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RANDOM SIMILARITY EFFECT OF HIGH SCHOOL STUDENTS IN PROBABILITY MATERIAL

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ABSTRACT

Artikel ini bertujuan untuk menganalisis bagaimana siswa SMA mengalami dan memanifestasikan *Random Similarity Effect (RSE)* dalam memahami materi peluang sebagai bentuk spesifik dari bias representatif. *RSE* merujuk pada kecenderungan siswa memilih pola yang tampak acak secara intuitif meskipun secara matematis semua kemungkinan memiliki probabilitas yang setara. Penelitian ini menggunakan pendekatan teoritis kognitivisme secara eksplisit, dengan fokus pada proses berpikir dan munculnya bias kognitif. Subjek penelitian adalah 36 siswa kelas X-D di SMAN 1 Turen. Data dikumpulkan melalui pemberian soal peluang kejadian yang dirancang untuk memicu bias *RSE*, diikuti dengan wawancara mendalam terhadap empat subjek terpilih. Analisis dilakukan dengan menggunakan rubrik indikator untuk mengklasifikasikan tingkat pemahaman siswa ke dalam tiga level. Hasil penelitian menunjukkan bahwa dua subjek berada pada Level 2 (terpengaruh *RSE* secara eksplisit), satu subjek pada Level 1 (jawaban benar tanpa pemahaman konseptual), dan satu subjek mencapai Level 0 (memahami konsep peluang secara logis dan bebas dari bias intuitif). Hasil ini menunjukkan bahwa sebagian besar siswa masih terjebak dalam penalaran intuitif, menegaskan pentingnya pendekatan pengajaran yang mendorong berpikir reflektif dan pemahaman mendalam terhadap konsep peluang.

This article aims to analyze how high school students experience and manifest Random Similarity Effect (RSE) in understanding probability material as a specific form of representative bias. RSE refers to the tendency of students to choose patterns that appear intuitively random even though mathematically all possibilities have equal probability. This study uses an explicit cognitive theoretical approach, focusing on the thinking process and the emergence of cognitive bias. The subjects of the study were 36 students of class XD at SMAN 1 Turen. Data were collected by giving probability problems designed to trigger RSE bias, followed by in-depth interviews with four selected subjects. The analysis was carried out using an indicator rubric to classify students' level of understanding into three levels. The results showed that two subjects were at Level 2 (explicitly affected by RSE), one subject at Level 1 (correct answer without conceptual understanding), and one subject reached Level 0 (understanding the concept of probability logically and free from intuitive bias). These results indicate that most students are still trapped in intuitive reasoning, emphasizing the importance of a teaching approach that encourages reflective thinking and deep understanding of the concept of probability.

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1. INTRODUCTION

Understanding the concept of probability in mathematics is an important indicator for tenth-grade students, as this material forms the basis for developing logical and analytical thinking skills, particularly when dealing with situations involving uncertainty and decision-making. The mathematical concept used to examine the likelihood of an event occurring is the concept of probability (Natalia, et al., 2024). The probability of an event is a number that expresses how likely an event is to occur in a given sample space. Probability relates the concept of chance (possibility) to events (Lumbantoruan, 2019). The greater the probability of an event, the greater the likelihood of that event occurring (Darmawan, et al., 2023). This understanding is not only important in the context of mathematics learning, but also has relevance in everyday life because sometimes events that occur can be predicted or guessed, such as predicting the weather, calculating the probability of a game score, calculating the probability of inheritance of traits, and so on.

In their learning practices, many students still have difficulty distinguishing between random events and patterns that intuitively seem familiar. This difficulty can be explained by Dual Process Theory, which states that human reasoning works through two systems: System 1, which is fast, intuitive, and automatic, and System 2, which is slower, analytical, and requires deep thought. When learning about probability, students tend to rely more on System 1, so their answers are often intuitive, i.e., given quickly and confidently without logical verification (Munairoh, et al., 2023). Intuitive thinking is efficient but prone to bias, especially when learning about probability, which involves uncertainty.

