This study aimed to investigate children's perceptions of scientists by using a novel, child-centred qualitative methodology scaffolded by children's drawings of scientists. The results are based on the analysis of children's descriptions of their DAST drawings, not on the analysis of DAST drawings. They indicate that children's perceptions of a DAST scientist could be distinguished in five profiles: Brainy, Crazy, Supernatural, Clumsy and Normal Scientists.

Despite this range of profiles, children's descriptions were heavily dominated by stereotypes. Four of the five profiles are related to common scientist stereotypes previously identified in the literature (e.g. Mead and Métraux, 1957; Chambers, 1983; Ferguson & Lezotte, 2020; Finson, 2003). Only one profile, the Normal Scientist, represents what could be considered as a non-stereotypical view, that is, a real STEM scientist.

The Brainy Scientist profile somewhat mirrors the same scientist type described by DeWitt et al. (2013) in examining children's perceptions of their STEM-talented peers. Archer & DeWitt (2017) said their Brainy scientist was often described as highly intelligent and associated with socially unfavourable characteristics such as 'nerdy', 'grumpy', 'shy' and 'doesn't really like people'. This is consistent with the children's expressions describing Brainy Scientists in this study. The present Brainy Scientist profile is also somewhat congruent with the 'positive stereotype' described by Mead and Métraux (1957). The results showed how this stereotype is also present in children's perceptions of an imaginary scientist today and is represented in their drawings and accompanying descriptions.

Compared to previous studies, the presented work identified more-refined characteristics of common scientist stereotypes, now newly articulated by children themselves. In particular, elements associated with the 'Crazy', 'Supernatural' and 'Clumsy' types have been previously described under the category of 'Negative stereotype' (Mead & Métraux, 1957), Crazy scientist (Chambers, 1983; Finson et al., 1995) or antisocial/eccentric (Ferguson & Lezotte, 2020). These three profiles – Crazy, Supernatural and Clumsy – can be distinguished by nuances in the children's descriptions of 'craziness'. Clumsy Scientists are not insane but somewhat clumsy in all their activities that create issues of 'craziness'. Crazy Scientists have a kind nature; their crazy character develops through his eccentric excitement about explosions. By contrast, Supernatural Scientists are associated with superpowers; these can be dangerous to humans due to the scientist's evil nature, or else the scientist protects humans from the evil powers. Children may form these misconceptions from depictions of scientists in popular culture and the media, such as cartoons. In a study with 9-10-year-old students in Singapore, Tan et al. (2017) reported that students that listed entertainment media only as their sources of inspiration for their drawings (as opposed to school-related sources) were more likely to draw stereotypical or 'unrealistic' scientists. It was informally noted in this present study that several of the scientist descriptions associated with the Supernatural profile seemed to depict the scientist protagonist 'Rick' from the cartoon Rick and Morty: a character who is portrayed as an eccentric and self-serving scientist who invents supernatural equipment and goes on adventures with his grandson 'Morty'. 'Rick' is an old, white balding man who always wears his lab coat. As argued before, media exposure can directly influence scientist representation (Steinke et al., 2007).

The Clumsy Scientist is not previously identified in the literature on children's stereotypical perceptions of a STEM professional. It is described in direct contrast to the Brainy Scientist type (DeWitt et al., 2013): 'dull' versus super-intelligent, 'clumsy' and 'not [a] very good one' versus 'perfect', the one who makes mistakes versus the one who never fails. This newly identified type in children's perceptions will need more detailed exploration in future research to refine its description and explore its origin. It is possible that the perception corresponding with a Clumsy scientist profile has origins in media and popular culture, i.e., scientists being portrayed as affable but awkward people.

In contrast to the four stereotypical profiles illustrating unrealistic scientist characters, the Normal Scientist is the only profile personifying general features common to real people, including the children themselves. Normal Scientist characteristics are consistent with real-life scientists and may represent children's perception of who scientists genuinely are. This profile depicts ordinary people keen on science in a positive light. Interestingly, it is the only profile to include 'normal', non-scientific characteristics and interests that any child or adult might

have. As such, the 'normality' of the scientist personality is well rounded and defined by children. However, as emphasised by children, the 'normality' of a scientist is in direct opposition to the four other profiles, outlining the strength and broad range of the children's stereotypical views of scientists.

Children describe Normal Scientists with the fewest details. More research is needed to find out if children consider these representations like the ones of real-life scientists. Moreover, the mediating relationships between children's science level of science capital (Archer et al., 2015) and their perceptions of scientists could guide future research directions.

