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Advancing the use of the repertory grid technique in the built environment: A systematic review

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Since the development of personal construct theory, the repertory grid technique (RGT) has been the most recognized tool to elicit personal constructs. Although RGT was found to be a viable scientific and practical method in different fields, its utilization in the built environment has been extremely limited. Therefore, this study aimed to explore RGT as a research method and advance its use in the built environment field. Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, this study conducted a systematic review to identify studies on Scopus that have used RGT before 2021. These studies were investigated according to subject area, location, year of publication, aim, and research design. Among the 782 studies contributing to more than 24 subject areas, 30 used RGT within the built environment scope. Results indicated the validity of RGT to the built environment by exploring different ways it may be employed. This review strongly recommends advancing the use of RGT in the built environment and taking advantage of its potential.

KEYWORDS

personal construct theory, repertory grid technique, built environment, systematic review, repgrid, architecture, engineering, design

1 Introduction

In the last 2 decades with the development of the technology and science, the research about human and built environment interaction has increased and developed interestingly. The Sustainable Development Goals' (SDGs) most topics are related to the subjective human well-being (De Neve and Sachs, 2020). New fields have emerged such as neuroarchitecture by combining the architecture field with the neuroscience to understand the interaction between human and built environment by exploring the unconscious mind of people (Choo et al., 2017; Albdour et al., 2022; Lee et al., 2022). The development in bioinformatics, computer devices, virtual reality, artificial intelligence and other technologies has supported the development of research about this interaction (Karakas and Yildiz, 2020). On the other hand, from epistemological and ontological perspective, studying and understanding the human cognition and perception of the built environment is more complex than directly asking people about them or neglecting their

opinion. Therefore in psychology, Personal construct theory (PCT) is a personality and cognition theory developed in the 1950s by the American psychologist George Kelly which can deal with this cognitive complexity with its Repertory Grid Technique (RGT). It concerns the psychological reasons for actions and suggests that variations among individuals arise from the various ways in which they predict and experience events in the world around them. Kelly (2003) explained, personal constructs are tools that each person uses to gather information and evaluate and interpret it. This theory has significantly influenced the history of the human science movement of constructivism (Butt, 2008). It has been first developed to be used for medical diagnosing. Later on, it has been used to contribute in various fields. Recent examples of this use, Sewell (2020) who used the PCP to investigate the children's own view about the educational experience as a better method to collect the Voice of the Child. In contrary, Nowruzi and Amerian (2020) tried to gain insight into the teachers' grading process and factors. Winter and Reed (2021) used the PCP to understand the employees' career shock caused by COVID-19 in Serbia. Also, Kawaf and Istanbulluoglu (2019) used the PCT in marketing to investigate the relevance of online fashion shopping. Additionally, Mullineux et al. (2019) used it to understand the mechanism of experts' judgement on the re-offending likelihood. While Samonas et al. (2020) used it to investigate the understanding of different stakeholders to the security policy. Walker and Winter (2007) found that people create personal constructs of how the environment works to understand their observations and perceptions. This method has a great potential to be used in many fields because it is providing the researcher with a theoretical base to understand how people's conscious and unconscious cognition and perception are working. The potential and applicability of PCT was the use of the repertory grid technique (RGT). Kelly developed RGT as an analytical compound to manage and understand the data elicited from each individual or a group of individuals. Therefore, in this study we investigated the use of this theory in the built environment field by conducting a systematic literature review for the papers which used this method to study the human-built environment interaction.

The use of RGT is not limited to researchers and practitioners within psychology; it is rather common across different disciplines and approaches. Jankowicz (2005) provided a brief list of applications of RGT. This was also evident in several systematic and bibliographic reviews. The most recent bibliographic review of RGT in 2012 covered the scientific production with or about RGT between 1998 and 2007 (Saúl et al., 2012). It evaluated the types of documents found, the evolution of the number of publications, the fields of application, and the degree of openness to other disciplines. However, no recent systematic review has been found on the use of RGT as a scientific research method.

Meanwhile, research on the built environment shares the concerns of PCT regarding human behavior, needs, actions, interactions, experiences, and social and cultural occurrences. Psychologists argue that people's perceptions of places and their plans to respond to them are determined by how they "construe" place (Kelly, 2003). Safiullah and Sharma (2017) defined the built environment as "everything humanly made, arranged, or maintained; to fulfill human purposes (needs, wants, and values); to mediate the overall environment; and with result that affect the environmental context". As a result, each aspect of the built environment has some psychological effect, creating contact with the user and influencing cognition, which in turn shapes human behavior. The observed lack of knowledge about human behaviors, attitudes, and values is an important problem in built environment design.

PCT and repertory grids are theoretical and methodological approaches that have been successfully applied in the area of the built environment. In the 1970s, Honikman (1970; Honikman, 1972; Honikman, 1973) studied the relation between the PCT approach and built environmental evaluation. He concluded with a discussion about the potential of this approach and its possible applications in developing humans' understanding of how people use and interpret the environment. Afterward, Harrison and Sarre (1975) assessed and highlighted the effectiveness of the repertory grid in measuring urban residents' environmental images. Their findings suggested possible significant links between these images and behavior in the urban environment.

Building on Honikman's work on the potential and application of PCT in environmental evaluation, Agiel et al. (2019) adopted the personal construct methodology to assess perceptions of traditional architectural images and strengthen the field of meaning in architecture. The results demonstrated the existence of architectural "brand images," "inherent images," and "ideal images" of the built environment in the perceptions of its inhabitants. Moreover, Agiel and Kutty (2019) analyzed and evaluated the visual aesthetics of contemporary architectural images of mosque designs and the influence of emotional, symbolic, and formal building qualities applied to them based on PCT. Although RGT was found to be a viable scientific and practical method in determining the cognitive features of participants and processes and assessing individuals' response to their environment, the utilization of this technique was extremely limited.

Because RGT last underwent a bibliometric review in 2007 (Saúl et al., 2012) and because of the evident limitations of its use in the built environment, this paper aims to explore RGT as a research method and advance its use in the built environment field. This is achieved by 1) systematically mapping the use of RGT as a scientific research method in terms of subject area, location, and year of publication; 2) reporting and exploring RGT as an effective scientific research method in the built environment field, and 3) forming a theoretical framework to

help advance its use in built environment research. This study intends to answer the following questions:

1) What is the current state of scientific research on RGT as a method in terms of subject area, location, and year of publication?
2) Within the scope of the built environment, what were the research aims of the studies that have adopted RGT?
3) Within the scope of the built environment, in what way was RGT methodologically practiced in terms of research design and procedure?
4) How can researchers in the built environment field advance RGT as a research method?

Before answering the research questions, we tried to explain more about the RGT in the following section and the major terms and components of this method to make it easier for built environment researchers to understand it and be able to use it.

1.1 Repertory grid technique

Since the development of PCT, RGT has been the most recognized instrument for generating personal constructs. Originally designed by Kelly (2003), this technique was a systematic method of using his theory of personal constructs. RGT combines elements, constructs, and rating scales to create an idiographic measure of one's personality. It deals with the reduction of human thoughts into basic understandable elements while perceiving any stimuli. Unlike other research approaches, the repertory grid allows for structured conversations by assigning mathematical values to the constructs and elements associated with the issue being investigated (Fransella, 2005).

