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Giant Genes! The Development of an Interactive Game to Engage Audiences in Genetics

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ABSTRACT: We describe the design, creation, and preliminary evaluation of a hands-on interactive game, "Giant Genes," which was developed to explain the concept of genetics and the central dogma of gene expression to audiences at Cardiff University's Brain Games. The Giant Genes game is a modified version of the traditional game "Jenga." The game begins with a central tower of wooden blocks which are stacked to create a "deoxyribonucleic acid (DNA) tower". Players then pick amino acid cards which show the three nucleotides that they need to remove from the tower to create a corresponding amino acid. Taking turns in removing blocks from the tower, the player who has created the most amino acids by the time the tower falls wins. After initial positive reviews, we further piloted the game at events including during school visits and a patient interest day. The Giant Genes game is a simple hands-on interactive activity which has attracted diverse audiences. It acts as a fun, informal way of discussing complex genetic issues with the general public and has received positive feedback in preliminary evaluation. The preliminary data demonstrate proof-of-concept that the game can be used successfully with a range of audiences.

INTRODUCTION

Why is Engaging the General Public in Genetics Important? Advances in science and technology mean that the general public are increasingly confronted with complex decisions in relation to their own genetic identity. A recent United Kingdom based survey, Public Attitudes to Science 2019, revealed that although a relatively large proportion of respondents had heard about genome editing, relatively few felt well informed about this technology (Department for Business, Energy and Industrial Strategy, 2019). Furthermore, media coverage of the potential use of genetic technologies has increased the public's interest around this important area of scientific research.

Research regarding the public understanding and perception of genetics in general has produced variable results (Bates, 2005; Lanie et al., 2004; Richards and Ponder, 1996). The majority of literature which explores the public knowledge of genetics indicates a lack of understanding regarding basic genetic concepts (Lanie et al., 2004). Although, other studies have highlighted the rising inclusion of genetic topics in popular culture including television documentaries, science fiction and news media, which have increased critical appraisal of genetics by the general public (Bates, 2005).

The public understanding of genetics is mainly focused around the hereditary nature of genes (Condit, 2010) rather than the molecular or structural biology which underpins genetic understanding. Research focused specifically on public attitudes towards genetic testing reveals a lack of knowledge regarding the application and consequences despite high educational status and prior genetic knowledge (Haga et al., 2013). A study based in Northern England suggested that in the United Kingdom, the general public apprehend genetic concepts specifically through personal, lived experiences (Edwards, 2002). Therefore, research indicates that while the public perception of genetics is changing, a gap exists in the public understanding of basic genetic concepts leading to unrealistic expectations about genetic testing, its conclusions and potential applications (Haga et al., 2013).

The Giant Genes game was created with the aim of increasing public understanding of the structure and function of genes to create a platform to further discuss the role ge-

netics has in everyday life, health and disease. We aimed to increase public understanding of genetics and used the game as a means of a fun introduction to draw audiences in and promote further discussions with researchers alongside playing the game. The game was initially designed with children in mind as the target audience at Cardiff University's flagship Brain Games event. After positive reviews we trialled the game at other events including school visits and patient interest days to demonstrate proof-of-concept and to gather feedback from a range of audiences.

Key messages:

- The Giant Genes game was initially developed after a need was identified to explain complex genetic topics to family audiences at Cardiff University's Brain Games flagship public engagement event.
- After the initial positive reviews, the game was piloted with a range of other audiences including during school visits and with patient interest groups. Preliminary evaluation demonstrated that the game was rated highly among these different audiences.
- The game provides an outreach opportunity for researchers to interact with a range of public audiences and explore complex topics in an interactive, entertaining and simple manner.

What is the Giant Genes Game? The Giant Genes game was developed as a fun and interactive activity to engage and teach the general public about genetics and the central dogma of gene expression. Gamification of learning has been shown to significantly increase motivation and concentration by providing a fun engaging learning method (Petty, 2004). We hoped that by presenting complex genetic topics through an informal game it would prompt discussion between the researchers running the game and those who were playing the game.

The central dogma of gene expression describes the fundamental and essential process of how genetic information is converted from deoxyribonucleic acid (DNA) code to proteins (Figure 1). For the purposes of the Giant Genes game, the messenger ribonucleic acid (mRNA) component of the process is not included in the game. Although, for those players who were interested, the researchers and scientists running the activity could expand upon this point if they felt it would be helpful for the players.