One bias in thinking that occurs when a person makes a judgment about something based on a recent event is called the recency effect (Radjanae, 2017). Recency is divided into two types, namely positive recency and negative recency. Positive recency occurs when students make judgments or predictions about an event because it has just happened. The tendency of positive recency is to predict the same results as in the past and is related to everyday problems that are often encountered (Darmawan, et al., 2023). Meanwhile, negative recency is the tendency to predict results that are opposite to the past or recent events. A person will tend to expect a change in results when the same results appear consecutively (Darmawan, et al., 2023).

In the context of probability, this recency effect can reinforce students' tendency to assume that past events will influence the outcome of subsequent random events, even though theoretically, probability produces the same outcome for each event. As a result, students often get caught up in deterministic thinking (the belief that every event is the result of a previous event). Another bias that often arises is the representativeness heuristic, which is the tendency to judge something as more likely to occur if it appears to fit the description of randomness. This is the basis of the random similarity effect. When someone considers the probability of a random event to be greater than the probability of the same event, the random similarity effect occurs (Darmawan, et al., 2022). In this case, the human mind is easily distracted. Students who have not developed the concept of probability tend to rely on intuitive thinking, which is prone to

biases such as the random similarity effect. From the perspective of Dual Process Theory, RSE is a form of System 1 dominance, which relies on surface similarity without considering that all random sequences of events have the same probability.

As researchers found in a preliminary study presented in Figure 1 below.

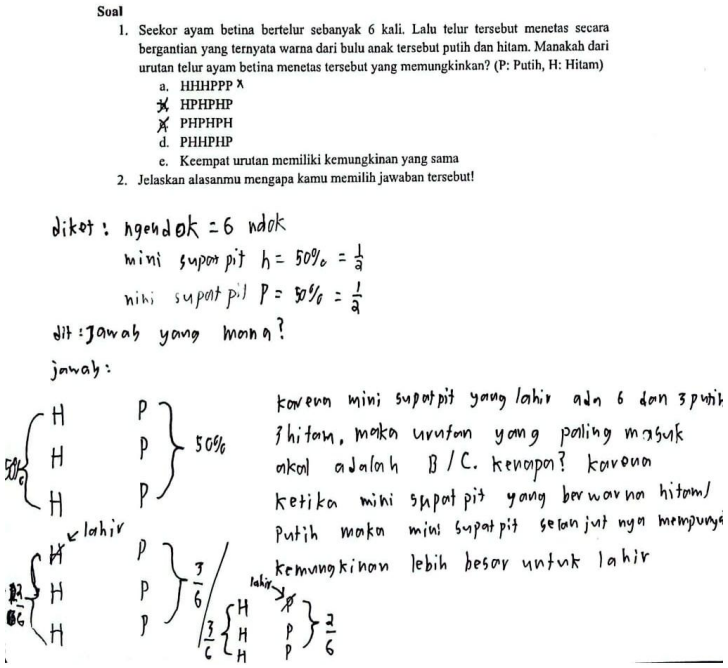


Figure 1. Student Responses to Preliminary Study Questions

Furthermore, the researchers interviewed students to find out the reasons behind their answers. The interviews are presented in Interview 1 as follows.

Researcher	:	From the questions you have worked on, what do you think the material is about?
Student	:	Like determining the probability of the order in which chickens are born, so it's included in the probability material.
Researcher	:	Then you answered choices A and B. Are you sure about your answers? What are your reasons?
Student	:	**Sure, ma'am.** So, in the question, there are 6 chicks, 3 black and 3 white. Now, we are asked to determine the approximate order of their birth, whether the black ones were born first or the white ones. From there, **I thought that if the first one born was a white chick, then the probability of a black chick being born next would be greater than a white chick, and vice versa.**
Researcher	:	When answering, did you immediately think of the answer or did you think about the formula used to solve this problem?
Student	:	**Let's get straight to the answer,** if I may.
Researcher	:	Were you sure about answers A and B when you first started working on the test, or did you have doubts?
Student	:	**There was some doubt because option D could be correct, but I chose**

		B and C because I thought they were the most likely to happen. In option D, the white one dies, then the black one is born, followed by another black one. That could happen, but the percentage is lower than for options B and C.
Researcher	:	Then, regarding the reason you wrote, what are your thoughts on that?
Student	:	Yes, as I explained earlier, ma'am. **If the first chick born is black, it is likely that the next chick will be white, and the percentage is also greater than that of black chicks being born, and vice versa.**
Researcher	:	Since you said that you looked at the answer right away, did you think about the probability formula while working on it?
Student	:	**When I read the question and answer, I didn't think about the formula. I immediately used logic and understood** what was being asked, so I didn't use the formula. I immediately thought of the answer and then wrote the formula to explain my reasoning.