5. Limitations of the study

Each drawing was not analysed separately in this work, as is conventionally done in the Finson et al. (1995) DAST-C method. Instead, the thematic analysis of children's descriptions on DAST drawings was employed. Representative drawings thus only approximate the ideal types described due to the identification characteristic of each profile. Future studies could explore the correspondence between analysis of children's DAST drawings using visual and arts-based analysis methods and the descriptions of drawings by children themselves to establish deeper insight into the representations of children's descriptions in the DAST drawings. Similarly, the gaps in the descriptions by each identified profile of a scientist in children's perceptions need to be addressed in future studies. The thematic analysis conducted in this study also did not make it possible to look at interconnections between the five scientist profiles and children's characteristics. For example, it cannot be determined whether the 'Brainy' profile is more likely to be drawn by participants of a particular gender or specific cultural heritage. Hence, this limit of the study suggests the possible direction of future studies in the field.

6. Conclusions and future directions

This study was designed with a qualitative child-centred approach, which gave children the opportunity to provide descriptions and explanations of their drawings of a scientist to understand children's perception of scientists better. Thus, it allowed for the emergence of more refined versions of existing knowledge on stereotypical views on scientists and new details in these not hitherto identified in the literature. These study results validate the researcher design as a suitable method for exploring children's perceptions of scientists, moving away from the conventional binary quantitative lens of absence/presence of stereotypes traditionally reported in DAST studies. This novel methodology may be used in similar studies to address gaps in the field and contribute to more accurate research findings on children's perceptions of scientists. For example, using this child-centred participatory approach could be used to investigate whether children associate ethnicity/race with the drawings of their scientists. It has been suggested by experts in the field that the use of traditional quantitative DAST analysis techniques may artificially inflate the number of scientists drawings that are interpreted as being Caucasian by not having skin colour explicitly coloured in (Reinisch et al., 2017, Losh et al., 2008). Future work could use this method to use the DAST drawings as a scaffold and include a question regarding skin colour in the questionnaire and/or interviews.

The findings of this study may have practical implications for practitioners aiming to impact young people's science perceptions. For example, many informal science education initiatives aim to address the shortage of science graduates by improving the perceptions of scientists and promoting science career awareness. This study demonstrated that children have minimal views of what it means to be a scientist, as illustrated by the little details within a 'Normal Scientist' 's perceptions and the emphasis on 'Normal' versus 'Crazy' distinctions in children's descriptions. These results align with findings obtained with traditional quantitative DAST studies (Ferguson & Lezotte, 2020) and qualitative work exploring more broadly children's perceptions of scientists (Archer et al., 2015).

Science education interventions may consider focusing more on addressing the specific stereotypes profiles newly identified in this study. For instance, by avoiding their stereotypical representations and instead showcasing who scientists are as people, both professionally and otherwise. Using real scientists as facilitators may widen children's understanding of who scientists are and what they do, shifting from stereotypical profiles and broadening the perceptions of the 'normal' profile. Interventions should also facilitate direct communication between scientists and children through live Q&A sessions, addressing children's curiosity with honest and relatable personal narratives on scientists' lives.

Author Contribution

TJB, SC, MJ and MG contributed to the design of the study. TJB and SC conducted fieldwork - recruited participants, and collected the data. TJB conducted the data analysis. SC and MG discussed the interpretation of the results with TJB. TJB and MJ wrote the first draft of the manuscript. TJB, SC, MG and MJ contributed to the revisions of the manuscript. MG acted as principal investigator of the project.

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Supplementary materials

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References

Archer, L., Moote, J., Macleod, E., Francis, B., & DeWitt, J., (2020), ASPIRES 2: Young people's science and career aspirations, age 10-19, https://discovery.ucl.ac.uk/id/eprint/10092041/.

Archer, L., & DeWitt, J. (2017). Understanding Young People's Science Aspirations : How students form ideas about "becoming a scientist" (1st Ed.). Routledge. 10.4324/9781315761077.

Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). Science capital": A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. *Journal of Research in Science Teaching, 52*(7), 922–948. https://doi.org/10.1002/tea.21227

Barman, C. R. (1999). Students' Views about Scientists and School Science: Engaging K-8 Teachers in a National Study. *Journal of Science Teacher Education, 10*(1), 43–54. https://doi.org/10.1023/A:1009424713416

Bourdieu, P., & Passeron, J.-C. (1977). *Reproduction in Education, Society and Culture* (2nd Ed.). Sage Publications.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-a-scientist test. *Science Education, 67*(2), 255–265. https://doi.org/10.1002/sce.3730670213

Coyne, I., & Carter, B. (2018). Being participatory: Researching with children and young people: Co-constructing knowledge using creative techniques. In I. Coyne T, & B. Carter (Eds.), *Being Participatory: Researching with Children and Young People: Co-constructing Knowledge Using Creative*. Techniques. https://doi.org/10.1007/978-3-319-71228-4.

Creswell, J. W. (2013). *Qualitative Inquiry & Research Design: Choosing among Five Approaches* (3rd ed). SAGE Publications Inc.

Department of Education. (2020). *STEM Education 2020: Reporting on Practice in Early Learning and Care, Primary and Post-Primary Contexts*. https://www.education.ie/en/Publications/Inspection-Reports-Publications/Evaluation-Reports-Guidelines/stem-education-2020.pdf.

Department of Education and Skills. (2017). *DEIS Plan 2017: Delivering Equality of Opportunity in Schools*. https://assets.gov.ie/24451/ba1553e873864a559266d344b4c78660.pdf.

DeWitt, J., Archer, L., & Osborne, J. (2013). Nerdy, Brainy and Normal: Children's and Parents'Constructions of Those Who Are Highly Engaged with Science. Reseach in Science Education. *Research in Science Education, 43*, 1455–1476. https://doi.org/10.1007/s11165-012-9315-0J

Ehrlén, K. (2009). Drawings as Representations of Children's Conceptions. *International Journal of Science Education, 31*(1), 41–57. https://doi.org/10.1080/09500690701630455

European Commission. (2015). *Science education for responsible citizenship*. https://op.europa.eu/en/publication-detail?p_p_id=publicationDetailsActions_PublicationDetailsActionsPortlet_INSTANCE_P7Lc96wTRLvv&p_p_lifecycle=1&p_p_state=exclusive&_publicationDetailsActions_PublicationDetailsActionsPortlet_INSTANCE_P7Lc96wTRLvv_javax.

Farland-Smith, D. (2012). Development and Field Test of the Modified Draw-a-Scientist Test and the Draw-a-Scientist Rubric. *School Science and Mathematics, 112*(2), 109–116. https://doi.org/10.1111/j.1949-8594.2011.00124.x

Farland-Smith, D., Finson, K., Boone, W. J., & Yale, M. (2014). An Investigation of Media Influences on Elementary Students Representations of Scientists. *Journal of Science Teacher Education, 25*(3), 355–366. https://doi.org/10.1007/s10972-012-9322-z

Ferguson, S. L., & Lezotte, S. M. (2020). Exploring the state of science stereotypes: Systematic review and meta-analysis of the Draw-A-Scientist Checklist. *School Science and Mathematics, 120*(1), 55–65. https://doi.org/10.1111/ssm.12382

Finson, K. D. (2002). Drawing a scientist: What we do and do not know after fifty years of drawings. *School Science and Mathematics, 102*(7), 335–345. https://doi.org/10.1111/j.1949-8594.2002.tb18217.x

Finson, K. D. (2003). Applicability of the DAST-C to the Images of Scientists Drawn by Students of Different Racial Groups. *Journal of Elementary Science Education, 15*(1), 15–26. http://www.jstor.org/stable/43155734.

Finson, K. D., Beaver, J. B., & Cramond, B. L. (1995). Development and Field Test of a Checklist for the Draw-A-Scientist Test. *School Science and Mathematics, 95*(4), 195–205. https://doi.org/10.1111/j.1949-8594.1995.tb15762.x

Gago, J. M., Ziman, J., Caro, P., Constantinou, C., Dvies, G., Parchmann, I., Rannikmäe, M., & Sjoberg, S. (2004). Europe needs more scientists. *In European Commission*. https://ec.europa.eu/research/conferences/2004/sciprof/pdf/final_en.pdf.

Gallup. (2019). *Wellcome Global Monitor 2018: How does the world feel about science and health*. https://wellcome.org/reports/wellcome-global-monitor/2018.

Government Of Ireland, & Department Of Enterprise Trade and Employment. (2009). *Science, Technology and innovation Delivering The Smart Economy*. Government of Ireland Publications. http://www.deti.ie/publications/science/2009/Delivering_the_Smart_Economy.pdf.

