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Unravelling early childhood pre-service teachers' implicit stereotypes of scientists by using the repertory grid technique

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Abstract
Considering teachers' roles in developing children's scientific literacy in preschools, a better understanding of pre-service teachers' conceptualizations about scientific inquiry and scientists' practices that have an impact on the science teaching practices offered to their future students is very much needed. Stereotypes were examined here as a component or root for many of the explanations for pre-service teachers' conceptualizations about scientists. Aligned with the interpretivist paradigm, this phenomenographic study was, mostly qualitative in nature, specifically concerned with exploring pre-service teachers' stereotypes of scientists by using the repertory grid technique, in which they perceived and differentiated between scientists. 119 early childhood pre-service teachers were recruited. Various types of analysis were carried out to analyze the data gathered in each repertory grid. We investigated the original 66 elicited bipolar constructs into 28 aggregated bi-polar construct groupings, systematically categorized into four bi-polar categories: (1) Recognition vs. Disregarded, (2) Scientific Integrity vs. Misconduct, (3) Communal vs. Dissociation, and (4) Agentic vs. Passivity. The findings suggest that pre-service teachers had typical stereotypical traits of scientists like being introverted, intelligent loners, into experiments and masters in their field with often-unrecognizable female figures. However, there was no association between gender, grade, and stereotypes of scientists elicited in the study. These types of stereotypes of scientists might potentially threaten effective science teaching at early ages. Science education practices can be rooted in these stereotypes of pre-service teachers. Considering these findings, structural changes in science education practices in teacher education programs are very much needed. This study also seems to confirm the importance of using the repertory grid technique as a good starting point to expose especially the implicit stereotypes of pre-service teachers about "who does science", "how scientists think" and "what scientists do" before their actual actions in future classrooms.

Keywords Stereotypes of scientists, Pre-service teachers, Repertory grid technique, Early childhood education, Phenomenographic study

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Introduction

Understanding the highly important roles of science and technology has resulted in a paradigm shift in standards and goals of science education to put much emphasis on "thinking and working as scientists" (Childs, 2015, p.381). Specifically, more recent attention in science education has focused on the recent paradigm that all today's school children are considered the next generation of the workforce and can be scientists in the future (Farland-Smith, 2019). For this purpose, there is an expectation from early childhood teachers that bear some of the responsibilities for improving children's certain thinking skills and scientific and technological knowledge that promotes their scientific literacy (Harlen, 1997). Regarding this, science needs to be more accessible and more relevant for all students, as curriculum planners, science educators, and policymakers have come up with the tagline "Science for All Students" (Yore, 2011). However, children's interest in science and scientists generally peaks at the beginning of their school careers and then begins a steady decline (Mantzicopoulos et al., 2013). The central question here asks "How does science education prevent losing children's interest in science rather it aspires to enhance their interest in science and related careers?

Given that every child is born a scientist (Eshach & Fried, 2005), children's interest in science and scientists is best increased when they are offered developmentally appropriate instruction (Campbell & Lee, 2021; Thompson et al., 2019). We can proclaim that this situation places teachers in the center of offering meaningful science experiences for children. Accordingly, teachers can either conserve or modify children's interest in science and scientists, as well as their attitudes towards science learning (Christidou, 2011). There is growing recognition that teachers' decisions and behaviors in science classrooms are substantially influenced and determined by teachers' conceptualizations about scientific practices and how scientists work and think (Hutner & Markman, 2016). We draw on the empirical literature with substantial evidence that teachers holding certain stereotypical conceptualizations of scientists and scientific practices limit scientific inquiry offered to their students (Besley, 2015; Brígido et al., 2013), thereby restricting students' interest in science education (Goodrum et al., 2012), and to pursue careers related to science (Regan & DeWitt, 2015; Roychoudhury, 2014).

Teachers' stereotypes about scientists originate in accumulated experiences throughout their lives (Thomas, 2017) and can be stable over time unless any opportunity is provided to shape precise cognition before they demystify it in real classrooms (Baker et al., 2009). For instance, stereotypical perceptions of in-service and pre-service teachers (PST)s about scientists are predominantly associated with physical appearance of a middle-aged Caucasian male, wearing a laboratory coat and eyeglasses and doing experiments in a laboratory (DeWitt et al., 2013). Earlier studies thus far have linked teachers' lack of knowledge on science practices and scientists with science education practices in teacher education programs (e.g., Reinisch and Krell, 2023). This appears to support that science courses at universities are one of the great sources of PST's stereotypical perceptions of scientists (Quarderer et al., 2019). Specifically, PST rarely goes into any depth in teaching science at university, making it difficult to transfer what counts as scientific inquiry (Gyllenpalm et al., 2010). Further, their stereotypes cannot be expressed explicitly nor shared with others because they are often unaware and difficult to control (Hassard, 1990). The lack of recognition of stereotypes among PST has been confirmed as the profound nature of stereotypes of scientist by previous studies (Reinisch & Krell, 2023). For this to be the case, it is in everyone's interest in providing PST the opportunities to make their implicit stereotypes of scientists explicit, especially to confront stereotypes and ultimately broaden perceptions of who scientists are that they might share with their future students.

Data from several sources have identified that cultural backgrounds contribute to the creation of teachers' stereotypes about scientific inquiry and scientists that particularly inhibit inquiry-based science teaching practices (e.g., Mansour, 2015). In addition to the roles of cultural backgrounds in the construction of the stereotypical perceptions about scientists, several attempts have been also made to address age-and gender- related differences in individuals' stereotypical conceptualizations about scientists (e.g., Miller et al., 2018). Specifically, recent evidence suggests that gender stereotypes appear across genders, cultures and time (Charlesworth & Banaji, 2019). Thus, addressing the age and gender- related differences in PST's stereotypical perceptions about scientists through cultural lenses can allow a more nuanced understanding of the potential impact on their future science teaching practices. When it is aimed to derive such stereotypical perceptions that are implicit and hard to express, alternative ways of how to get this information have great significance to researchers.

Yet, eliciting stereotypes of scientists cannot be easily externalized by traditional methods such as scales (Reinisch et al., 2017). A primary concern here is whether participants' actual perceptions are represented or whether their views reported are impacted by the researcher's own agenda (Ehrlén, 2009). Further, earlier studies mostly used the stereotypes identified in one of the earliest studies conducted by Mead and Metraux (1957). This might not entirely represent the current perceptions of scientists (Schinske et al., 2015). We also recognize that the data gathered from such methods are predominantly limited to the physical characteristics of scientists and might not make explicit some other characteristics such as nature of the science activities (Ferguson & Lezotte, 2020). Accordingly, in this study, we were much concerned with the idea that there is no certain way of knowing whether the students use the same words or language with the same meaning as the researchers do in a structured data collection tool. To overcome these deficiencies of lacking participants' voices and explanations of their perceptions, the previous researchers tend to use supplementary qualitative data collection tools (e.g., interviews or qualitative questionnaires) (Brumovska et al., 2022). To response to this call, the current research was conducted based on "Personal Construction Theory" developed by Kelly (1955) particularly by using the repertory grid technique (RGT), considered to be superior to the use of questionnaires and interviews alone in terms of revealing the detailed analysis of the stereotypes of scientists held by PST. This technique enables respondents to use their own words in comparison with other techniques through which they can use the terms offered by researchers (Solas, 1992). In that case, personal conceptualizations can be uncovered based on the respondents' thoughts and feelings in a more credible way to encourage them to self-assess their stereotypical perceptions from their authentic perspectives, thereby, leading to the desired changes that will only occur when they begin to evaluate their understanding. For this purpose, we designed this phenomenographic to seek to address the following research questions:

(1) What were stereotypes of scientists of early childhood PST?
(2) How did stereotypes of scientists of early childhood PST differ in terms of their grades and gender?

Literature review

Stereotypes of scientists

Considering research on stereotypes in general, while a variety of definitions of a stereotype have been suggested, this paper uses the definition first suggested by Perkins (1979) seeing it as an overgeneralized and oversimplified way of describing a group of people (scientists) by listing specific characteristics based on a shared perception and belief held by another group of people (PST) through the collective consensus within a society. Stereotypes can occur constantly and implicitly because of various factors within different contexts throughout an individual's lifetime (Lee et al., 2013). Such perceptions are not necessarily negative but can involve positive qualities or both positive and negative aspects (Subramaniam et al., 2013). Although we cannot assume all stereotypes are inaccurate perceptions, they can still be detached from the reality (Lee et al., 2013), such as stereotypes that men have more science ability than women (Bigler & Liben, 2006) or scientists are brilliant (Master & Meltzoff, 2020).