The repertory grid is a matrix that was manually constructed at its early stages and then developed into digital forms to make it more accessible and easier to use. Among these forms are DOS-based software such as CIRCUMGRIDS, GRIDSTAT, GRIDSCAL, FLEXIGRID, and OMNIGRID, which were later replaced by Windows/Web-based software including Gridcor, GridSuite, Idiogrid, OpenRepGrid, Rep Plus, rep:grid, and Sci: vesco. As continuing developing technology, there are attempts to involve the artificial intelligence (AI) in data elicitation process in the RGT (Rosenberger, 2022).

RGT is a primarily quantitative and statistical technique, but it also offers great potential for qualitative work (Fransella, 2005). Qualitative grids may contain words or pictures rather than numbers and are conceptually straightforward but rich in their ability to capture interpersonal situations. Their usefulness has been observed when working with families, teams, and other groups (Procter, 2005; Procter, 2007; Bannister and Fransella, 2019). Studies have discussed and further elaborated on these qualitative grids (Procter, 2014). However, this paper focuses on promoting the use of the original quantitative repertory grids in the field of the built environment as a method for data elicitation.

The design of a grid can be a delicate process that requires a high level of skill and understanding of the nature of research problem being studied. While it can be quite easy to design new forms of a grid, they will not yield relevant information unless their design is appropriate. Furthermore, the design of a grid must consider the manner in which it will be interpreted as well as the available analysis methods. Kelly (2003) demonstrated the utility of the repertory grid in psychological settings; meanwhile, several researchers discussed the use of RGT in other different fields (Honikman, 1970; Honikman, 1972; Honikman, 1973; Easterby-Smith, 1980; Rozenszajn and Yarden, 2015; Gardiner et al., 2021; Berghoefer and Vollrath, 2022).

This section summarizes the relevant findings on the main components of RGT and the elicitations accompanying its use. These components are as follows:

1) Elements refer to "the things or events which are abstracted by a construct" (Kelly, 2003) (p. 137); that is, they pertain to the stimuli that a research study considers significant.
2) Constructs are discriminations made between people, events, or things in life. Each construct, however, applies to a regulated number of people, events, or things (Fransella, 2005). They differ from elements in terms of their properties. They are considered bipolar dimensions that each person has created and formed into a system through which they interpret their experiences of the world (Fransella, 2005).

1.1.1 Element selection

Fransella (2005) argued that the nature of elements depends on the context being explored. Elements must be "within the range of convenience of the constructs used" and "representative of the area being investigated" (Fransella, 2005) (p. 18). They must also be discrete, evaluative (Stewart et al., 1981), homogenous, and relevant to all participants (Easterby-Smith, 1980). The selection of elements has two feasible alternatives:

1) Supplied elements, which are provided by the researcher;
2) Elicited elements, in which participants provide their own elements.

According to Reger (1990), several factors support a researcher's decision to supply elements. First, elements may be provided if a researcher's aim is to learn about a given set of elements from several participants. Second, elements may be supplied if a researcher wants an existing theory to guide the selection. Third, elements may be given if the researcher is interested in comparing the responses of different participants to a standard set of elements. Such comparison could be within a homogenous group of participants or across different ones.

Meanwhile, researchers can ask participants to elicit elements that they themselves consider relevant. Elements can be elicited in different ways (Easterby-Smith, 1980):

1) Researchers can define role or situation descriptions in which participants provide their own specific examples that fit these descriptors.
2) Researchers can define a "pool" in which participants list certain elements that fit the description, such as "name three effective and three ineffective managers."
3) Researchers can help participants elicit elements through discussions.

1.1.2 Construct elicitation

A "good" construct expresses participants' meaning precisely and completely, has a clear contrast, is detailed appropriately, and has a direct link to the research topic (Jankowicz, 2005). RGT supports several construct elicitation methods. Minor variations and combinations can be applied to some of these methods depending on the research aim (Easterby-Smith, 1980; Beail, 1985; Reger, 1990). The triadic sort method is believed to be the most convenient when exploring participants' constructs (Kelly, 2003).

1) Supplied constructs, in which the researcher provides the constructs.
2) Minimum context form (triadic sort method), in which each elicitation entails the selection of three random elements from the full set. Here, participants identify how two elements are similar yet different from the third. Researchers may provide participants with contextual cues to facilitate their attention toward a specific research problem. The researcher repeats the elicitation process until all relevant constructs are identified. Research has shown that in most domains, the required number of triads to elicit constructs from participants is usually 7–10 (Reger, 1990). Dyads can also be used if participants find it difficult to generate constructs from the triadic method or if the elements themselves are complex (Easterby-Smith, 1980).
3) Full context form, in which participants are presented with the full set of elements and are asked to sort them into an unlimited number of piles based on similarities they identify (Easterby-Smith, 1980). Afterward, participants are asked to provide short descriptive titles for each group of elements.
4) Group construct elicitation (Stewart et al., 1981), in which the researcher facilitates a group of participants involved in the research. These participants collaboratively reach an agreement on the elements of the repertory grid. The minimum context form, or any other construct elicitation method, may then be employed to elicit bipolar constructs. In this process, the researcher collects the constructs from the participants and randomly selects them. After completing this phase, the researcher assists all the participants in the group to connect elements to constructs. However, eliciting the individual grids then analyzing multiple grids to understand a group of participants' views is more supported as no biased ideas is expected as in the group discussions.
5) Laddering may be used with any of the above elicitation methods. This process allows participants to further build on the elicited constructs through a series of probing questions, such as how or what and why (Easterby-Smith, 1980).

1.1.3 Linking elements to constructs

As with all methods for eliciting personal constructs, the resulting constructs are not required to be used in some form of repertory grid (Fransella, 2005). The obtained information can be of sufficient use in itself. However, elements are linked to constructs in three ways: dichotomizing, ranking, and rating (Easterby-Smith, 1980; Tan and Hunter, 2002).

1) In dichotomizing, elements are either close to the left construct pole or the right construct pole and are labeled accordingly.
2) In ranking, elements are placed in order between two construct poles. This method allows for more discrimination and gives participants possibility to exclude elements that are not relevant to the scale.
3) In rating, participants have no reference to make discriminations between elements and exercise more freedom when sorting them might not in line with original method of Kelly. When the range of rating values is larger than the number of elements, participants' freedom is maximized. Research suggests that anything higher than a five-point scale is considered quite complex to assess visually and that seven-point scales are considered the limit for most participants. This process of evaluation, however, is advanced with the new rep:gird and no need to use values to determine differences. The system requires sorting the elements visually on a scale while the rep:grid identify statistical values based on programed algorithms.
4) No linking.

1.1.4 Sample size

The intensive nature of RGT often means the sample size is relatively small but it can be also large using the new rep:grid systems. This helps in generating quantitative data to understand a large population. However for qualitative data, a sample size of 15–25 within a population will frequently generate sufficient constructs to approximate the "Universe of meaning" regarding a given domain of discourse (Dunn, 1986; Ginsberg, 1989). That is, no new constructs are normally added despite an increase in sample size. Studies using RGT with a small sample size can develop items for larger sample instruments such as closed-ended preprepared constructs.