Hickey, R. (2011). *The Irish Economy in Perspective*. http://www.finance.gov.ie/documents/pressreleases/2011/mn001presrev.pdf.

James, A., & Prout, A. (1997). *Constructing and reconstructing childhood: Contemporary issues in the sociological study of childhood*. Falmer Press.

Losh, S., Wilke, R., & Pop, M. (2008). Some methodological issues with "draw a scientist tests" among young children. *International Journal of Science Education, 30*(1), 773–792. https://doi.org/10.1080/09500690701250452

Lundy, L. (2007). 'Voice'is not enough: conceptualising Article 12 of the United Nations Convention on the Rights of the Child. *British Educational Research Journal, 33*(6), 927–942.

Mead, M., & Métraux, R. (1957). Image of the Science among High-School Students. *Science, 126*(3270), 384–390. https://doi.org/10.1126/science.126.3270.384

Murphy, C., Varley, J., & Veale, Ó. (2012). I'd rather they did Experiments with us.... Than just Talking: Irish Children's Views of Primary School Science. *Research in Science Education, 42*(3), 415–438. https://doi.org/10.1007/s11165-010-9204-3

National Science Foundation. (2018). *Building the future investing in discovery and innovation: NSF strategic plan for fiscal years (FY) 2018-2022*. https://files.eric.ed.gov/fulltext/ED594467.pdf.

Newton, L. D., & Newton, D. P. (1998). Primary childrens' perceptions of science and the scientist: is the impact of National Curriculum breaking down the stereotype? *International Journal of Science Education, 20*, 1137–1149. https://doi.org/10.1080/0950069980200909

OECD. (2019). *Education at a Glance 2019. In Education at a Glance: OECD Indicators*. OECD Publishing. https://doi.org/10.1787/f8d7880d-en

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049–1079. https://doi.org/10.1080/0950069032000032199

Reinisch, B., Krell, M., Hergert, S., Gogolin, S., & Krüger, D. (2017). Methodical challenges concerning the Draw-A-Scientist Test: a critical view about the assessment and evaluation of learners' conceptions of scientists. *International Journal of Science Education, 39*(14), 1952–1975. https://doi.org/10.1080/09500693.2017.1362712

Schreiner, C., & Sjøberg, S. (2010). *The ROSE project An overview and key findings* (pp. 1–31). Oslo: University of Oslo. *March* http://www.uv.uio.no/ils/english/research/projects/rose/publications/the-rose-project.pdf.

Science Foundation Ireland. (2018). *SFI 2020: Agenda 2020*. https://www.sfi.ie/research-news/publications/AGENDA-2020-(2018)-WEB.pdf.

Science Foundation Ireland. (2020). *SFI Science in Ireland Barometer 2020*. https://www.sfi.ie/engagement/barometer/SFI-Science-in-Ireland-Barometer-2020-Research-Report.pdf.

Steinke, J., Lapinski, M., Crocker, N., Zietsman-Thomas, A., Williams, Y., Higdon Evergreen, S., & Kuchibhotla, S. (2007). Assessing media influences on middle school-aged children's perceptions of women in science using the Draw-A-Scientist Test (DAST). *Science Communication, 29*(1), 35–64. https://doi.org/10.1177/1075547007306508

Tan, A.-L., Jocz, J. A., & Zhai, J. (2017). Spiderman and science: How students' perceptions of scientists are shaped by popular media. *Public Understanding of Science, 26*(5), 520–530. https://doi.org/10.1177/0963662515615086

The Stem Education Review Group. (2016). A Report on Science, Technology, Engineering and Mathematics (STEM) Education: Analysis and Recommendations. *In Department of Education and Science*. Issue November 2016 https://assets.gov.ie/25068/d5c86a91ac3b43869f827438f58d88c0.pdf.

Thomas, G., & Durant, J. (1987). Why should we promote the public understanding of science? In M. Shortland (Ed.), *Scientific Literacy Papers* (pp. 1–14). Rewley House.

Tindall, L., Smith, J. A., Flower, P., & Larkin, M. (2009). Interpretative Phenomenological Analysis: Theory, Method and Research. *Qualitative Research in Psychology, 6*(4), 346–347. https://doi.org/10.1080/14780880903340091

United Nations. (2019). *Transforming our world: The 2030 agenda for sustainable development*. https://sustainabledevelopment.un.org/content/documents/21252030. Agenda for Sustainable Development web.pdf.