Accordingly, certain stereotypes about scientists and attributes imputed to scientists lead to embed social messages in classrooms about "who does science", "how scientists think" and "what scientists do" (Hilton & von Hippel, 1996), thereby, children either identify or disidentify themselves with scientists (Miller et al., 2018). As an example, when a teacher implies, "scientists are brainy and competitive", this quote might invite children to think that people with certain attributes are good at scientific inquiry by nature. Indeed, almost anyone could probably argue that students considering themselves to be different from scientists are likely to fear developing a science identity and are unlikely to be engaged in science education (Knobe et al., 2013). Notably, it is beyond the idea they are simple mental constructs used to label a group of people because they can shape how one feels about this specific group of people, or how one can engage with them (Thomas, 2017). Rather, stereotypes have an ideological nature with complicated and cultural backgrounds through which they might make biased social judgments that are not necessarily experienced personally. (Schinske et al., 2015). In line with this understanding, stereotypes are considered an important factor in the development of attitudes, motivations and strategies for success in science education (Schneider, 2010; Thomas, 2017). Thus, stereotypes are examined here as a component or root for many of the explanations for PST's conceptualizations about scientists.

Among the long list of identified stereotypes of scientists, the word scientist generally refers to white males, intelligent, hardworking, and dedicated to work with limited interpersonal skills (Dikmenli, 2010). These images are increasingly recognized as general stereotypical traits conveying the message that scientists are different from ordinary people (Wood et al., 2020). These images also suggest that science is a masculine world where women are less likely to be a part of it (Miller et al., 2018) because science is a challenging work for women, not being considered good enough mainly due to their natural paternity roles (Tintori & Palomba, 2017). Furthermore, as another typical stereotype of scientists, scientists work for their gain but not for the good of humanity (Losh, 2010). This image conveys an idea that scientists only care about making their experiments and have a lack of concern for the consequences of their actions, greatly contributing to making people less supportive of any actions that scientists take (Tintori & Palomba, 2017), and conflicting with the traits associated with women (Carli et al., 2016). Considering stereotypes have different impacts on different groups of people (Thomas, 2017), these stereotypes associated with scientists and women might cause female students to become distant from science careers (Diekman et al., 2017).

Closely tied to a growing body of research addressing how stereotypical perceptions of children are developed and maintained as they go through formal education (Scholes & Stahl, 2022), several studies have highlighted the differences of their experiences with the scientific inquiry and scientists stereotypes influencing their engagement in science depending on their gender, social and cultural backgrounds (Tintori & Palomba, 2017; Thomas, 2017). These personal, social and cultural influences can serve as a mechanism of either support for or a barrier to the development of children's images of themselves as potential scientists (Steinke, 2017). Specifically, it has been further discussed that before children go to school, they do not have any gender stereotypes of scientists and pointed out the significance of early childhood teachers' roles in deactivating stereotypes of scientists (Miller et al., 2018). The existing accounts have specified that while children's positive experiences with science and scientists at school can influence their persistence and success in science (Thomas, 2017), negative experiences are often very harmful to children's science career choices in the future (Tintori & Palomba, 2017). Further, positive or negative experiences at school might be because of interesting or uninteresting content (Kerkhoven et al., 2016) or effective or poor teaching (Tintori & Palomba, 2017). For instance, Calabrese Barton et al. (2013) investigated that the girls from low social class raised aspirations to attend science-related professions only if they engaged in science education where their identity work was acknowledged. Previous research has also indicated that university students also have stereotypes of scientists like children's stereotypes at early ages (Finson et al., 2006) and they keep holding them unless they perceive positive impacts of the changes in stereotypes (Tintori & Palomba, 2017). Assuming the changes in stereotypes have limited success (Master et al., 2016), we can assert that it can take a long time to reach an inclusive representation of scientists (Wood et al., 2020). To make it happen, it is valuable to exclusively highlight stereotypes of scientists by offering expanded learning opportunities through which students can understand not only who scientists have been, but also who can become scientists (Carrier et al., 2020).

Personal constructs theory and repertory grid technique

According to Kelly (1963), individuals have some assumptions in the process of making sense of the world. The basic units of these assumptions are called "personal constructs" that provide a unique "model of reality" for the individual (p. 50). Each experience can be filtered through personal constructs. Through time and experience, individuals can obtain new constructs and they can change the existing ones. As a result, everyone holds a complex and unique set of constructs to understand and interpret an event or a phenomenon in the world around their reality (Kelly, 1963). Notably, individuals belonging to the same cultural group are expected to "construe their experience in the same way" (Kelly, 1963, p.94) by using same or similar sets of constructs.

"Construct" is terminologically expressed as a way of seeing the aspects of the world as similar or different, i.e., bipolar (Fransella et al., 2004). Each personal construct has a dichotomous nature where it has two extremes (hard/soft, interesting/boring). Another central concept in the theory is referred to as "element" explained as "The things/events abstracted by a construct" (Kelly, 1963, p. 137). RG is always conducted about a particular topic; to elicit just those constructs that the individual uses in making sense of that experience. The elements are the "objects" or "entities" that are studied; the constructs are the "attributes" of those objects or entities. (Kelly, 1963). When a researcher discovers an individual's constructs and their terms of reference, RG allows the researcher to identify exactly what the individual means when they use those constructs and terms. Each element is rated on each construct, to provide an exact picture of what the individual wishes to say about each element within the topic. To sum up, the elements, constructs, and ratings of elements on constructs provide us with a kind of mental map with a precise statement of how participants think of and give meaning to the topic in question (Kelly, 1963). It, therefore, can be a rich source of qualitative data in such a way that people are allowed to express things in their language. Since RG also uses rating scales, both qualitative and quantitative data can be obtained.

RGT has been widely considered as the most effective way of deriving deeper understanding that predesigned questionnaires and surveys are unlikely to uncover; as a more reflective and sensitive tool in providing many kinds of information; and as a reliable and valid way to elicit actual perceptions in many aspects of education (Cohen et al., 2018). Although RGT has been used in the field of education for various reasons, so far this instrument has not been applied to elicit PST's mental constructs regarding scientists (Oberg, 1987). Diamond (1988) suggests that "the grids proved a useful, speculative tool which reflected the teachers their changing views of themselves and teaching as seen through their own eyes" (p. 176). Given the advantages of the RGT over other data collection tools, it was therefore decided for the present research to utilize it to fulfill the aim of the study. Manuals for the RGT (Fransella et al., 2004) offer diverse models of application.

Method

Design

This phenomenographic study aimed at examining PST's stereotypes about scientists through RGT, not only offering rich and contextual descriptions of their perceptions but enabling them to unpack a holistic understanding of “different patterns of awareness and non-awareness of parts” (Åkerlind, 2018, p. 3). In that case, this can allow the sources of misconceptions to be revealed more easily (Newton & Martin, 2013). It is critical to discuss here the relationship between the RGT and the phenomenographic research approach to analyzing PST’ conceptualizations about scientists. The phenomenograhic study was mostly qualitative in nature, seeking input from the PSTs without predetermined notions of the expected responses and how these conceptualizations are perceived and differentiated across the group of PSTs depending on gender and age differences (Åkerlind, 2018). Through RGT, PSTs’ conceptualizations are derived without disappearing personal meanings by preserving their own words, reflecting their own expressions of their thoughts and understandings about scientists (Marton, 1986). To do that, the phenomenographic research provided us with a theoretical framework aligned with the interpretivist paradigm aiming to investigate “the qualitatively different ways in which people (PSTs) experience, conceptualize, perceive, and understand various aspects of phenomena (scientists) in the world around them” (Marton, 1986, p.31). The approach to conducting this research takes into consideration its culturally-situated nature since it specifically suggests that PSTs’ stereotypes can be influenced by the personal, social and cultural contexts in which it occurs (Richardson, 1999). Indeed, PTSs were asked to express how they described scientists so that we could explore the source of misunderstanding following the procedure as in Han and Ellis (2019) describe in “analyzing phenomenographic data” (p. 6). Within this in mind, in this study, we intentionally did not ask directly about stereotypes of scientists because especially implicit stereotypes about scientists can be hard to discover in the case of that the respondents are not consciously aware of that they have such stereotypes (Nosek & Smyth, 2011). Instead, we asked students to give us their perceptions of scientists through the association between widely known scientists and the bipolar constructs elicited.