The game can be played individually or as part of a team. Prior to beginning the game, risk assessments were undertaken, particularly in relation to the falling tower. Soft foam mats were situated directly under the towers and players were instructed to take care and not sit on the floor when playing the game to prevent any potential injuries. Research scientists oversaw players completing the game and were on hand to answer any questions and discuss the science behind the activity.

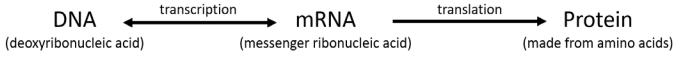

Figure 1. Schematic representation of the central dogma of gene expression.

The game begins with a central tower of wooden blocks (painted to represent nucleotides) which are stacked to create a tower of deoxyribonucleic acid (DNA) (see photos in Figure 2). Players then pick an amino acid card (Figure 3) which shows the three nucleotides (trinucleotide repeat) that they need to remove from the tower in order to create the amino acid. Once an amino acid has been created from the nucleotide blocks, the player picks another card. The game continues until the tower falls and the play who has been able to create the most amino acids wins.

Figure 2. Giant Genes game set up at the Cardiff University Brain Games.

Who Were the Target Audiences? The game was initially trialled at one of Cardiff University's flagship public engagement events, the Brain Games. The Brain Games welcomes thousands of people to the National Museum of Wales to take part in fun, family friendly games and activities. Previous feedback from the event, which is held annually, demonstrated that repeat visitors felt that the event could be improved by including new games and activities. Therefore, the Giant Genes game was created to meet the need for new activities and was offered as one of the "Brain Games" at the 2018 event. The game saw STEM ambassadors from across Cardiff University (from different career stages) volunteer their time to help facilitate the event in which hundreds of people took part. In running the event volunteers were able to talk to players about the implications of gene expression for particular conditions, such as cystic fibrosis, cancers and neurodegenerative diseases.

After a largely positive initial evaluation of the Giant Genes activity at the Brain Games, we sought to trial the game in different environments to evaluate its suitability for use with other audiences. We used the Giant Games during a school visit with two classes aged 12-13 years at Pontard-

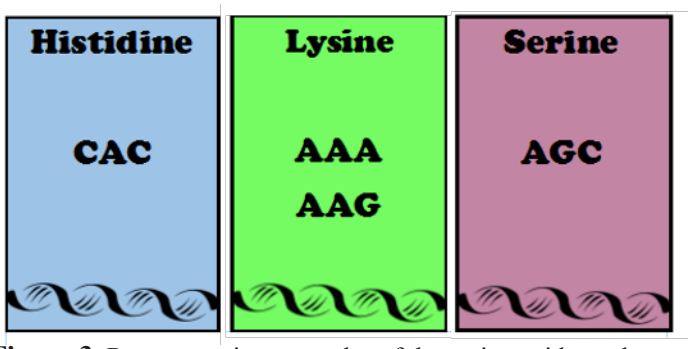

Figure 3. Representative examples of the amino acids cards players use to play the Giant Genes game.

dulais Comprehensive School. We also took the game to a patient interest group day. This audience included a broad demographic of people who were impacted by Huntington's disease.

RESULTS

What Did the Target Audiences Think? We conducted a preliminary evaluation of the Giant Genes game at each of the events which we trialled the game at: Cardiff University's Brain Games, a visit to Pontarddulais Comprehensive School and a patient interest group day.

Cardiff University's Brain Games. We sought to complete preliminary evaluation of the Giant Genes activity at Cardiff University's Brain Games in two ways. Due to previous experience of high footfall at the event, collecting feedback was challenging, therefore, feedback boxes were developed as a way of capturing feedback for large audiences (Figure 4). After playing the Giant Genes game those who played it were asked to press a button on the feedback box which indicated how they felt about their experiences playing the game. Green indicated "Great," orange meant that there was "Room for Improvement," and red indicated a "Poor" experience. The feedback boxes were designed so as to avoid duplicate responses from the same person. A slight delay (approximately 1 second) was implemented after each button was pressed to ensure unique responses each time.

The results from the feedback box (Figure 5) indicated that 49/73 (67.1%) responded "Great," 20/73 (27.4%) responded "Room for Improvement," and 4/73 (5.5%) responded "Poor." These data give a good indication of the players' overall feelings towards the game, and strengthens our confidence that this activity was well received and worthy of further evaluation.