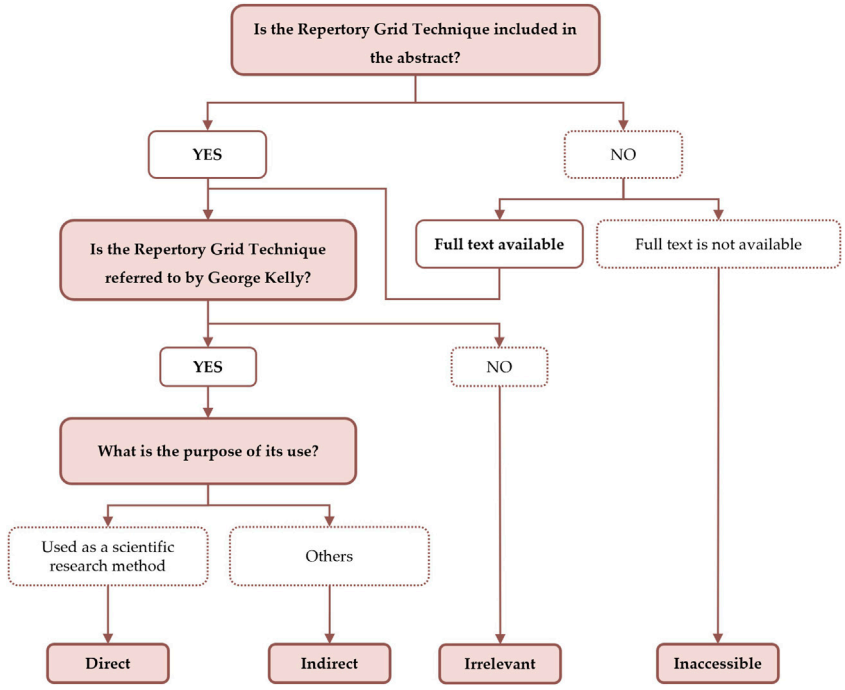

FIGURE 1
Second and third exclusion stages and validation processes.

TABLE 1 Descriptions of the validation process categories.

Category	Description
Direct	Studies that used repertory grid technique (RGT) as a scientific research method solely or in conjunction with other methods
Indirect	Studies that investigated the potential of RGT as a tool without using it as a scientific research method; studies that described or explained RGT; studies that compared RGT to other methods without using it as a scientific research method
Inaccessible	Studies in which RGT was not cited in the abstract and full text is not available on UAEU's online library or open-access databases
Irrelevant	Studies in which the discussed RGT was not by George Kelly

2 Materials and methods

This study was conducted as a systematic review to answer the above research questions. It followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Tricco et al., 2018).

2.1 Eligibility criteria

To be eligible for inclusion in this systematic review, the studies must be peer-reviewed articles published before 2021. The analysis excluded books, book chapters, conference papers, conference reviews, letters, and review articles (such as scoping reviews, systematic reviews and bibliographic reviews, meta-analyses, etc.). Only articles written in English or those with available English translation were included.

Articles were required to use RGT as a research method or any of its derived tools or extensions to be eligible. Studies were included if RGT was used solely or in conjunction with other methods but excluded if it was not used as a research method or if the full text was not accessible.

2.2 Information sources

A structured literature search during the first quarter of 2021 was conducted to identify relevant studies found in the Scopus database. The final search results were exported into CSV format on 16 April 2021 (provided as supplementary material).

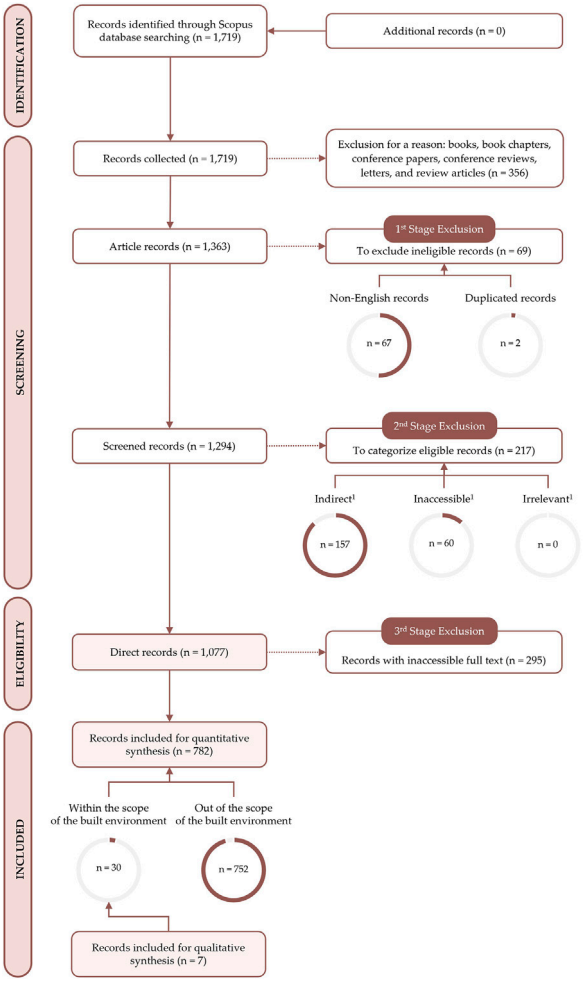

FIGURE 2
Literature search process flowchart developed in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

This feature allowed Scopus to be an effective search tool for the purpose of this study unlike other databases such as Google Scholar, ResearchGate, or JSTOR, where data exportation was not possible. Given that the Scopus content was checked and revised by an independent Content Selection and Advisory Board, the publications on this database were considered reputable. Also when compared to Web of Science, Scopus database is the largest database which contains 20% more journals than Web of Science (Falagas et al., 2008). However, for this topic we found it 70% more (1817 Scopus/ 1064 Web of Science). However, because of time limitation we couldn't scan multidatabaes, we relied on Scopus database. The exported database consisted of citation information, bibliographical information, abstracts, keywords, funding details, and other information. In the further stages of this research, where the full text of the records was required, the United Arab Emirates University (UAEU) online library and open-access databases were used to retrieve the full text.

2.3 Search strategy

This review selected search terms based on the main concepts of the research question: RGT and method. To find records in Scopus, Boolean operators were used to develop the following search string: "TITLE-ABS-KEY ("RepGrid" OR "repgrid technique" OR "repertory grid technique" OR "repertory grid method" OR "repertory grid") AND PUBYEAR <2021" (without quotation marks). All records from this search had to comply with the condition expressed, and at least one keyword from each OR operator was required in the title, abstract, or keywords.

2.4 Selection and data collection process

To define the current state of scientific research utilizing RGT and answer the first research question, the final database search results identified several records, and the screening process was performed in three exclusion stages. In the first exclusion stage, all non-peer-reviewed articles, non-English articles, and articles with no abstracts were removed, in that order. Duplicates were later removed through an Excel command that highlights cells with identical values. To decide whether the highlighted publications were duplicates, the titles, document types, years of publication, and abstracts had to be the same as well. For further verification, an additional free online tool was used to compare the abstracts of the duplicated records. Before starting any of the screening processes for this review, two reviewers filtered 33 random publications and discussed the results to develop and amend a standardized validation process illustrated in Figure 1. Disagreements on study selection and data validation were resolved by discussion and consensus with other reviewers if needed. The aim of this stage was to prepare the data for validation.