Interview 1. Reasons Students Chose Their Answers

The student chose two answers, namely options B and C. Based on the interview results, the student was influenced by their perception of the sequence of results, rather than the mathematical concept of probability. The student showed a tendency to determine the answer based on the possibility of a result that seemed more balanced and reasonable according to their own logic, without first using the probability formula. The student stated that if the white chick hatched first, then the probability of the next chick hatching being black was greater, and vice versa. This shows the influence of the condition where the student assumed that the patterns HPHPHP and PHPHPH had a greater probability of occurrence, even though all possibilities had the same probability in the context of random events. Furthermore, the student also mentioned that they “had doubts” when answering the question because there were alternative choices that were intuitively possible, but the student still chose the percentage that was greater according to their thinking. This statement indicates that the assessment of probability was based on subjective selection rather than objective calculation. Based on the answers and the results of the researcher's interviews with students, this reinforces the finding of a random similarity effect occurring in 10th grade students. The student also confirmed that the new probability formula was written down after the student had arrived at the answer, which means that the initial decision-making process was not based on the concept of probability, but on visual intuition and personal logic.

Based on the results of preliminary studies conducted by researchers, it is important to conduct a more in-depth study of the random similarity effect of high school students in probability material through tests and interviews. Table 1 presents several previous studies conducted by experts and their differences.

Table 1. Previous Research

Author (Year)	Title	Research Focus
Fischbein et al., (1984)	Does the Teaching of	Representative heuristics in

	Probability Improve Probabilistic Intuitions?	students' probabilistic reasoning
Lamprianou et al., (2003)	A Scale for Assessing Probabilistic Thinking and the Representativeness Tendency	Developing a scale to measure representative probabilistic and heuristic thinking
Ingram (2022)	*Randomness and probability: exploring student teachers' conceptions*	- Qualitative/exploratory research on the concepts of randomness and probability among student teachers. - Analyzing how the meaning of randomness is understood and how heuristic tendencies (e.g., representativeness/similarity) emerge in their reasoning.
Damayanti et al., (2025)	Random Similarity Effect of High School Students in Probability Material	Mapping the level of achievement of the random similarity effect.

Based on Table 1, research by Fischbein, et al., (1984) also found that even though students had been taught the concept of probability, many of them still believed that random results should appear balanced and evenly distributed in the short term. Lamprianou, et al., (2003) developed a scale that aims to measure the way of thinking or mental strategy (heuristics) in which a person assesses the probability of an event based on how similar (representative) the event is to the image in their mind, rather than based on objective data calculations. This scale allows for the identification of representativeness bias in general, but does not yet specifically point to the concrete form or manifestation of the concept in observable behavior, thought patterns, or events, such as the random similarity effect. Research conducted by Ingram (2022) provides a new perspective on how the concept of randomness is understood by learners, in this case prospective mathematics teachers. Through a qualitative and exploratory approach, Ingram found that many study participants had a limited understanding of randomness, especially when they were asked to assess patterns or sequences of events that should be random. These findings show that prospective teachers still tend to use heuristics such as representativeness and similarity heuristics, which is the tendency to assess a random sequence based on its similarity to the ideal random pattern they imagine. This reflects intuitive thinking that is inconsistent with the principles of probability and is directly related to the emergence of the random similarity effect, which is when a person misjudges the probability of an event that appears "similar" or visually balanced.