Participants

The present study was conducted at a faculty of education in a north-western city in Türkiye. 119 early childhood PST agreed to participate in the study, approved by the human-subjects research board at the university. This phenomenographic research adopted purposeful sampling, through which the participants were selected based on the criterion of whether they have experienced the phenomenon of scientists under investigation (Han & Ellis, 2019). The number of participants was sufficiently large for variations to be revealed within the time constraints (Han & Ellis, 2019), and deemed adequate to achieve data saturation for generating various PST’s stereotypes of scientists as the minimum of 15–25 interviewees is often considered sufficient (Ginsberg, 1989). The mean score of the participants’ ages was calculated as 23.21 ($SD=2.02$). Most of the participants ($n=91$, %77.1) were female and the rest of them ($n=27$, %22.9) were male. Half of the participants were juniors, and the other half were sophomore students, mostly from the lower socioeconomic level regarding their parents’ educational attainment. The mean score of participants’ Grade Points Average (GPA) was 2.94 ($SD=0.23$).

Site of the study

Early childhood teacher education in Türkiye requires a four-year bachelor’s education at a university. The content and scope of the courses to be included in the nationwide early childhood teacher education curriculum is recently shaped by the Higher Education Council (2018). Although there are various courses addressing the developmental areas of children, there is only one elective course named “Teaching Science in Early Childhood” offered in the second year, covering the topics that lay the foundation for the development of scientific concepts and how to teach these concepts in early childhood classrooms. Although only half of the senior students ($n=24$, 41%) took the elective course, all participants were supposed to attend mandatory science education in primary and elementary schools including scientific knowledge in astronomy, biology, physics, chemistry, and earth science.

Data collection instrument

We focused on representing more accurately how PST perceived scientists by RG as a means of data collection. RG is simply a way of interviewing in a highly structured manner, using participants’ word labels and setting out their responses in the form of a grid (Kelly, 1963), with four components: topic (scientists), elements (e.g., whom do you call scientists?), constructs (e.g., how do you describe scientists?), and ratings (how much do you associate each scientist with each construct?). A blank grid sheet with the topic in the top left-hand corner, the elements along the diagonal lines at the top, the constructs along the left-hand and right-hand sides, and the ratings inside the grid, also row by row, construct by construct were provided for each participant (See Fig. 1).

Data collection procedures

RG interviews were taken place in a quiet room with an uninterrupted atmosphere from September through December 2021. The purpose of the study and the research process were presented to get the full consent of the participants freely volunteer to take part or to withdraw at any time. The state of confidentiality and

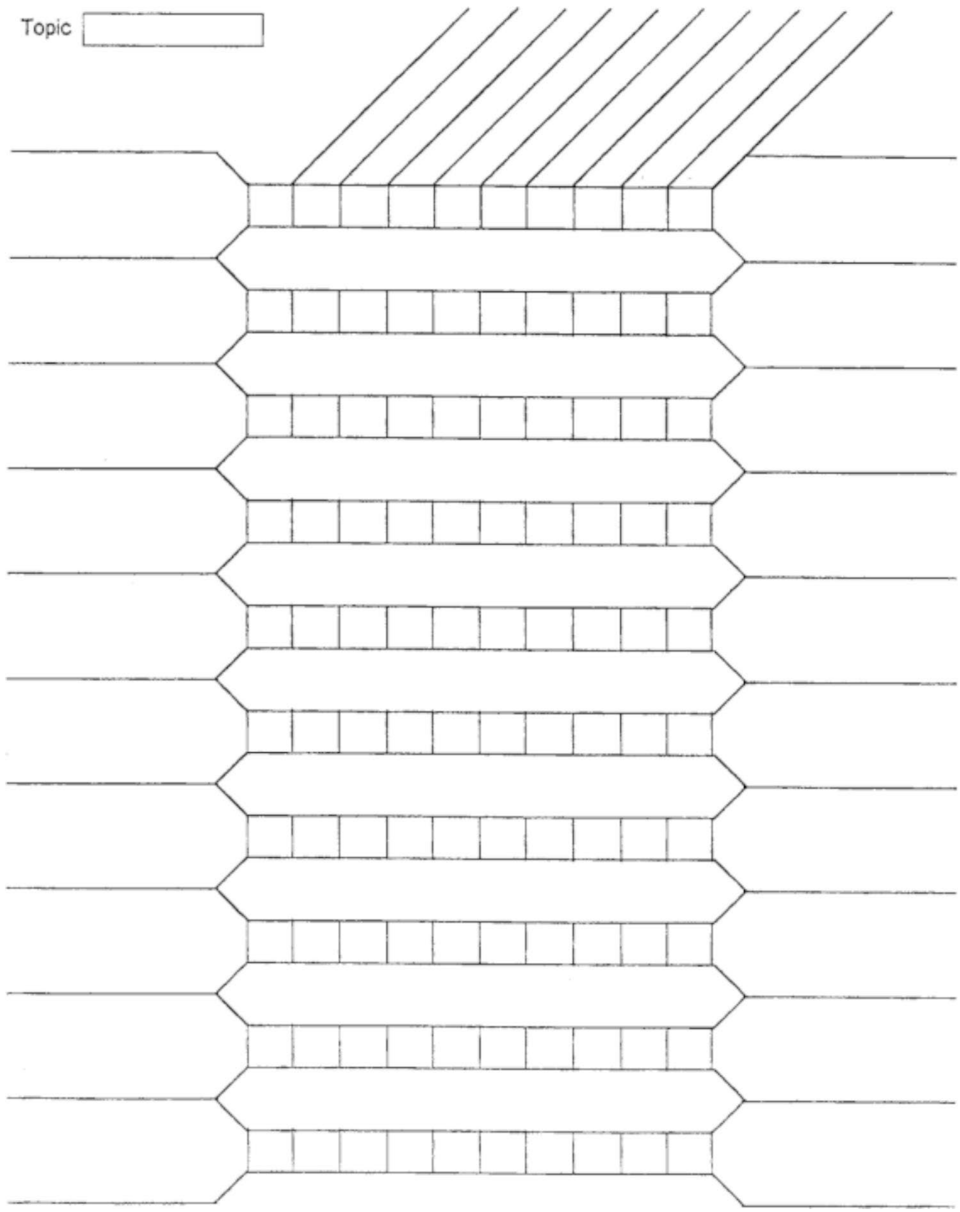

Fig. 1 A blank RG sheet as the data collection tool

anonymity of the participants and the use of data for only scientific purposes were ensured. The participants were invited to a session in which interviews were conducted by the following steps.

Elements identification

At the beginning of the session, RG was introduced and explained how to fill it to each participant. In this study, elements (scientists) were kept constant to make any meaningful comparison between elicited bipolar constructs (Jankowicz, 2004). The participants were provided a set of cards including the names and photographs of 12 widely known scientists from different majors with various backgrounds (gender and ethnicity) as seen in Fig. 2. The set of scientists were identified based on three criteria: (a) the ones predominantly mentioned in the previous studies on stereotypes of scientists (Dikmenli, 2010; Schinske et al., 2015), (b) the ones whom the participants were familiar with from their departments, (c) the ones commonly recognized by the mass-media. As with supplying elements, we intended to reduce the cognitive load on the participants in the RG process (Faccio et al., 2012). Collectively, Caucasian male scientists were detected as the most common stereotypes of scientists in the literature. Another main characteristic of stereotypes of scientists has been found that these scientists have two different disciplinary specializations: hard sciences and social sciences. In considering hard science disciplines,