In the second exclusion stage, the validation process for identifying direct records involved screening RGT in the abstract alone. If cited, the technique had to be related to Kelly's PCT and used as a scientific research method. Whether used solely as the main research method or in conjunction with other methods, the record was defined as ."**direct**. If cited and if RGT was used for description or comparison, literature review, or part of a case study, the record was defined as ."**indirect**. If cited but the technique was unrelated to Kelly's PCT, the record was defined as ."**irrelevant**. In case the abstract did not cite RGT or any of the terms used in the search string, the full text was retrieved using the previously stated information sources, screened, and categorized. If the full text was not accessible to the reviewers, the record was excluded and ."deemed **inaccessible**. Excluded records at this stage had to meet both conditions, in which

key terms were not cited in the abstract and the full text was not accessible for screening. This stage sought to identify direct records and exclude indirect, irrelevant, and inaccessible ones.

In the third exclusion stage, the direct records were screened for eligibility where their full texts were required. Excluded records needed to comply with three conditions, that is, key terms were cited in the abstract, the technique was related to Kelly's PCT and used as a scientific research method, but the full text was not accessible for screening. The aim of this stage was to identify eligible records for quantitative synthesis.

A data-charting Excel form was developed to determine which variables to extract and store the records obtained from the reviewed studies. Following an iterative process, reviewers independently charted the data, discussed the results, and continuously updated the data-charting form. To increase consistency among themselves, the reviewers sequentially validated the titles, abstracts, and keywords of the eligible publications. Using the same validation process, they classified each study according to their purpose into one of the following categories: 1) direct, 2) indirect, 3) inaccessible, and 4) irrelevant. Table 1 summarizes the category descriptions.

To report on and explore the use of RGT in the built environment, relevant studies in the previous stage were further screened in two phases. In the first phase, titles and abstracts were filtered to categorize studies 1) within or 2) out of the built environment scope according to the definition of the built environment stated earlier. In the second phase, the full texts of the studies classified within scope were retrieved, carefully reviewed, and listed with their use of RGT.

2.5 Data items

The data-charting elements were as follows:

1) Author(s): first author's last name, first author's first name, etc.;
2) Document title: as specified in the data-charting Excel form;
3) Publication year: as specified in the data-charting Excel form;
4) Document type: as specified in the data-charting Excel form;
5) Country: manually extracted from the first author's affiliation;
6) Subject area: manually extracted from Scopus;
7) Use of RGT: manually extracted from research papers.

2.6 Synthesis methods

The figures and tables in this study were created using both automated and manual processes. The data-charting Excel form included the author(s), document title, publication year, and document type. However, the publication country was manually extracted by reviewers from the first author's affiliation. The study's subject area was exported from Scopus into a CSV format sheet and merged back into the original Excel form.

3 Results

This section should concisely and precisely describe the experimental results, their interpretation, as well as the experimental conclusions that can be drawn from them.

3.1 Study selection

Figure 2 illustrates the PRISMA flowchart used to answer the first research question. To define the current state of scientific research utilizing RGT, the review team started with a total of 1,719 records for screening. The first exclusion stage removed books, book chapters, conference papers, conference reviews, letters and review articles ($n = 356$), non-English articles ($n = 67$), and duplicates ($n = 2$), in that order. Afterward, 425 of the 1,719 studies were eliminated; hence, 1,294 publications were eligible for validation in the second exclusion stage. After the second exclusion stage, a further 217 studies were removed, resulting in 1,077 eligible publications for validation in the third exclusion stage. After the third exclusion stage, a further 295 studies were excluded, resulting in a total of 782 publications eligible for quantitative synthesis.

In the second exclusion stage, studies that cited the terms "RepGrid," "repgrid technique," "repertory grid technique," "repertory grid method," or "repertory grid" in their abstracts and referred to the technique discussed by Kelly were screened and categorized. If RGT or any of these terms were not cited in the abstract, the full text was retrieved, screened, and categorized. As a result, 1,077 of 1,294 studies were categorized as "direct," as they used RGT as a scientific research method. Then, 157 of the 1,294 studies were categorized as "indirect," as they described, explained, compared, cited, or studied the grid without using it as a scientific research method. A total of 60 of the 1,294 studies were inaccessible. No records were identified as irrelevant.

In the final exclusion stage, the full texts of 295 of 1,077 "direct" studies were inaccessible; consequently, 782 were included for quantitative synthesis. Among these papers, reviewers identified 30 records within the scope of the built environment and 752 out of scope.

3.2 Study characteristics

Figures 3–5 present the characteristics of the 782 studies using RGT as a scientific research method and simultaneously highlight the characteristics of the 30 studies within the built environment field.

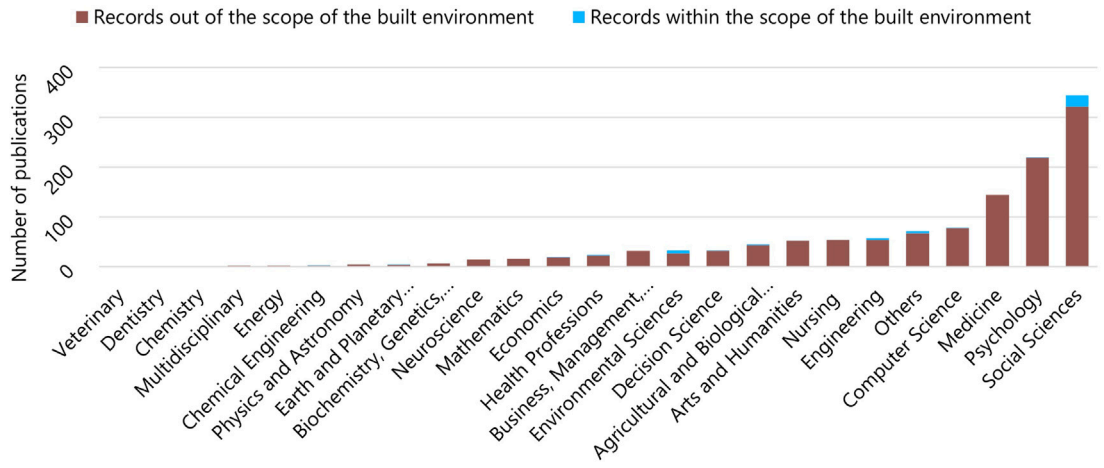

FIGURE 3
Number of publications according to subject area in the included studies.

3.2.1 Subject area

According to Scopus, more than half of the studies in our sample (432 of 782) were published in more than one subject area. One record contributed to six different subject areas: social sciences, health professions, agriculture and biological sciences, arts and humanities, psychology, and nursing. Another contributed to five different subject areas. Of the 432 records, 14 contributed to four subject areas, 36 three subject areas, and 315 two subject areas. The remaining 350 of the 782 records contributed to only one subject area, in which the subject areas of 72 studies were classified as "others." Figure 3 illustrates the distribution of these studies among subject areas defined by Scopus.

As highlighted in Figure 3, a total of 30 records identified within the built environment scope also contributed to one or more subject areas such as social sciences ($n = 19$), environmental science ($n = 2$), engineering ($n = 2$), agricultural and biological sciences, decision sciences, and economics ($n = 1$ each). The subject areas of four studies were classified as "others."

3.2.2 Location

The included records were published in several parts of the world as indicated in Figure 4. To a greater extent, and since 1967, research has been conducted in the United Kingdom ($n = 290$), the United States ($n = 77$), Australia ($n = 67$), Spain ($n = 36$), Canada and Germany ($n = 35$ each), Taiwan ($n = 28$), Italy ($n = 21$), Sweden ($n = 20$), the Philippines ($n = 14$), New Zealand and Turkey ($n = 12$ each), China and Netherlands ($n = 11$ each), and Hong Kong and Switzerland ($n = 10$ each).