Furthermore, based on the issues and focus of these studies, this study differs from previous studies. Previous studies have not achieved a level of random similarity effect. Therefore, this study shows the need for an approach that not only identifies the existence of a random similarity effect but also maps the level of achievement of the random similarity effect. The levels of achievement referred to are levels 0, 1, and 2 in the random similarity effect. The random similarity effect greatly influences students' correct answers. Therefore, the level of achievement of the random similarity effect needs to be known. Once this level of achievement is known, researchers can take action or implement strategies in delivering material so that there are no errors in thinking about the probability of events.

2. METHODS

2.1. Type of Research

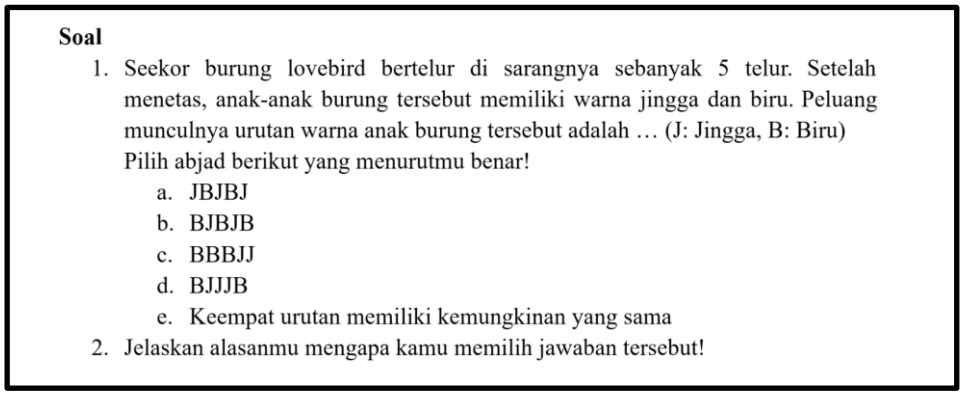
This study uses a qualitative descriptive approach based on cognitive theory. This approach was chosen because the focus of the study is to examine the thinking process of students in solving probability problems, not just the final results. The research design is aimed at identifying forms of cognitive bias, particularly the Random Similarity Effect (RSE), and mapping its level of occurrence in students.

2.2. Research Subject

The researcher selected the subjects of this study, which consisted of 34 students in class X-D at SMAN 1 Turen in the 2024/2025 academic year, because the subjects had studied probability. This research was conducted while the researcher was implementing the Teaching Assistance program in the even semester. The selection of interview subjects was carried out using purposive sampling, namely 4 out of 34 students were selected because they were indicated to have experienced a random similarity effect. Purposive selection was based on conceptual criteria, not statistical criteria, thus allowing for in-depth exploration of the subjects' relevant mindsets.

2.3. Data Collection

Data collection in this study was conducted by presenting questions about the probability of events shown in Figure 2. Selected subjects were then interviewed and assessed using an indicator rubric to determine their eligibility as subjects. The questionnaire, indicator rubric, and interview guidelines used in this study had previously been validated by a professor in the field of mathematics education with more than 15 years of experience.



Soal

1. Seekor burung lovebird bertelur di sarangnya sebanyak 5 telur. Setelah menetas, anak-anak burung tersebut memiliki warna jingga dan biru. Peluang munculnya urutan warna anak burung tersebut adalah … (J: Jingga, B: Biru)
   Pilih abjad berikut yang menurutmu benar!
   a. JBJBJ
   b. BJBJB
   c. BBBJJ
   d. BJJJB
   e. Keempat urutan memiliki kemungkinan yang sama
2. Jelaskan alasanmu mengapa kamu memilih jawaban tersebut!

Figure 2. Research Questions

The interview guidelines used were semi-structured interview guidelines aimed at gathering information from the subjects in a more flexible manner or in accordance with the circumstances. The interviews were conducted to obtain information that had not been revealed in the subjects' written responses. Table 2 below shows the interview guidelines used in this study.