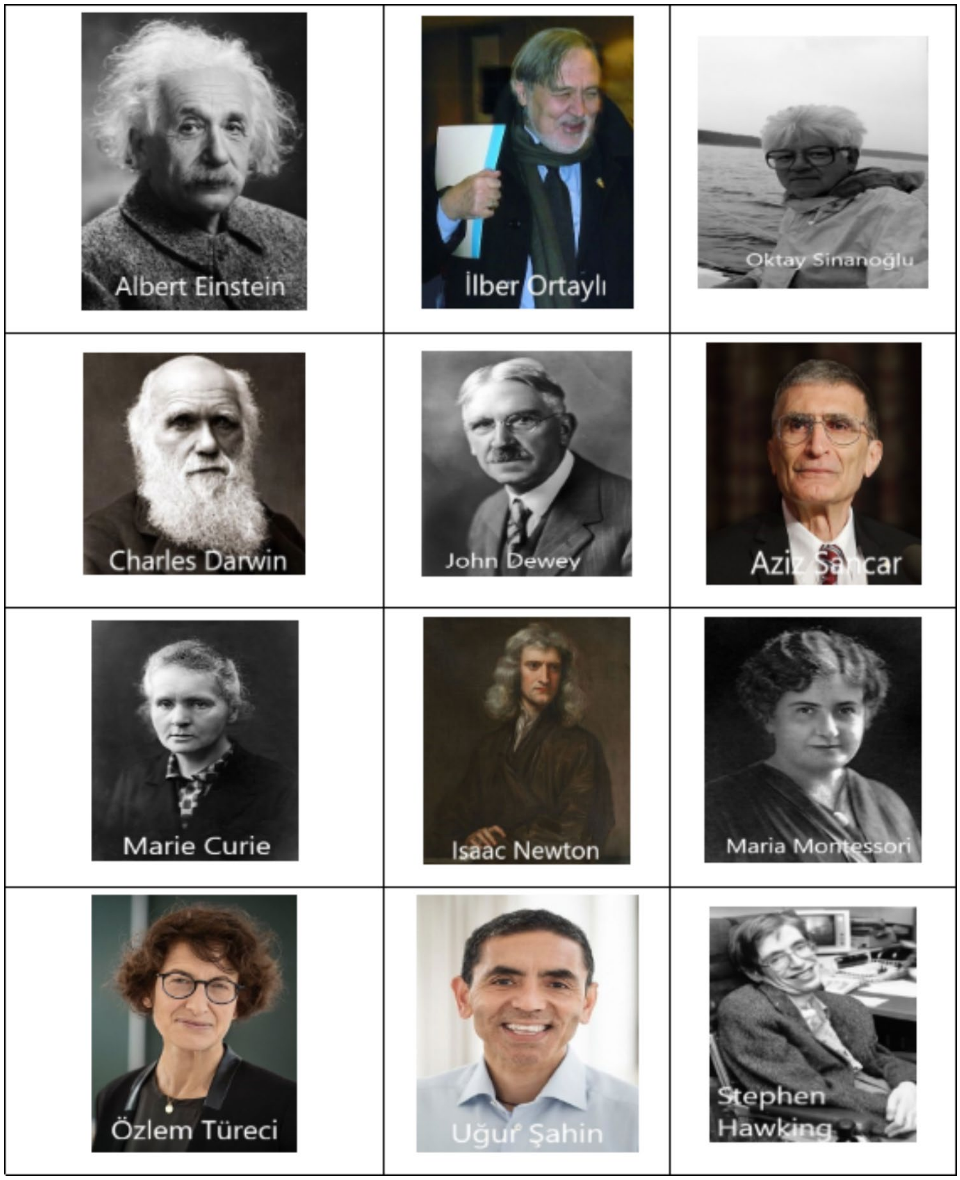

Fig. 2 Photographs adopted as the elements of RG interviews

Uğur Şahin (Turkish Physician and Co-founder of BioNTech - COVID 19 vaccine-), Einstein (German-born Theoretical Physicist), Aziz Sancar (Turkish Molecular Biologist, 2015 Nobel Prize Winner), Oktay Sinanoğlu (Turkish Physical Chemist, Two-time Nominee for the Nobel Prize in Chemistry), Isaac Newton (English Mathematician and Physicist), Stephen Hawking (English Theoretical Physicist, having a biographical 2014 film - The Theory of Everything), Özlem Türeci (Turkish Physician and Co-founder of BioNTech - COVID 19 vaccine-), and Charles Darwin (English biologist, widely known for his contributions to Evolutionary Biology) are well-known laboratory-based natural scientists (physics, genetics, biochemistry, molecular biology, and medicine). It is also worth noting that while Maria Montessori is a female physician and an educator in the field of early childhood education, John Dewey is primarily a theorist in the field of education, and İlber Ortaylı is a well-known historian, all of whom are social scientists. These 12 scientists were introduced briefly and provided what contributions they made to science shortly at the beginning of each interview. The visual images of scientists as illustrated in Fig. 2 were preferred to facilitate a "*triadic presentation*" to the PSTs (Gains, 1994) in the case that they were not familiar with or did not recall the scientists listed immediately. Here, the use of visual images is suggested as an established approach in previous studies focusing on the stereotypes of scientists (Thompson et al., 2019) to relate the participants' conceptualizations of the phenomenon in the context of interest as Kelly (1963) described.

Constructs elicitation

As a further step, the interview continued with the construct elicitation stage, also referred to as "*triadic comparison*" (Adams-Webber, 1996; Bell, 1990). For this stage, the participants were asked to randomly select three cards from the pile, to pair up two of these cards that had something in common, distinguishing them from the third card, and to answer the following questions: Which two of these were similar in some way and different from the third? What did the two have in common, as opposed to the third? How did you compare them with your ideal scientist? How do you mean or in what way?

Asking prompting questions is called "*laddering*" (Reynolds & Gutman, 2001), in which the meanings of different constructs and their hierarchical relationships are explored (Rugg et al., 2002). For instance, the construct of "objective – subjective" was mutually opposite and embodied one construct, but the construct of "objective – biased" could be a mix of two constructs: "objective – subjective" and "unbiased – biased". Through the laddering technique, the participants were probed and asked for clarification as appropriate, giving the researchers an insight into ambiguous constructs (Reynolds & Gutman, 2001). To elicit further deeper constructs, the participants were provided with the cards twice and in different orders, called "an incomplete Williams Latin Square" order (Jaeger et al., 2005, p.482). The sorting process was repeated until the participants could no longer think of meaningful differences or similarities among the elements (scientists). All elicited bipolar constructs were manually recorded verbatim on pre-printed grid sheets and comments were written down to form a matrix in which the thing the two elements had in common was written in the first row on the left side of the grid sheet, and the converse of this was written in the same row on the right of the grid sheet. 10 to 12 bipolar constructs were obtained from each participant, an acceptable number for further analysis (Fransella et al., 2004).

Association between elements and constructs

In this final stage, the participants were asked to rate each element (scientists) in the grid on a scale of 1–5 (*1 = the construct is not associated with the element at all, 5 = the construct is highly associated with the element*). A rating of "5" represents that the elements are judged to be fully in agreement with the left pole of the bi-polar construct; a rating of "1" represents that the elements are best explained by the right pole. The same process of "An incomplete Williams Latin Square" order was followed when the participants rated the elements on each construct. At the end of the interview, an RG sheet was shown to the participants to check whether what was being said was precisely written or if there was anything to add (Hunter, 1997). In this stage, ratings, constructs, or elements could be revised until the RG accurately represented the participants' perceptions of scientists. The interview lasted on average about one and a half hours. A sample of RG is presented in Fig. 3.

Data analysis

The main aim of the data analysis was to elucidate the relationships existing among the scientists and the stereotypes in the overall construct system elicited by using the RGT (Adams-Webber, 1996). To fulfill this aim, RGs were open to different types of data analysis as specified in the following sections.

Content analysis

Personal constructs (stereotypes) were first submitted to content analysis. The amount of data was generated from each participant via the 12×5 matrix grids. 119 face-to-face in-depth RG interviews produced 66 bi-polar stereotypes. A data reduction method was employed to categorize similar stereotypes, in which the original 66 elicited bipolar constructs were reduced into 28 aggregated bipolar construct groupings. For instance, "socially beneficial- individually beneficial" and "caring about society-caring about personal interest" have similar meanings, which were aggregated under the construct grouping of "serving the common good-individualist".