On a smaller scale, studies have been published in Belgium ($n = 9$); Denmark, Ireland, and Japan ($n = 6$ each); India and South Africa ($n = 5$ each); France, Malaysia, and the Russian Federation ($n = 4$ each); Norway ($n = 3$); Argentina, Brazil, Czech Republic, Finland, Greece, Pakistan, Portugal, and other countries ($n = 2$ each); and Bahrain, Bangladesh, Chile, Cyprus, Iceland, Indonesia, Iran, Luxembourg, Mexico, Namibia, Singapore, South Korea, Thailand, and the United Arab Emirates ($n = 1$ each).

As for the records within the built environment field, research has been conducted in the United Kingdom ($n = 10$); Australia ($n = 5$); Malaysia ($n = 3$); Japan and Switzerland ($n = 2$ each); and Bahrain, Greece, Hong Kong, Luxembourg, Taiwan, Turkey, Spain, and the United States ($n = 1$ each). One record was classified as "others."

3.2.3 Year of publication

Figure 5 illustrates the 782 studies published between 1967 and 2020 as a line graph. Overall, the publication rate improved during that period. From 1967 to 1994, the publication rate remained consistent, from one to seven publications per year. The rate increased dramatically afterward, peaking at 36 publications in 1997 and again in 2000. Between 2001 and 2015, the publication rate fluctuated, reaching a low of 17 studies published in 2003 and 2008 and a high of 31 studies published in 2012 and 2014. Later, the number of publications increased to 44 in 2017 but slightly fell to 38 in 2020. Meanwhile, studies within the built environment field emerged in 1978. Studies published in 2012 and 2014 peaked at four (out of 30).

3.3 Results of individual studies

3.3.4 Research aim

Within the built environment scope, Table 2 lists the research aims of studies that have adopted RGT.

Based on the definition of the built environment cited earlier, these studies can be classified as either direct or indirect

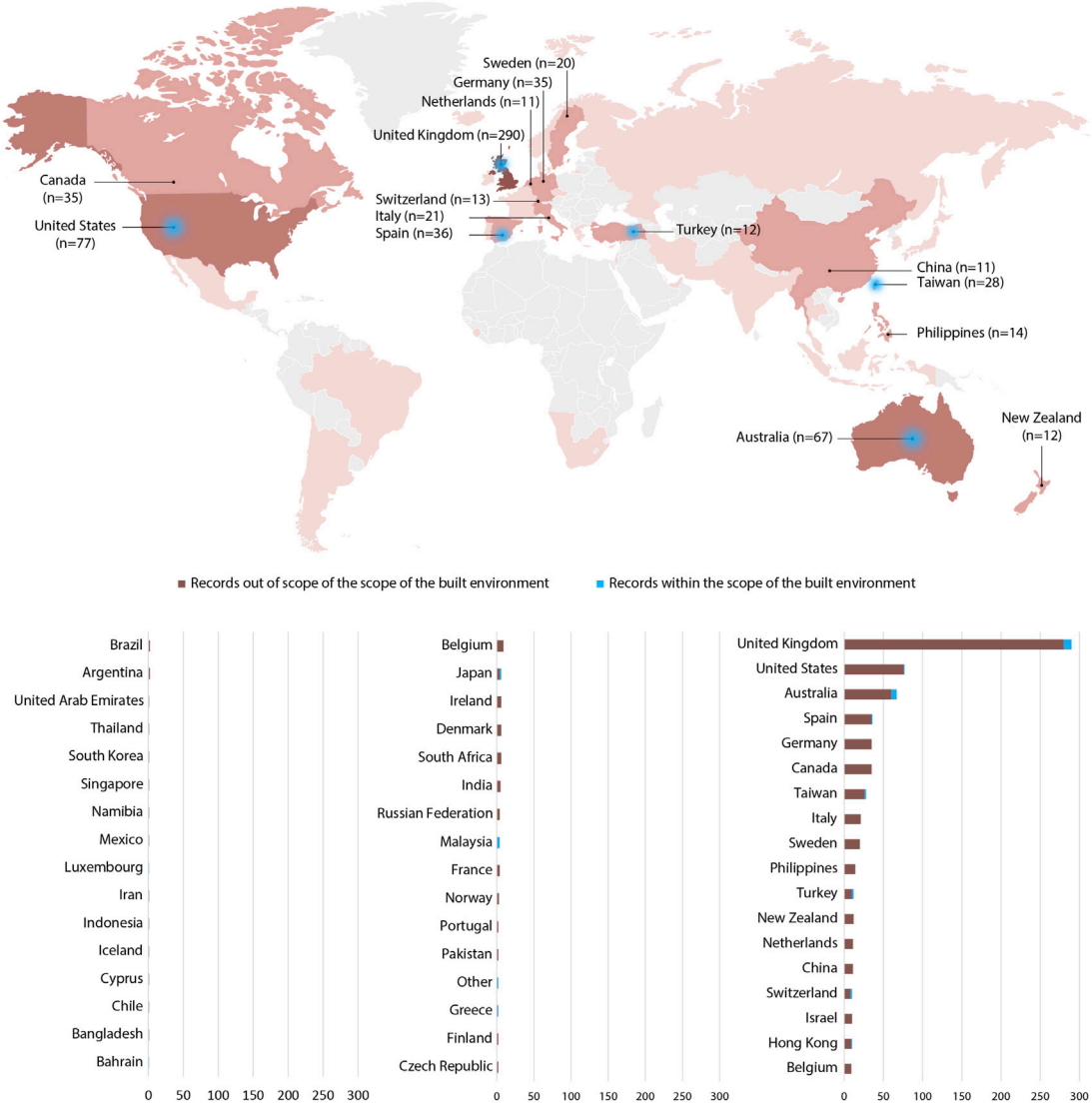

FIGURE 4
Number of publications according to authors' affiliation countries.

contributors to the field. Direct contributors included record 234 (Dayaratne, 2016), which used RGT to examine the applicability of physiological techniques in a housing project, and records 133 (Tu et al., 2018) and 135 (Cheah et al., 2018), which adopted RGT to promote sustainable behavior practices or avoid extra energy consumption. Additionally, records 26 (Ratnasingam et al., 2020), 209 (Lallemand and Koenig, 2017), 712 (Vassiliadis and Fotiadis, 2007), 1078 (Mitchell and Kiral, 1999), and 1088 (Mitchell and Kiral, 1998) used RGT to explore human–space interaction, user experience, and spatial experience; assess images of space, or determine material selection. Records 301 (Wan and Shen, 2015), 541 (Abdul-Rahman et al., 2011), 606 (Home et al., 2010), 740 (Home et al., 2007), 875 (Selby, 2004), 1503 (Potter, 1986), 1505 (Potter and Coshall, 1986), and 1652 (Taylor and Stough, 1978) used RGT to elicit users' perceptions of key attributes of urban green spaces, understand the meanings of urban green spaces, provide planners with the necessary tools, identify spatial inequalities, or perform multivariate analysis in geography.