Table 2. Interview Guidelines

No.	Interview Item	Level Achievement
1	Why did you choose option e to answer this question? Are you sure?	Level 0, Level 1
2	Explain why you chose answer e?	Level 0, Level 1
3	Why did you choose option a/b/c/d to answer this question? Are you sure?	Level 2
4	Explain why you chose answer a/b/c/d?	Level 2

2.4. Data Analysis

The data from this study consists of written responses from subjects, researcher notes, and interview recordings. The data was then analyzed using a rubric of indicators for achieving the random similarity effect level, as shown in Table 3. This indicator rubric was developed based on dual-process theory and representative heuristics.

Table 3. Random Similarity Effect Indicator Rubric

	Level Achievement	Indicator
Random Similarity Effect	Level 0	1. Students realize that the concept of probability is that events have equal chances when there is uncertainty about the outcome. 2. Students answer e. All four sequences have equal chances. 3. Students can give the correct reason.
	Level 1	1. Students realize that the concept of probability is that events have equal chances when there is uncertainty about the outcome. 2. Students answer e. All four sequences have equal chances. 3. Students cannot give the correct reason.
	Level 2	1. Students do not realize that the concept of probability is that events have equal chances when there is uncertainty about the outcome.

2. Students give answers other than option e.
3. Students can provide reasons.

3. RESULTS AND DISCUSSION

3.1. Results

This section details the results of 34 written test questions on the random similarity effect among 10th grade high school students, which were grouped into several answer choices. The results of the 34 subjects' answers are presented in Table 4 below.

Table 4. Grouping of Written Test Answers for 34 Subjects

Answer Choices	Statement of Reasons	Number of Subjects
a. JBJBJ	Accurate	2
	Inaccurate	0
b. BJBJB	Accurate	1
	Inaccurate	0
c. BBBJJ	Accurate	0
	Inaccurate	1
d. BJJJB	Accurate	0
	Inaccurate	1
e. All four sequences have the same probability.	Accurate	13
	Inaccurate	16

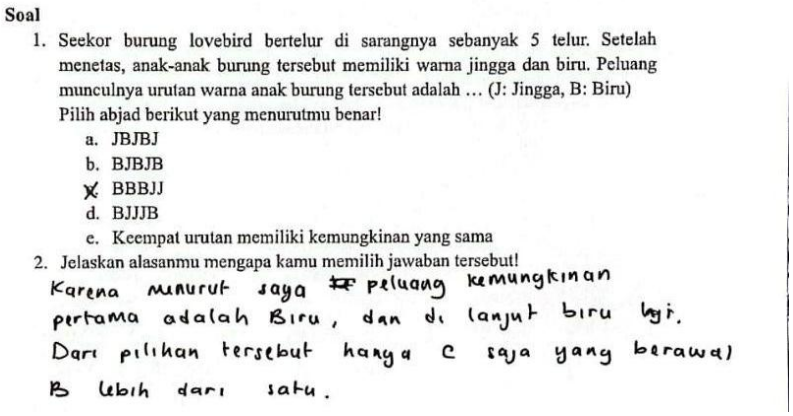
Table 4 shows the grouping of subjects' answers in the written test conducted prior to the interview to obtain more in-depth answers. From Table 4, it can be seen that although the subjects chose different answers, most of them chose answer e. All four options have the same probability. The division of the table columns into correct and incorrect provides an initial picture of how subjects understood and responded to the questions given in the test. The purpose of this grouping is to select subjects who have relevant answers to be interviewed in more depth about their thought processes and to validate the random similarity effect phenomenon at its levels, namely level 0, level 1, and level 2.

Through the written test, four subjects were selected as representatives to be interviewed by the researcher. Based on the results of the interviews conducted by the researcher, several

thoughts were obtained from the subjects interviewed. The purpose of these interviews was to validate the question of whether the subjects experienced the random similarity effect. There were several questions used as guidelines in the interviews, but the researcher also used semi-structured questions in conducting the interviews with the aim of finding out more details about the subjects' thoughts. The following are the results of the written test and interviews with the 4 selected subjects.

3.1.1 Subject 1

Subject 1 is the subject who stated that the probability of the sequence of events of the orange and blue birds hatching is that the blue bird will hatch first. This is presented in Figure 3 and reinforced by Interview 2 presented below.