After aggregation, the "core categorization procedure" was followed as suggested by Jankowicz (2004) to obtain a series of categories into which stereotypes fell and then to assign them to the categories, to define one or more common lists of them or to uncover common trends among the participants (Bezzi, 1996). This process involved iterative coding to check that the newly identified codes were

(+)	Scientists												(-)
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	
Reliable	1	3Δ	2	6Δ	5Δ	6Δ	3Δ	4Δ	4Δ	3Δ	3	5Δ	**Unreliable**
Experimentalist	1	5Δ	1	5Δ	4Δ	5Δ	1Δ	3Δ	5Δ	5Δ	1	5Δ	**Ordinary people**
Hardworking	3	5Δ	4	6Δ	6Δ	6Δ	5Δ	5Δ	5Δ	5Δ	4	5Δ	**Lazy**

Fig. 3 A sample of a repertory grid

not missed in the earlier coding rounds. For this analysis, the bipolar stereotypes were considered the base unit of analysis. After getting familiar with the data, we worked collaboratively coding the same set of 5 RGs until an agreement was reached on a coding frame and the units were then sorted by codes. Further consideration was required to combine some of the codes to create broader categories of stereotypes. And then, we worked independently while labeling the categories to ensure they came up with the same labels. If not, we worked together until we reached an agreement on labeling the categories. Then, the frequencies of the stereotypes were counted in each category for further analysis.

Specifically, for the analysis of stereotypes, given the importance of retaining their bipolar nature (Burr et al., 2022), all were assigned to four bipolar categories. In this regard, a hybrid approach was used in which the categories utilized in the content analysis of the constructs were both theory and data-driven (Green, 2004). Accordingly, two categories of "scientific integrity vs misconduct" and "recognition vs disregarded" were derived from the RG data inductively. Further, we also adopted a two bipolar taxonomy for coding and analysis of the constructs ("communal vs dissociation and "agentic vs passivity"), initially developed by Wiggin (1981), and applied by Carli et al. (2016) for exploring individuals' stereotypes about scientists and was refined to best represent the current data.

Descriptive statistics

All aggregated bipolar stereotypes ($n=28$) were recorded in standard form as an SPSS file. The file included a field identifying each grid and the number repeated for each row of the grid referring to the same stereotypes. Subsequently, each column corresponded to the ratings for scientists, and each row corresponds to the ratings for a given bipolar stereotypes. Then, every participant was scored on their personal list with the help of this file. Further, to obtain information about a range of convenience between each scientist with two poles, this analysis also involved a simple counting of the number of times particular stereotypes were mentioned and the percentage of the participants who mentioned at least one stereotype in the category to provide an approximate indication of the importance of each one (Janckowicz, 2004).

Visual cognitive maps

Given the nature of RGT, we were able to produce levels of analysis statistically rigorous while simultaneously producing visual cognitive maps (principal component analysis) and Focus Tree Diagrams (cluster analysis) (Fransella et al., 2004; Jankowicz, 2004). After the stereotypes were elicited and the scientists were rated, RGs were analyzed using various statistical data reduction techniques by using WebGrid Plus software, initially developed by Gaines and Shaw & Gaines (1998) and publicly available worldwide (See WebGrid Plus (uvic.ca).

Explorative statistics

For further analysis, ordinal data (the frequencies of constructs per RG in each category) were converted to nominal data (whether each RG involved the construct in each category or not). And then, Chi-square tests were used to compare nominal data based on gender and grades of the participants.

Ensuring the trustworthiness of the study

Several procedures were used to ensure the trustworthiness of the study. The percentage of agreement across the researchers, referring to inter-coder reliability, was measured to ensure the reliability of the findings (O'Connor & Joffe, 2020). In calculating inter-coder reliability, we independently analyzed the same randomly selected 30 RGs (25% of the entire data set), acceptable for ensuring the representativeness of the entire data (O'Connor & Joffe, 2020). After coding the sample of the data set, Cronbach's alpha reliability was conducted on the coding by RGs. For that purpose, the coded data was exported from Excel into SPSS and then generated an SPSS file to present each data unit as a row and each code as a column. If a code was applied to a data unit, then the relevant cell showed 1; if that code was not applied, then the cell recorded 0. A high percentage of agreement was obtained through inter-coder reliability analysis using Cronbach's alpha coefficients across four categories ($a>0.89$). In addition, the structure of stereotypes of scientists was shown to each participant so that they could reflect on their thinking and understanding (Collier-Reed et al., 2009) since in the phenomenographic study, individuals' ways of experiencing the phenomenon can even change during the interview due to its nature of context-sensitivity (Akerlind, 2018). Further, to allow the results of this research to be transferred to other contexts, the study used thorough descriptions of the research setting, the participants, and the data collection and analysis procedures (Lincoln & Guba, 1990).

Results

Descriptive statistics in Table 1 showed where each scientist was located on average across stereotypes of scientists and how each scientist varied across the stereotypes. The mean scores of the "Ugur Sahin" ($M=4.76$, $SD=0.60$) and "Einstein" ($M=4.84$, $SD=0.14$) were the most reflecting the participants' perceptions of the "Ideal scientist" in all ways. It was also apparent that "Maria Montessori" ($M=2.32$, $SD=0.87$), "Marie Currie" ($M=3.34$, $SD=0.40$) and "Özlem Türeci" ($M=2.72$, $SD=0.42$) had lowest values of the mean scores among other scientists. Although

Table 1 Descriptive statistics for scientists

Elements	*Min*	*Max*	*M**	*SD*
Albert Einstein	4.00	5.00	4.84	0.14
Uğur Şahin	4.00	5.00	4.76	0.60
Aziz Sancar	4.00	5.00	4.56	0.70
Isaac Newton	4.00	5.00	4.30	0.49
Stephen Hawking	3.00	5.00	4.24	0.56
Oktay Sinanoğlu	2.00	5.00	3.56	0.72
Marie Currie	3.00	5.00	3.34	0.40
Charles Darwin	2.00	5.00	3.26	0.78
John Dewey	2.00	5.00	2.96	0.92
Özlem Türeci	2.00	5.00	2.72	0.42
Maria Montessori	2.00	5.00	2.32	0.87
İlber Ortaylı	1.00	5.00	2.02	0.46

**It represents the average importance score for each scientist*

the participants viewed them as scientists, they were located the furthest from the "Ideal scientist" compared to others.

As a tree diagram, in Fig. 4, a sample RG visually portrayed the possible relationships between the scientists and between the stereotypes of scientists. By glancing at this figure, three main groups of closely correlated elements: (1) "Aziz Sancar", "Newton" and "Einstein"; (2) "Ugur Sahin", "Özlem Türeci", "Marie Curie", "Darwin", "Hawking", and "Oktay Sinanoglu"; and (3) "Montessori", "Dewey" and "İlber Ortaylı". The first and second groups of scientists also formed a cluster that were more like each other than they were the third group scientists.

To represent relationships among the constructs and the elements spatially, principal components analysis (PCA) (Bell, 1990) was conducted by using WebGrid Plus. The spatial distance between and among the elements and the constructs suggested how they might be related to each other (Easterby-Smith et al., 1996). For instance, it could be observed from the Fig. 5 that the general cluster of scientists in the field of natural sciences (e.g., Hawking, Oktay Sinanoglu, and Aziz Sancar) was spatially closest to the constructs that effectively describe them as brainy beings displaying a keen sense of curiosity and persistence in their pursuit of experimenting. On the other hand, it could be easily noticed that "Montessori", "İlber Ortaylı" and "Dewey" were viewed in a different cluster and distant from these constructs mostly associated with characteristics of any type of person.