Meanwhile, indirect contributors included record 1062 (Okoroh and Torrance, 1999), which used RGT to analyze the subcontractor's risk elements in constructing refurbishment projects, and records 24 (Kislali et al., 2020), 736 (Byrne and Skinner, 2007), 745 (Pike, 2007), 751 (Naoi et al., 2007), 797 (Naoi et al., 2006), 885 (Hankinson, 2004), 917 (Pike, 2003), 922 (Waitt et al., 2003), 933 (Caldwell and Coshall, 2002), 1025

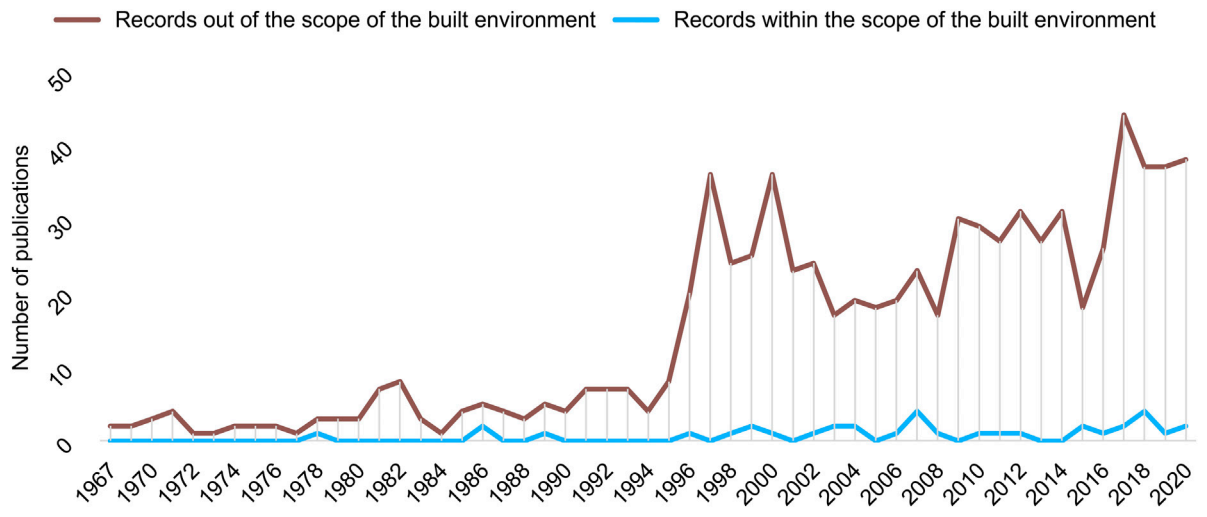

FIGURE 5
Number of publications according to year of publication.

(Coshall, 2000), 1174 (Botterill and Crompton, 1996), and 1411 (Embacher and Buttle, 1989), which adopted RGT to evaluate users' experience, perception, and destination image and its assessment. Finally, the reviewers grouped 30 records into six main topics according to the research aim and keywords: architecture and meaning, building sciences, interior architecture, management and decision-making, tourism and city branding, and urban planning and design. Table 3 summarizes these topics and their typologies.

3.1.5 Repertory grid technique design and procedure

To explain how RGT can be methodologically practiced within the built environment field, this section presents the results of the seven records categorized as direct contributors to the field and published after 2010. The main components of RGT are reported for each record. Table 4 summarizes the use of RGT design components for these records.

Records in the above table used RGT to explore the personal constructs of end users, subcontractors, managers, architects, and urban designers with the aim to evaluate users' experience, perception, and destination image; promote sustainable behavior practices; manage energy consumption; and elicit key attributes of urban green spaces.

3.1.6 Repertory grid technique in architecture and meaning of space

To develop and construct a housing neighborhood in Sri Lanka (Dayaratne, 2016), residents' input was used over two tasks. The first sorting task was conducted with 12 families to achieve a profound understanding of their existential consciousness and conceptualization of their setting. The authors asked participants to elicit elements by writing the locations they recognize of the present setting on sorting cards. These sorting cards were then presented to each participant as elements to sort into several groups and elicit 10 positive and negative constructs. The sorting process was conducted until no further groups could be generated. The second sorting task was conducted with 20 participants to divulge their conceptualizations and fantasies about the places they wished to see in the new neighborhood. The previous process was repeated, and 28 spatially relevant constructs were used.

3.1.7 Repertory grid technique in building sciences

In (Tu et al., 2018), two phases were used to promote sustainable behavior practices. The first phase used RGT to understand participants' views of the Design for Sustainable Behavior (DfSB) approach, develop an assessment tool in the form of a grid, and propose design strategies for improving the sustainable behavior of household appliances. The second phase used a questionnaire to verify the developed tool. In the first phase, four designers were given six design approaches written on cards as elements. The participants were asked to randomly select three cards, elicit the similarities between two cards, and elicit the difference between those and the third card. The participants repeated the process until no new constructs could be extracted or a certain period had elapsed. A total of 187 constructs falling under 23 typologies were obtained. The 10 most common constructs elicited and the six supplied elements were used to build a 6 × 10 grid tool for understanding the perceptions and

TABLE 2 List of records within the scope of the built environment.

Rec. No.	Research aim	Author
24	To develop a holistic framework of destination image formation capturing the dynamic nature of the image and incorporating information sources and sociocultural factors	Kislali et al. (2020)
26	To determine the most preferred attributes of overlay materials used in wood-based panel furniture	Ratnasingam et al. (2020)
133	To explore opportunities for promoting sustainable behavior practices	Tu et al. (2018)
135	To investigate the motivations and impediments in avoiding electricity wastage	Cheah et al. (2018)
178	To investigate the decision-making process of travelers	Keshavarzian and Wu, (2017)
209	To explore students' perceptions of learning environments	Lallemand and Koenig, (2017)
234	To examine the applicability of two psychological techniques in a housing project	Dayaratne, (2016)
301	To elicit users' perceptions of key attributes of urban green spaces	Wan and Shen, (2015)
541	To extract a set of core factors in site planning focusing on the tacit knowledge acquisition process to develop a tacit-based decision support system	Abdul-Rahman et al. (2011)
606	To understand the meanings of urban green spaces and provide planners a tool to match urban natural resource management with the needs of residents	Home et al. (2010)
712	To demonstrate the importance of the analysis of constructs in relation to management (local authorities or private institutions) suggestions concerning the museums of a specific area	Vassiliadis and Fotiadis, (2007)
736	To understand the brand of Dublin and explore the way the marketing of a national capital city for business tourism both influences and is influenced by the marketing of the nation itself	Byrne and Skinner, (2007)
740	To reveal a dominant anthropocentric attitude toward urban green spaces	Home et al. (2007)
745	To report the first trial of RGA in eliciting salient destination image attributes using group settings	Pike, (2007)
751	To illustrate the complex nature of visitors' evaluation of historical districts as tourism destinations	Naoi et al. (2007)
797	To discuss the complex nature of visitors' evaluation of a historical district	Naoi et al. (2006)
875	To study tourists' knowledge of Cardiff	Selby, (2004)
885	To elicit attributes associated with 25 destination images in the United Kingdom.	Hankinson, (2004)
917	To identify salient attributes for New Zealanders when differentiating domestic short-break holiday destinations	Pike, (2003)
922	To report on how tourists discriminate between their perception of human artifacts as attractions and the region's gorges, rivers, billabongs, flora, and fauna	Waitt et al. (2003)
933	To focus on visitor motivation in the field of museums and galleries	Caldwell and Coshall, (2002)
1025	To analyze tourists' images of London's museums and art galleries	Coshall, (2000)
1062	To analyze the subcontractor's risk elements in constructing refurbishment projects	Okoroh and Torrance, (1999)
1078	To explore the prima facia case for using perceived-risk theory in analyzing store perceptions and set out definitions of store risks in this context	Mitchell and Kiral, (1999)
1088	To assess store images of three United Kingdom grocery retailers	Mitchell and Kiral, (1998)
1174	To explore Kelly's PCT to better understand the nature of tourists' experience	Botterill and Crompton, (1996)
1411	To investigate English vacationers' images of Austria as a summer destination	Embacher and Buttle, (1989)
1503	To present a method to identify, analyze, and monitor spatial inequalities in developing countries	Potter, (1986)
1505	To use repertory grids as a general method of multivariate analysis in geography	Potter and Coshall, (1986)
1652	To assess the empirical validity of Altman's typology of human territories	Taylor and Stough, (1978)

TABLE 3 Categorization of records using RGT in the built environment according to topic.