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1. Seekor burung lovebird bertelur di sarangnya sebanyak 5 telur. Setelah menetas, anak-anak burung tersebut memiliki warna jingga dan biru. Peluang munculnya urutan warna anak burung tersebut adalah … (J: Jingga, B: Biru)
   Pilih abjad berikut yang menurutmu benar!
   a. JBJBJ
   b. BJBJB
   c. BBBJJ
   d. BJJJB
   e. Keempat urutan memiliki kemungkinan yang sama
2. Jelaskan alasanmu mengapa kamu memilih jawaban tersebut!

Karena menurut saya peluang kemungkinan pertama adalah Biru, dan di lanjut biru lagi. Dari pilihan tersebut hanya C saja yang berawal B lebih dari satu.

Figure 3. Subject 1's response

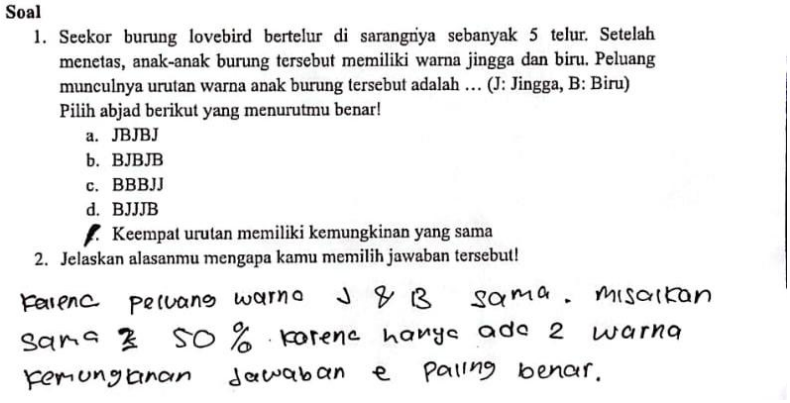
Researcher	:	What do you think this is about?
Subject 1	:	probability question
Researcher	:	For this question, you chose answer C. Why did you choose this answer? Are you sure about your answer?
Subject 1	:	Actually, I'm not sure, ma'am.
Researcher	:	In answer C, it starts with blue first, and the reason you wrote also confirms that blue appears first. When you first read this question, did you immediately think of answer C, or how did you come to that conclusion?
Subject 1	:	At first I was confused, ma'am. **Then it suddenly occurred to me that it appeared blue at first.**
Researcher	:	Why did you think of blue first? Why not orange?
Subject 1	:	**I don't know, ma'am, I can only think of blue.**
Researcher	:	Oh, so it's random, and suddenly blue comes to mind. Did you also see that in the answer choices, option C has blue appearing three times in a row, so the probability is greater?
Subject 1	:	**Yes, ma'am, it suddenly occurred to me, then I saw answer choice C, so I chose that.**

Interview 2. Subject 1's Reason for Choosing the Answer

Based on the results of the interview with Subject 1, it is known that the selection of answers in probability questions is based on spontaneous thinking and lacks complete confidence. The subject revealed that he chose answer C because the color blue suddenly came to mind for the first birth without any deep logical and mathematical consideration. When asked further, the subject admitted that he had only thought of the color blue from the start, and that was what prompted him to choose that answer. This process shows that the subject's decision-making was influenced more by visual perception and intuition than by a conceptual understanding of probability.

3.1.2 Subject 2

Subject 2 is a subject who states that the probability of the sequence of events of orange and blue birds hatching is that all the probabilities of the colors that come out are equal. This is presented in Figure 4 and reinforced by Interview 3 presented below.


Soal

1. Seekor burung lovebird bertelur di sarangnya sebanyak 5 telur. Setelah menetas, anak-anak burung tersebut memiliki warna jingga dan biru. Peluang munculnya urutan warna anak burung tersebut adalah ... (J: Jingga, B: Biru)
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   b. BJBJB
   c. BBBJJ
   d. BJJJB
   e. Keempat urutan memiliki kemungkinan yang sama
2. Jelaskan alasanmu mengapa kamu memilih jawaban tersebut!

Karena peluang warna J & B sama. misalkan sama 2 50 % karena hanya ada 2 warna kemungkinan jawaban e paling benar.