Our second evaluation method of the Giant Genes game at the Brain Games event was based on an overall event survey. A random sample of people attending the Brain Games were asked to fill out a digital evaluation questionnaire upon leaving the event which asked about their overall experiences of attending the entire event. In the overall event evaluation, the Giant Genes game was mentioned specifically in the attendee feedback and 4/35 (11.4%) respondents highlighted the game as their particular favourite (Figure 6).

The Giant Genes game was a new game that was introduced alongside some "tried and tested" popular games such as "craft stations," "the shoot flip-out" game, and "car racing," which regularly attract repeat visitors and can lead to long queues. Although we must acknowledge the relatively small numbers of respondents in the event feedback, this was a notable achievement given some of the other tried and tested activities on show. Anecdotal feedback from speaking to families demonstrated that attendees particularly liked the Giant Genes game because the concept was simple and familiar. Therefore, volunteers could focus more on the learning and explanation of the science behind the game rather than the game play itself. Families found that it was easy to understand as it allowed them to play together and improved their knowledge.

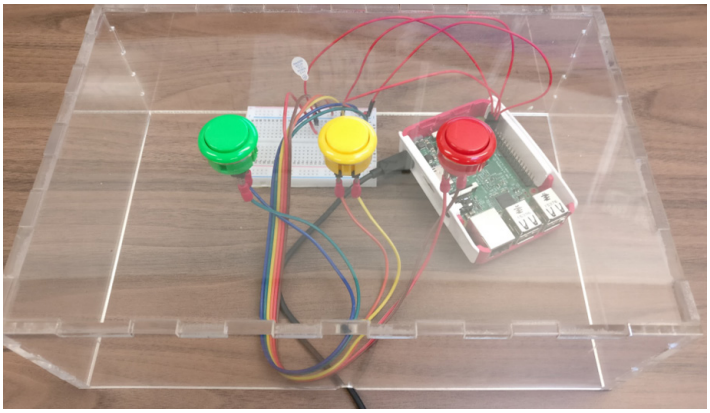

Figure 4. Feedback boxes which were developed to capture feedback for large audiences. Green was used to represent "Great," Orange meant "Room for Improvement," and Red indicated a "Poor" experience.

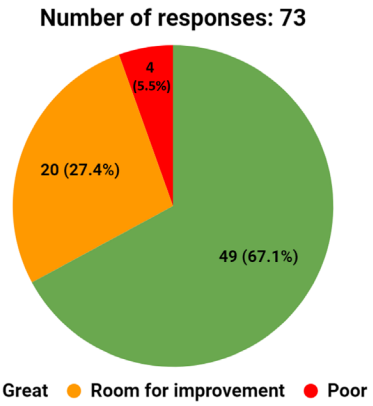

Figure 5. Preliminary evaluation from the feedback box at Cardiff University's Brain Games 2018 on the Giant Genes activity. A total of 73 responses were recorded. 49/73 (67.1%) "Great", 20/73 (27.4%) "Room for Improvement," and 4/73 (5.5%) "Poor."

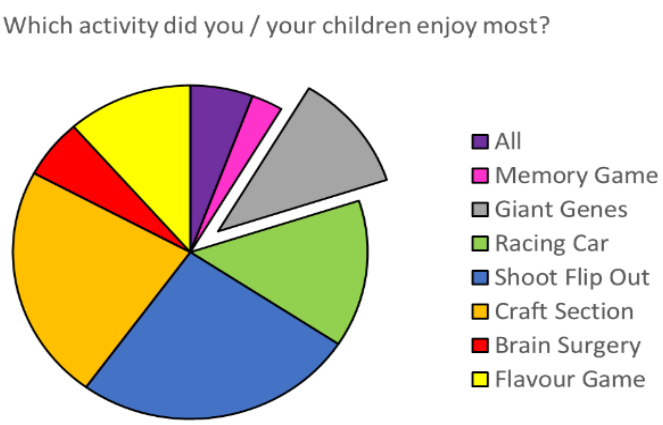

Figure 6. Respondent feedback on their favorite game from the 2018 Brain Games. 35 respondents answered the evaluation questionnaire upon leaving the event. 4/35 (11.4%) chose the Giant Genes game as their particular favorite.

Visit to Pontarddulais Comprehensive School. Two researchers visited Pontarddulais Comprehensive School as STEM Ambassadors to run a class-based activity on genetics. The sessions began with an interactive talk which was followed by the Giant Genes activity. As the students left the class, they were asked to indicate on the feedback box how they felt the activity went.