Contribution	Topic	Record number
Direct	Architecture and Meaning of Space	234
	Building Sciences	133, 135
	Interior Architecture	26, 209, 712, 1078, 1088
	Urban Planning and Design	301, 606, 740, 875, 1503, 1505, 1652
Indirect	Management and Decision-Making	541, 1062
	Tourism and City Branding	24, 178, 736, 745, 751, 797, 885, 917, 922, 933, 1025, 1174, 1411

TABLE 4 Summary of the use of RGT design components.

Topic	Record no. (ref)	Element selection			Construct elicitation			Linking elements to constructs			
		Supplied	Elicited	Supplied constructs	Minimum context form	Group construct elicitation	Full context form	Dichotomizing	Ranking	Rating	No linking
Architecture and Meaning of Space	234 Dayaratne, (2016)		•				•				•
Building Sciences	133 Tu et al. (2018)	•	•		•					•	
	135 Cheah et al. (2018)		•		•					•	
Interior Architecture	026 Ratnasingam et al. (2020)	•			•					•	
	209 Lallemand and Koenig, (2017)	•			•						•
Urban Planning and Design	301 Wan and Shen, (2015)		•		•						•
	606 Home et al. (2010)	•			•					•	

experiences of 38 new young designers, who rated each element based on the construct poles using a five-point Likert scale. To establish the basic concepts of DfSB approaches among participants in the two parts of the first phase, the participants read a short descriptive essay before the interview sessions.

To investigate motives and challenges in preventing electricity wastage, the participants in (Cheah et al., 2018) were asked to list up to six household electricity users. They were supplied with two additional elements and were then asked to randomly select three cards representing three household members and group two cards that were similar but different from the third. The selection criteria were based on members' motivations for not wasting electricity. Once the participants began answering, the constructs were elicited. In every triad process, the participants rated family members according to the constructs in the grid and using a seven-point scale. The elements were placed back into the pile and reshuffled once the participant could no longer elicit new constructs from the same set of cards. Laddering was used, and the process was repeated until the participants either could not generate new constructs or became visibly tired.

3.1.8 Repertory grid technique in interior architecture

To determine the most preferred attributes of overlay materials used in wood-based panel furniture, the participants examined three wood samples (Ratnasingam et al., 2020) by describing the characteristics and attributes in which one sample was different from the other two. The participants rated all three samples with regard to the elicited constructs on a five-point Likert scale.

To explore students' perception of learning environments, 26 students were given 37 printed Web pictures representing different learning spaces during three focus sessions (Lallemand and Koenig, 2017). They followed standardized instructions on how to compare triads and elicit constructs and had 20 min to complete this task individually and repeat the process until saturation was reached. The authors then clustered all contract pairs into six distinct and relevant categories under an affinity diagram format.

3.1.9 Repertory grid technique in urban planning and design

To elicit users' perceptions and assessments of key attributes of urban green spaces (UGS) in Hong Kong, 21 participants were asked to elicit nine UGS that fit a given set of descriptors (Wan and Shen, 2015). Eight descriptors were assigned to a UGS they recall visiting in a certain period, and a ninth descriptor labeled "ideal urban green space" was not assigned but was for their imagination. Each participant was presented with at least six different triad combinations of the elicited elements to generate 131 constructs, which were later used to develop a questionnaire.

To understand the meanings of UGS and provide planners with a tool to match urban natural resource management with residents' needs (Home et al., 2010), 17 participants were supplied with nine photographs of UGS representing different green spaces in Zurich and one imaginary ideal landscape. They were presented with random groups of three elements to elicit construct pairs. A total of 118 constructs were generated and linked using a Likert scale.

4 Discussion

4.1 Interpretation

This systematic review identified a total of 782 studies that used RGT as a scientific research method. According to Scopus, these studies contributed to more than 24 subject areas, with more than half being listed under two or more areas together. Higher contribution rates were identified in three main areas—social sciences, psychology, and medicine, in which PCT was initially introduced.

Regarding location, the highest number of publications was 290 in the United Kingdom, followed by the United States, Australia, Spain, Germany, and Canada, in that order. The high publication rate in these countries is expected because of the international congresses and conferences taking place in these regions. The United Kingdom alone is home to several regional "interest groups" working in personal construct psychology. Nevertheless, publications were not limited to these countries but were spread throughout more than 43 other countries.

In terms of period, the publication rate increased between 1967 and 2020. From 1967 to 1994, the rate of publication remained almost consistent, especially during the evolution of PCT and RGT as tools. Afterward, rates increased dramatically, peaking in 1997 and again in 2000, and then fluctuated between 2001 and 2015 before increasing again in 2017 and finally dropping slightly in 2020. These rates do not necessarily reflect publications on RGT as a tool; instead, they reflect its use as a scientific method in the research field.

Out of the 782 included studies, this review identified only 30 within the scope of the built environment. According to Scopus, these records also contributed to one or more subject areas, such as social sciences, environmental science, engineering, agricultural and biological sciences, chemical engineering, decision sciences, Earth and planetary sciences, health professions, and psychology. In terms of location, the highest number of publications was 10 in the United Kingdom, followed by Australia, Malaysia, Japan, Switzerland, Taiwan, Turkey, Bahrain, Greece, Hong Kong, Luxembourg, Spain, and the United States, in that order. While studies using RGT had a high rate of publication over the period 1967–2020, RGT in the built environment was noticeably absent. Studies started emerging in 1978 and increased to a maximum of four publications between 2007 and 2018.

Studies within the built environment scope used RGT to examine the applicability of physiological techniques in a housing project (Dayaratne, 2016), promote sustainable behavior practices (Tu et al., 2018), and avoid energy consumption (Cheah et al., 2018). RGT was also used to elicit users' perceptions of key attributes of UGS, understand the meanings of UGS (Taylor and Stough, 1978; Potter and Coshall, 1986; Selby, 2004; Home et al., 2007; Wan and Shen, 2015), provide planners with necessary tools (Home et al., 2010), identify spatial inequalities, and integrate it with multivariate analysis in geography (Potter, 1986). In general, RGT was used to explore and evaluate human–space interactions, user experience, spatial experience, perception, and images of space—factors that designers consider important in architectural engineering.

These studies were categorized into direct and indirect topics based on their contributions to the built environment field. Topics included architecture and meaning, building sciences, interior architecture, management and decision-making, tourism and city branding, and urban planning and design. This categorization indicates how RGT contributed to the divergent fields of the built environment.