Figure 4. Subject 2's answers

Researcher	:	In this question, you chose answer E. Are you sure about your answer? What is your reasoning?
Subject 2	:	**Sure, ma'am, I chose that answer because it's possible that the bird was born randomly and all four other answers could have appeared.**
Researcher	:	Okay, so in your opinion, the chances are that blue will appear first or orange will appear first. Then, when reading the question, do you immediately focus on answer E or how?
Subject 2	:	Actually, I'm still unsure, ma'am. **At first, I chose answer B, ma'am.**
Researcher	:	What is the reason you chose B?
Subject 2	:	**I don't know, ma'am. At that time, I only had B on my mind.**
Researcher	:	Why did you end up choosing answer E?
Subject 2	:	Yes, because **after reading it again, it's possible that all four answers are correct.**

Researcher : So, after hesitating, you reread the question and finally chose answer E. While working on it, did you think about the concept of probability in solving this problem?

Subject 2 : **No, ma'am, I went straight to the answer.**

Interview 3. Subject 2's Reason for Choosing the Answer

The interview with subject 2 revealed that the answer selection process was done intuitively with the belief that all possibilities could occur randomly. The subject chose answer E because he thought that the birth of birds could occur in any order, so all options could be correct. However, the subject was initially unsure and had chosen answer B because at that time only B came to mind. After rereading the question, the subject concluded that all answers could be correct, which then led them back to choice E. This reflects that the subject's decision-making was influenced more by general reasoning and intuition than by an explicit understanding of the concept of probability.

3.1.3 Subject 3

Subject 3 is a subject who states that the probability of the sequence of orange and blue birds hatching is that all color probabilities are equal and there is an analogy in the process. This is presented in Figure 5 and reinforced by Interview 4 presented below.

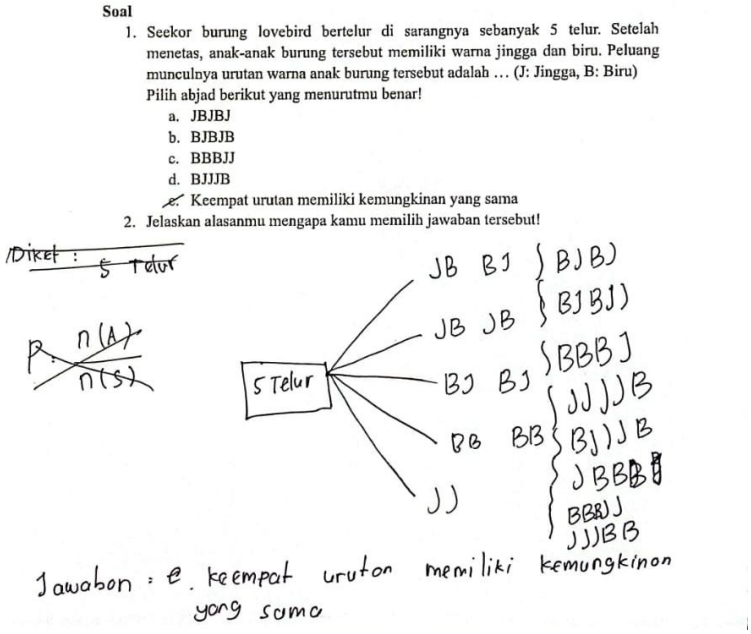


Figure 5. Subject 3's response

Researcher : When answering this question, you chose answer E. Are you sure about your answer?

Subject 3 : **Actually, I'm sure the answer is A**, but I saw that most of my **friends chose E, so I just followed suit.**

Researcher : Why did you think of answer A?