Another important finding was that "Einstein", was the most widely dispersed on the construct of "experimentalist-ordinary people" (M=4.93, SD=1.97) and the least dispersed on the construct of "cold-friendly" (M=4.67, SD=1.62). "Newton" was the most widely dispersed on the construct of "reliable-unreliable" (M=4.17, SD=1.95) and the least dispersed on the construct of "contemporary-former" (M=4.02, SD=1.54). "Aziz Sancar" was the most widely dispersed on the construct of "Trusting-Mistrusting" (M=4.32, SD=1.79) and the least dispersed on the construct of "gifted-normal" (M=4.16, SD=1.25). "Charles Darwin" was the most widely dispersed on the construct of "arrogant-humble" (M=3.18, SD=1.74) and the least dispersed on the construct of "ethical-unethical" (M=2.31, SD=1.26). "Ugur Sahin" was the most widely dispersed on the construct of "serving the good-individualist" (M=4.80, SD=1.64) and the least dispersed on the construct of "impersonal – emotional" (M=4.49, SD=1.40). "Özlem Türeci" was the most widely dispersed on the construct of "persistent-quitter" (M=2.76, SD=1.65) and the least dispersed on the construct of "popular-unknown" (M=2.09, SD=1.53). "Marie Curie" was the most widely dispersed on the construct of "hardworking-lazy" (M=3.46, SD=1.63) and the least dispersed on the construct of "independent-dependent" (M=3.13, SD=1.24). "Stephen Hawking" was the most widely dispersed on the construct of "masters of subjects-layman" (M=4.46, SD=1.13) and the least dispersed on the construct of "detailed-hasty" (M=4.13, SD=1.14). "Oktay Sinanoglu" was the most widely dispersed on the construct of "free from bias-biased" (M=3.76, SD=1.21) and the least dispersed on the construct of "brave-lack of courage" (M=3.24, SD=1.20). "Montessori" was the most widely dispersed on the construct of "credible-incredible" (M=2.76, SD=1.30) and the least dispersed on the construct of "brave-lack of courage" (M=2.24, SD=1.07). "Dewey" was the most widely dispersed on the construct of "curious-lack of curious" (M=3.06, SD=1.64) and the least dispersed on the construct of "competitive-collaborative" (M=2.44, SD=1.20). "İlber Ortaylı" was the most widely dispersed on the construct of "strong intellectual interests - lack of intellectual interests" (M=2.06, SD=1.03) and the least dispersed on the construct of "respected-no name" (M=2.24, SD=1.04).

Of the total aggregated 28, 13 stereotypes were the most frequently mentioned more than 10 times (e.g., "experimentalist-ordinary", "gifted-normal", "hardworking-lazy", "serving the common good- individualist"). More systematically, we represented the relationships among the stereotypes of scientists as a result of the "core categorization procedure", they fell into four categories: (1) Recognition vs. Disregarded, (2) Scientific Integrity vs. Misconduct, (3) Communal vs. Dissociation, and (4) Agentic vs. Passivity.

Recognition vs. Disregarded This category consisted of a list of stereotypes, representing how scientists received the recognition they deserved. A specific generation-based stereotype, "contemporary vs. former" was also revealed in this category. A lack of recognition means that although some scientists made crucial discoveries, they were still disregarded by the community.

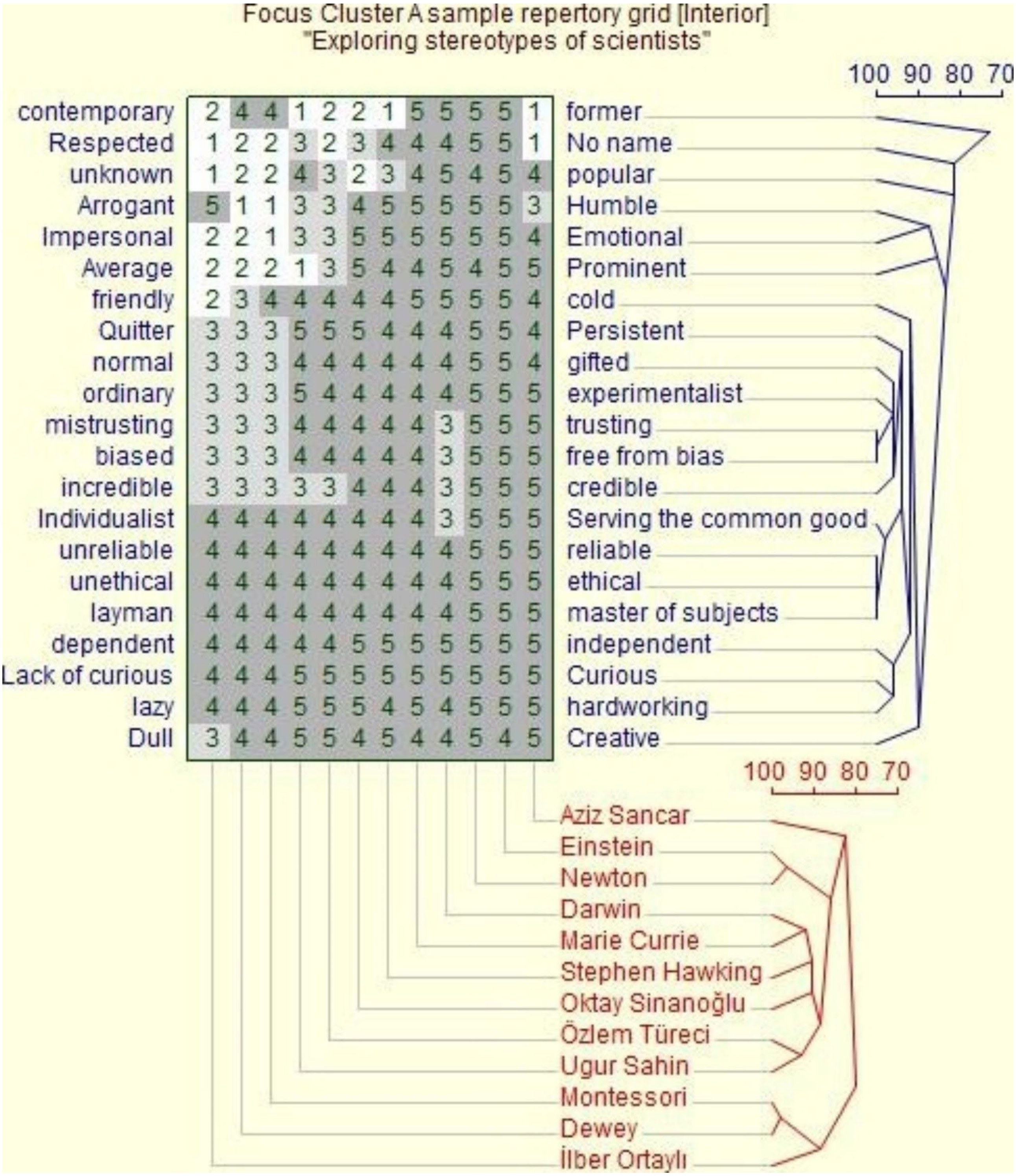

Fig. 4 A tree diagram of the scientists and the stereotypes of scientists

Scientific integrity vs. misconduct This category involved a list of stereotypes, indicating how scientists were committed to sound scientific practices. Scientists held some standard of ethics, integrity, and honesty. For a scientist, scientific integrity was a condition ensuring objectivity, clarity, and reproducibility, and provided insulation from any bias. Noteworthy was that this competence-related category referred to the attributes that participants believed characterized a scientist. A lack of scientific integrity referring to misconduct manifested itself as, the