Results were combined for both classes with a total of 56 responses. 37/56 (66.1%) responded "Great," 14/56 (25.0%) responded "Room for Improvement',' and 5/56 (8.9%) responded "Poor" (Figure 7). Any future evaluation should incorporate more detailed feedback via a post-session survey rather than a feedback box.

Patient Interest Group Day. In order to trial the Giant Genes game with a different audience, it was presented as an activity at a patient interest day for families impacted by Huntington's disease. Although participation in the activity initially required some encouragement, numerous people and families played the game. The audience demographic were slightly different in this case, because the game could be used to explain the relevance of genetics to Huntington's disease, a condition which directly affected them or their family members.

The game generated a lot of discussion with researchers who were working on the condition, some in pre-clinical as well as clinical settings. At the end of the day, patients were asked to use the feedback boxes to indicate how they found the Giant Genes game. The feedback (Figure 8) revealed that 28/40 (70.0%) responded "Great," 7/40 (17.5%) responded "Room for Improvement," and 5/40 (12.5%) responded "Poor." These results further indicate the activity's popularity alongside the potential for further use and development of the game.

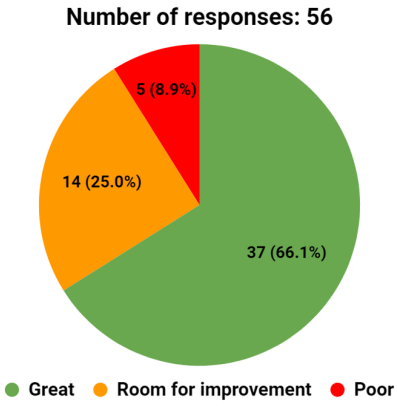

Figure 7. Preliminary evaluation from the feedback box at Pontarddulais Comprehensive School on the Giant Genes activity. A total of 56 responses were recorded. 37/56 (66.1%) "Great" 14/56 (25.0%), "Room for Improvement," and 5/56 (8.9%) "Poor."

Future Directions. Preliminary evaluation of the Giant Genes game revealed largely positive results (Figures 5-8) although the evaluation was at an early pilot stage. In future events, we will seek to further evaluate what players learnt after taking part in the game. The data generated (Figures 5-8) were intended to act as a preliminary evaluation to give the team an initial indication as to whether the game was well received by a range of audiences. Additional studies should now look to extend the preliminary evaluation to generate a more robust and thorough evaluation and to consider modifying and adapting the game for specific audiences. The future evaluation plan could consider post game knowledge, captured through pre and post event surveys, alongside feedback from the researchers to determine their views on running the game and interacting with the players. Furthermore, the game could be integrated into a range of workshops which focus on particular genetic conditions to provide a visual representation of the genetic cause of the disease.

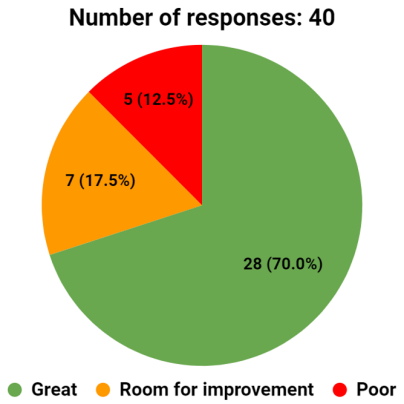

Figure 8. Preliminary evaluation from the feedback box at the patient interest group day on the Giant Genes activity. A total of 40 responses were recorded. 28/40 (70.0%) "Great." 7/40 (17.5%) "Room for Improvement," and 5/40 (12.5%) "Poor."

CONCLUSION

In this report we present the Giant Genes activity, a game that was originally created to engage audiences in a fun and interactive activity at Cardiff University's Brain Games. Initial pilot evaluation demonstrated that the activity was well received by a range of audiences including families, school children and patients. The preliminary results show that a simple hands-on game provides a mechanism for STEM researchers to positively engage with the varied audiences in the topic of genetics. Furthermore, feedback from people playing the game was largely positive and this demonstrates both feasibility and proof of concept that the game can be used at and integrated into future events.

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Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

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ABBREVIATIONS

DNA: Deoxyribonucleic Acid; mRNA: Messenger Ribonucleic Acid; STEM: Science, Technology, Engineering and Mathematics

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