4.2 Theoretical framework: Using repertory grid technique in the built environment

This analysis provides a broader discussion of what built environment research should consider when designing the RepGrid. Because the decision and elicitation of a repertory grid can be a delicate process that requires high levels of skill and sensitivity, researchers must select among several design alternatives described below.

4.2.1 Element selection

Elements can be supplied if the research aim is to learn about a given set of elements from several participants. For example, in (Ratnasingam et al., 2020), the researcher provided participants with a set of overlay materials to learn more about their characteristics and attributes from the participants' perspectives. In (Lallemand and Koenig, 2017), the researcher supplied participants with 37 printed Web pictures of learning spaces to explore their perceptions of learning environments. In (Lallemand and Koenig, 2017), the researcher presented participants with nine photographs of UGS that represent different green spaces in Zurich. Elements can also be given if the researcher is interested in allowing an existing theory guide element choice or in comparing the responses of several respondents given a standard set of elements. None of the seven records followed these criteria. Meanwhile, elements can be elicited if they are implied by the study or if they must be relevant to the participants (Easterby-Smith, 1980). This method is particularly effective if the researcher's aim is to involve laypeople's perceptions in the

design process. For example, in (Dayaratne, 2016), the researcher (designer) asked participants to elicit places they recall in their current neighborhood and places they wish to have in a future development. In (Wan and Shen, 2015), because of the large number of elements that meet the research criteria and their relevance to the participants, researchers asked participants to elicit places they have visited relying on their real-life experience. They were provided with descriptors to guide their elicitation process. However, in (Cheah et al., 2018), because the research sought to study specific behaviors toward energy consumption, participants were asked to elicit names of household users as elements for the experiment.

Whether supplied or elicited, elements refer to stimuli that are significant in a research study. They can be in the form of printed or digital photographs (Home et al., 2010; Lallemand and Koenig, 2017), text, people (Cheah et al., 2018), or objects (Ratnasingam et al., 2020) or any other suitable format based on research purpose. In cases where real experiences are difficult to reproduce, researchers can use pictures or objects without introducing particular biases. When a large number of elements is relevant to the study or when the identification of a common list for all participants is difficult, researchers can provide participants with a set of descriptors, roles, or situations from which they can elicit their own specific examples that fit these categories. For cases where participants might be unfamiliar with the topic, researchers can provide them with short descriptive essays before interview sessions as in (Tu et al., 2018).

4.2.2 Construct elicitation

RGT supports several methods for eliciting constructs to which minor variations and combinations can be applied. The minimum context form, also known as the triadic sort method, is considered the most convenient and common method for exploring a participant's constructs. This method involves the selection of three random elements from a full set of elements. Participants then identify how two elements are similar yet different from a third. In (Home et al., 2010; Wan and Shen, 2015; Lallemand and Koenig, 2017; Cheah et al., 2018; Tu et al., 2018; Ratnasingam et al., 2020), researchers asked participants to elicit constructs through the minimum context form.

Dyads can also be used to elicit constructs if participants find it difficult to generate constructs *via* the triadic method or if the elements themselves are complex (Easterby-Smith, 1980; Keen and Bell, 1980). None of the records in Table 4 implemented this approach.

Another method to elicit constructs is the full context form. In this method, participants sort a full set of elements into groups using any similarity criteria of their choice (Easterby-Smith, 1980). In (Dayaratne, 2016), the full context form was adopted, and the participants were asked to elicit constructs in the form of short descriptive titles for each pile of elements. Other methods include supplied constructs or group construct elicitation. Again, none of the studies in Table 4 used group construct elicitation or supplied the constructs, as the methods did not elicit the required data to answer the research question.

4.2.3 Linking elements to constructs

As with all methods for eliciting personal constructs, the resulting constructs are not required to be used in some form of repertory grid (Fransella, 2005); the information gained can be deemed sufficient in itself. Therefore, not all researchers will perform linking. As Table 4 indicates, in (Wan and Shen, 2015; Dayaratne, 2016; Lallemand and Koenig, 2017), researchers were satisfied with the information they obtained and did not use any linking method.

In most cases, elements are linked to constructs through ratings. When rating elements, participants exercise greater freedom and are not compelled to make discriminations where none exist. In (Home et al., 2010; Cheah et al., 2018; Tu et al., 2018; Ratnasingam et al., 2020), ratings were used. When the range of rating values exceeds the number of elements, participants' freedom is maximized. For example, in (Ratnasingam et al.), the participants rated three samples on a five-point scale; in (Tu et al., 2018), the participants rated six elements using a five-point scale; and in (Cheah et al., 2018), the participants rated eight elements on a seven-point scale.

It is important to mention that not all the practice of RGT is responding effectively to the original theory of Kelly especially in the case of group elicitation and rating approaches.

4.2.4 Other considerations

It is important to note that RGT can be used as a scientific research method solely or in conjunction with other approaches. It can also help validate other methods or serve as a preliminary phase for further research. This was evident in most studies such as (Wan and Shen, 2015), where researchers used the construct elicitation results as a base to develop a closed-ended constructs for their research purpose.

Furthermore, Dayaratne (2016) believed that in conventional surveys, participants mostly express negativity. However, RGT allows participants to freely express both negative and positive conceptualizations that are real and strongly experienced.

Also worth noting is that in some cases, elements and constructs can be elicited by a participant group and then supplied to another participant group for research purposes. For example, in (Tu et al., 2018), four designers elicited elements and constructs that were then rated by another group of 38 young designers. However, the data analysis of individual RGT can be studied in groups of individuals to understand how they perform in a certain task.

4.3 Limitations

To make this review more sufficient we considered Scopus data as a benchmark. Therefore, only Scopus was used for the initial identification of records. The scope of this study is to

review articles that were published before 2021. However, there are 60 new articles have been published from 2021 until 22nd of December 2022 which passed the second stage of exclusion on Scopus. Further as acknowledged earlier in the literature search process flowchart, only the UAEU online open-access databases were used to retrieve the full text of the records.

5 Conclusion

This study explored the use of RGT as a research method and advance its use in the built environment field. Following PRISMA guidelines, this research conducted a systematic review to identify studies from Scopus that have adopted RGT before 2021.

The scientific community has become increasingly aware of the potential of RGT in the social sciences, arts, and humanities, but the technique remains underused in the built environment, especially given that the latter field shares several attributes with the former ones in terms of user experience.

Results also indicate that 70 years after RGT was formulated, extended efforts in the development of George Kelly's PCT and the current state of scientific research utilizing RGT as a method are evidently substantial despite the large number of existing evaluation tools. Simply put, widespread research conducted worldwide since the discovery of this theory, especially in the United Kingdom, illustrates its importance and value for research. However, the limited number of publications in the Middle East suggests the need to further investigate RGT. With the growing interest of the MENA region in sustainability and user-centered design, a promising direction for future studies could focus on integrating RGT into the design process. The RGT is in a study work exploring the potential of artificial intelligence as a technique for facilitating data elicitation which can be interesting to deal with human needs with the built environment.

Finally, this review provides insights for scholars and practitioners who want to learn more about applying RGT as a scientific research method in the built environment field. By providing a theoretical framework for design decisions, this review recommends advancing the use of RGT in the built environment and developing future innovations in this fast-paced field especially by involving the artificial intelligence and machine learning field which might reduce the time and efforts of conducting the interviews for RGT for huge number of participants.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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