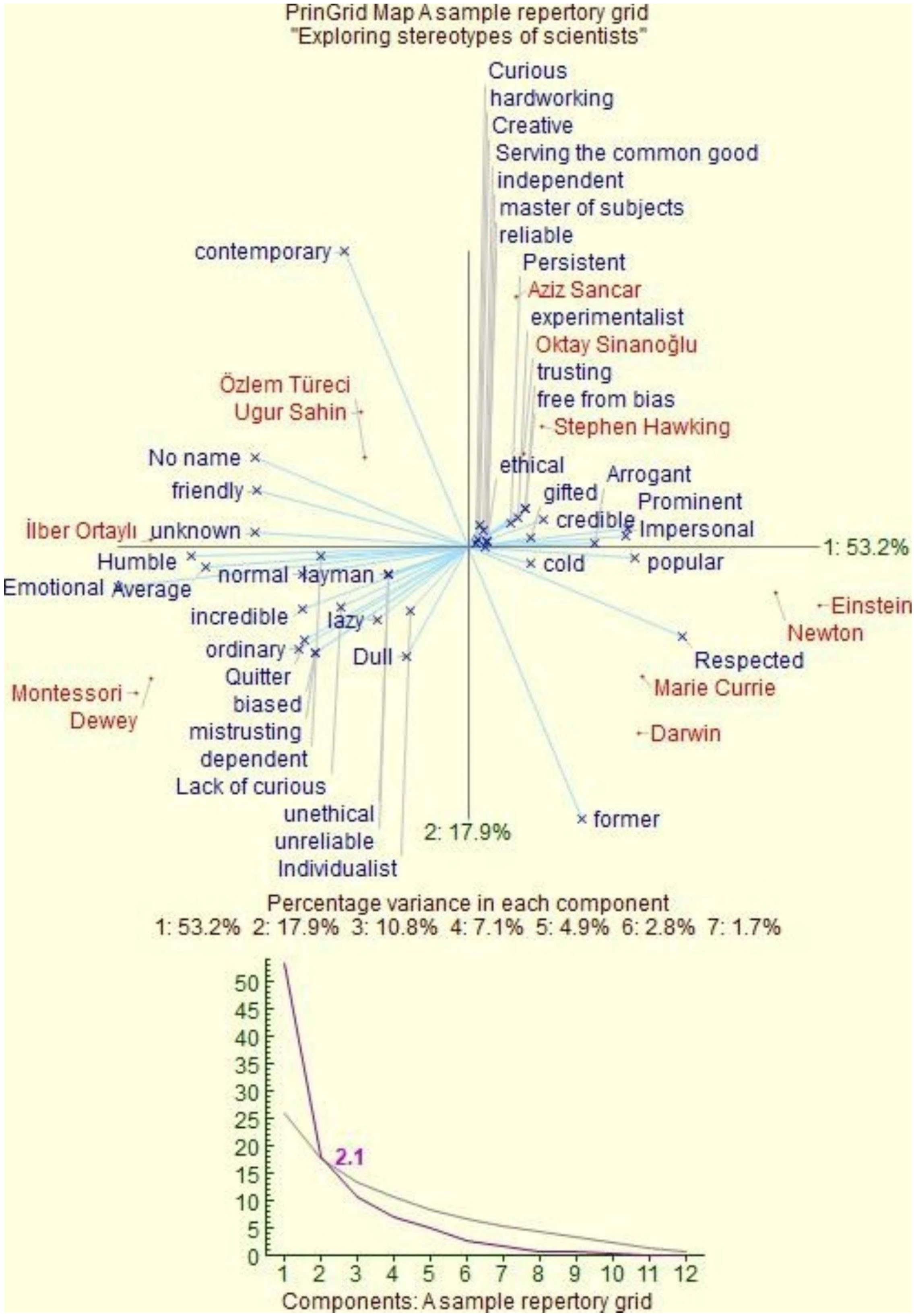

Fig. 5 Principal component analysis results and factor loadings

Table 2 Stereotypes of Scientists Elicited from RG Interviews (n = 119)

Core Category	Bipolar constructs	*M*	*SD*	*f*	%
Scientific Integrity vs. Misconduct	Ethical-Unethical	4.92	1.16	5	4.20
	Credible-Incredible			4	3.36
	Reliable-Unreliable			6	5.04
	Free from bias-Biased			12	10.08
	Trusting-Mistrusting			7	5.88
	Independent-Dependent			3	2.52
	Experimentalist-Ordinary			54	45.38
Recognition vs. Disregarded	Popular-Unknown	4.81	1.13	12	10.08
	Respected-No-name			8	6.72
	Contemporary-Former			6	5.04
	Prominent-Average			14	11.76
Communal vs. Dissociation	Cold-Friendly	3.85	1.24	13	10.92
	Caring-Careless			11	10.04
	Working to live - Living to work			24	20.17
	Serving the common good-Individualist			31	26.05
	Emotional- Impersonal			4	3.36
	Collaborative- Competitive			6	5.04
Agentic vs. Passivity	Persistent-Quitter	4.03	1.17	7	14.29
	Hardworking-Lazy			48	40.34
	Detailed-Hasty			23	19.33
	Analytic-Intuitive			3	2.52
	Curious-Lack of curious			8	8.40
	Brave-Lack of courage			3	2.52
	Creative-Dull			4	3.36
	Arrogant-Humble			7	5.88
	Gifted-Normal			19	24.37
	Strong intellectual interests - Lack of intellectual interests			4	9.24
	Master of subjects- Layman			5	7.56

violation of the accepted standards of scientific research and publication ethics.

Communal vs. dissociation This category involved a list of stereotypes, indicating how communal scientists were. "Communion" referred to a scientist being a part of a community, establishing interpersonal relationships with community members, and giving importance to the common good rather than individual gains. Communal individuals were usually caring, friendly, emotional, and collaborative. A lack of communion referring to dissociation manifested itself in, for instance, coldness, selfishness, and individualism.

Agentic vs. passivity This category was representing a list of stereotypes, indicating how agentic scientists were. "Agency" refers to scientists being creative, independent, competent, competitive, hardworking, and analytic. Agentic scientists were persistent and aspiring to achieve their goals. This category covered what investigative and realistic characteristics were important for judging scientists. At high levels, agentic scientists could be arrogant. A lack of agency referring to passivity manifested itself in, for instance, laziness, lack of courage, and hasty.

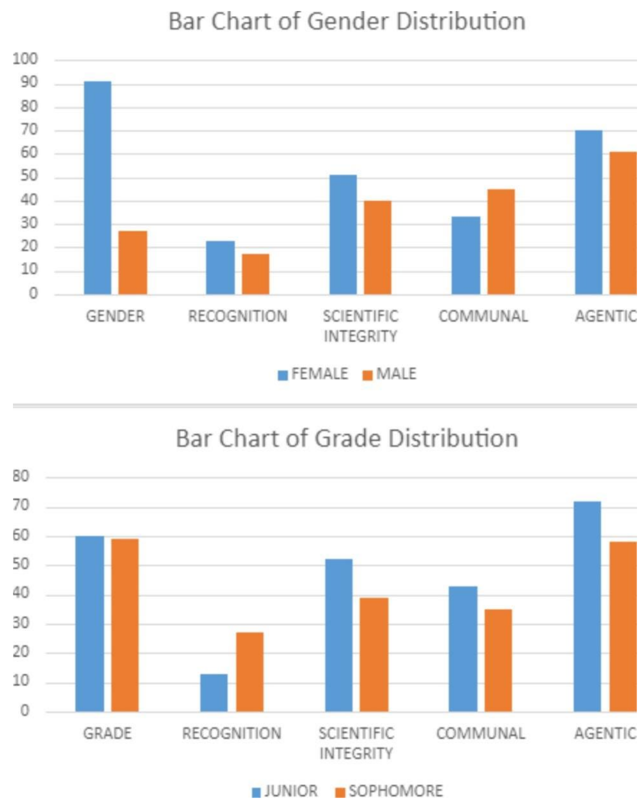

Fig. 6 Bar charts of gender and grade distributions in each stereotype of scientists category

The descriptive statistics of PST's stereotypes of scientists along with each core category were calculated as displayed in the following Table 2. It should be noted that scientists would be perceived as highest in scientific integrity characteristics (e.g., experimentalist and reliable); lower in communal-dissociation characteristics (e.g., caring and collaborative); lower in agentic-related characteristics (e.g., analytic and brave); and lowest recognition-disregarded characteristics (e.g., gifted and respected).

The Fig. 6 emphasized the differences within four different categories of stereotypes of scientists regarding participants' grades and gender. It should be noticed that there was an approximately equal number of juniors and sophomores in each stereotype category, and an approximately equal number of males and females in each category. Accordingly, there was no association between gender and stereotypes of scientists ($X^2(3)>=1.101$, $p=0.121$), and no significant association was found between grades and stereotypes of scientists ($X^2(3)>=3.171$, $p=0.205$).

Discussion

This paper gives an account of early childhood PST's stereotypical perceptions of scientists. Accordingly, PST held common stereotypes, mostly associated with competency-based, investigative and realistic attributes of scientists such as experimentalist, hardworking, gifted, analytic, etc., consistent with the previous research (Millford & Tippet, 2013; Turgut et al., 2016). A possible explanation might be that PST had limited understandings of scientific inquiry described as experiments in a laboratory, and through which well-known laboratory-based scientists do "hard sciences" including observing, questioning, generating and testing a hypothesis, and investigating new things (Ramirez & Cayón-Peña, 2017). In considering hard sciences, Einstein, Ugur Sahin, and Aziz Sancar were predominantly recognized as idealist scientists. This reflects the overwhelming representation of men doing experiments as scientists, and there was too little recognition of social sciences and women scientists. Although several successful and well-known women scientists and social scientists were included in the list of scientists, the participants did not perceive women as a good "fit" and did not consider social scientists as an ideal representative of scientists. In relation to this finding, men scientists in natural sciences were mostly considered as agentic but less communal, whereas women scientists and social scientists regardless their gender usually associated with communal traits rather than agentic ones. These cultural stereotypes between specific traits associated with scientists in terms of gender and field could be explained by the fact that this makes it less likely that PST would have concrete examples to shape their views of women and social scientists (Carli et al., 2016; Miele, 2014). Accordingly, although this study did not directly find any result related to gender bias in the science field, this still might contribute to the underrepresentation of women and social sciences even though there is much good news about the improved status of women in science recently (Meyer et al., 2019), and even though earlier research has shown that there is not any gender bias in the scientific attributes of men and women (Sharma & Honan, 2020).

Not surprisingly, cultural influences were also revealed in our study. PST had a different concept of idealist scientists as Aziz Sancar, Oktay Sinanoglu, and Ugur Sahin, given a considerable emphasis on Turkish culture. The reasons why they held certain stereotypes might be that their perceptions of scientists might be associated with their self-images and self-concepts (Thomas, 2017). Because of the positions of these scientists in our society, PST's perceptions of what it takes to be successful in science were also especially relevant to culturally specific traits. Additional evidence concerning a link between stereotypes and culturally specific traits such as ethnicity, and religion were provided, however, it may differ among different cultural contexts (Hamilton & Sherman, 1996).

Notably, the results also provided empirical evidence that scientific integrity traits were considered the most important for being scientists than other traits in other categories of recognition, communal and agentic traits. This might be explained by the fact that having scientific integrity traits could be viewed as essential for the activities involved in science, where being objective, precise and honest was predominantly valued by the participants. Concerning that, there seemed to be little recognition of communal attributes that scientists had (friendly, caring, emotional, and collaborative), and very few descriptions of scientists regarding agentic attributes were elicited (brave, competitive, and intellectual). Still, this further supported the idea that the PST had a humanistic view of a scientist, appreciating their human attributes in addition to their work-related characteristics (Andersen et al., 2014; Wyer et al., 2010).

Still, regardless of why scientific integrity traits were associated with being an idealist scientist especially more than communal traits, we can imply that this association did not encourage the idea that communal traits were also important in doing science. Further, what scientists do was perceived as a solitary activity with several stereotypical attributes of serving the common good, independent, persistent, credible, and trusting. This can imply that PST regarded science as a social enterprise or as a form of human activity with their obsession over issues consuming most of their attention rather than having interpersonal skills (Kaya, 2012). Concerning that, PST also thought that scientists were competitive so that they worked as lone wolves (Cakmakci et al., 2011).

Moreover, the responses of PST in different grades regardless of their gender were relatively similar, even though their educational and personal experiences might be different. Concerning grade differences, this finding remarkably contradicted the previous study findings suggesting that the more students have science education experiences the more students' stereotypes can reduce (Miller et al., 2018; Reinisch & Krell, 2023). Regarding gender differences, although there was a very low number of male PST compared to female ones in our study, still, an overall dominance of male scientists and the traits associated with making scientists were present, and there was no difference between PST's gender and their stereotypes of scientists. A possible explanation for these results could be that their sources of scientists' stereotypes might come from other contexts (e.g., media, TV, and books) than having formal science education experiences (Thomson et al., 2019). Another probable explanation might be that there was a lack of representatives of diversity among scientists and a diversity of practical experiences in science (Reinisch & Krell, 2023; Thomson et al.,2019), thereby, PST had a limited understanding of who scientists were and what was the nature of their work without considering their gender and grade levels.

As another remarkable finding, it was somewhat surprising that the young generation living in a digital world associated the scientists only with the discovery and producing new things and ideas, but they failed to relate technological development to the activities that scientists did. It might be difficult to explain this result, but distinguishing between science and technology might be probably a very difficult task for them (Rubin et al., 2003). Indeed, the PST lacked the commonplace understanding of science and technology and their interactions in society as foundational to the nature of science in accordance with the previous studies (Deng et al., 2011).

Conclusion

The results of this study seemed to confirm that typical stereotypes of scientists like being introverted, intelligent loners, into experiments and master in their field derived from common clichés against scientists in early childhood PST. These mostly negatively connotated stereotypes of scientists could potentially threaten effective science teaching in early childhood classes. This result is not surprising because as stressed in previous studies, what scientists do should be precise, quantifiable, predictable, certain, and value neutral. However, the issues dealt with by social scientists are generally value-laden, vague, and not necessarily to be quantified or reliably predicted. These findings might be explained by the fact that how individuals perceive science and scientist can be linked to their epistemological understandings (Thomas et al., 2001), and several characteristics of one's social environment such as gender related differences and cultural differences, widespread in a particular context (Miller et al., 2018; Thomas, 2017). These are more likely to be learned through the influence of pre-existing everyday experiences and additional resources such as mass media, textbooks and influential adults (Steinke et al., 2007).

However, changing one's epistemological understanding within a particular cultural context is not an easy task, even if educational courses are specifically aimed at achieving this goal (Roth & Lucas, 1997). Further, simply teaching science does not change one's perceptions about who scientists are and what they do (Bezzi, 1996). Accordingly, teacher education has little impact on practice, if PST are unable to implement instruction consistent with their scientific understanding. Evidently, to improve a more complete understanding of science, pre-existing cognition should be identified as an initial step for meaningful science learning and teaching (Bell et al., 1998). Consequently, using the RGT to expose stereotypes seems to be important for raising awareness to develop a more accurate understanding of scientific inquiry and how scientists do science, not just the content.

Besides the insight into PST's stereotypes of scientists, the significance of this kind of research was reflected in the idea of effective science teaching that they need to attend more to the science classroom for a non-stereotypical understanding of science and the work of scientists (Avraamidou, 2013). The analysis of the RGT undertaken here, therefore, served as a base for teacher education programs and science teaching practices.

Limitations and further studies

While the RGT is extremely useful, several limitations need to be acknowledged. At first glance, RGT seems to take time to complete for the participants and the quantity of data generated can be a significant analytical challenge for the researchers. For this current research, RGT was preferred for the researchers who found the research study was interesting and useful, and spared enough time on responding to research (Brown, 1992).

Also, although the sample size was sufficient for the use of RGT (Ginsberg, 1989), it might not be appropriate for drawing wider inferences, and might only reflect a specific cultural and social context. We did not find any significant differences in how scientists were perceived in terms of grade and gender. This could be due to the limited sample size in the diversity of gender and grade. Hence, future research needs to consider larger samples with diversity in background of PST. Notably, the data were gathered from a sample of early childhood pre-service teachers whose understanding and knowledge may not reflect those of a more diverse group another cultural context. Thus, findings from this study can only be treated with caution. Further, the scope of this study was limited in terms of its duration, the timing of the study, and the list of scientists provided for the participants.

This research has also thrown up many questions in need of further investigation exploring effective strategies to change PST's stereotypical perceptions of scientists will be undertaken. The RGT is applied to reveal PST's wide range of alternative ways of making sense of the same elements regarding scientists and illuminating the rich diversity in its construction. Various meanings of scientists elicited in this study by using the RGT confirmed Kelly's philosophical position of constructive theory and reinforce the paradigm of a constructivist perspective of science teaching and learning making noteworthy contributions to the great majority of teacher professional development research. Also, the data obtained from the RGT could be widely adopted for the item generation of a survey to investigate the stereotypical perceptions of scientists. Considering these advantages, the RGT would be a valuable method for exploratory studies.

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Authors' contributions
EY made a significant contribution to conceptualization, to analyze, interpret and validate the data. EY was a major contributor in writing the original draft, reviewing and editing. Validation. ES Data made a significant contribution to collect data, analyze, interpret and validate the data. All authors read and approved the final manuscript.

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Data Availability
Data will be made available on request.

Declarations

Competing interests
The authors declare that they have no competing interests.

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