Subject 3 : Because I think there are **only two possible colors: orange and blue.**

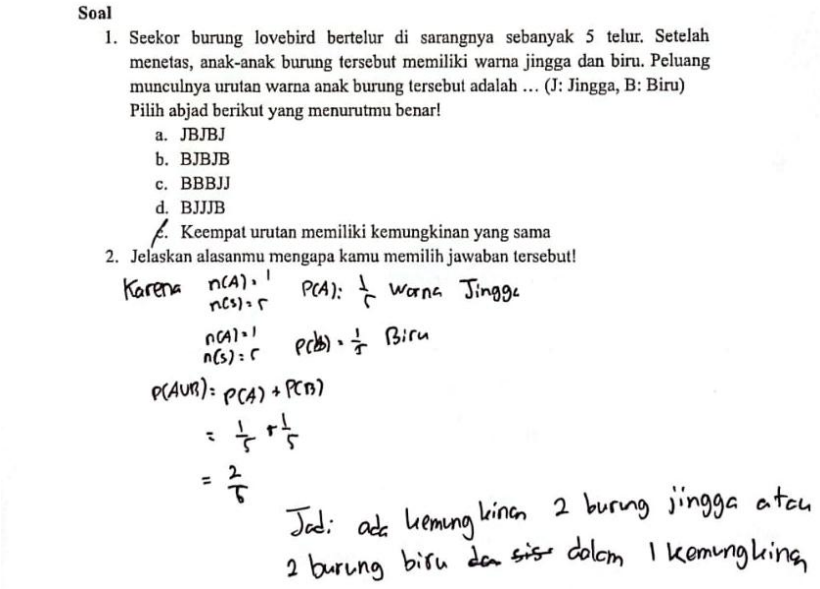
		There are 5 eggs in the sample space, so it's possible that the results will be orange, blue, orange, blue, and then orange again.
Researcher	:	Why did the thought come to mind first? It could have been blue that appeared first.
Subject 3	:	Because **I saw in the question that orange was written first, then blue.**
Researcher	:	Then here you write down the reason for choosing answer E. Try to explain why you wrote that reason.
Subject 3	:	I **just reversed the model, ma'am.** It was originally JBJB, then I reversed it to BJBJ.
Researcher	:	So, in your opinion, selecting a sample space is just a matter of flipping it over?
Subject 3	:	Yes, ma'am.

Interview 4. Subject 3's Reason for Choosing the Answer

Based on the results of the interview with subject 3, it was revealed that the selection of answers in probability questions was not entirely based on conceptual understanding, but was influenced by several external factors and intuition. The subject initially felt confident with answer A because he considered that the colors that appeared were only orange and blue, and the possibility of color combination sequences in five samples. However, because the majority of their friends chose answer E, the subject followed that choice without full confidence. The subject also tried to model the color sequence randomly and reversed the pattern from JBJB to BJBJ without using in-depth calculations. This shows that subject 3 made decisions based on patterns that were visually and intuitively similar.

3.1.4 Subject 4

Subject 4 is a subject who states that the probability of the sequence of events of orange and blue birds hatching is that all the probabilities of the colors that come out are equal, and there is a formula on the answer sheet provided. This is presented in Figure 6 and reinforced by Interview 3 presented below.



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   e. Keempat urutan memiliki kemungkinan yang sama
2. Jelaskan alasanmu mengapa kamu memilih jawaban tersebut!

Karena $\frac{n(A)}{n(S)} = \frac{1}{5}$ $P(A) = \frac{1}{5}$ warna Jingga

$\frac{n(A)}{n(S)} = \frac{1}{5}$ $P(B) = \frac{1}{5}$ Biru

$P(A \cup B) = P(A) + P(B)$

$= \frac{1}{5} + \frac{1}{5}$

$= \frac{2}{5}$

Jadi: ada kemungkinan 2 burung jingga atau 2 burung biru dan sisa dalam 1 kemungkinan

Figure 6. Subject 4's answers

Researcher : In this question, you chose answer E. Are you sure about your answer?

Subject 4 : **I'm not quite sure, ma'am.**

Researcher : Why did you choose answer E?

Subject 4 : Because **all answers have the same probability. After I calculated the odds, they are the same, but I'm still confused about the order. How do I find it?**

Researcher : Then when answering this, did you immediately go for answer E or how?

Subject 4 : **I see that answer A is most likely, but answer B also has a high probability based on my logic because the sequence is regular.** Actually, it is possible for blue to be born again and again, but after I tried using the formula, it seems impossible.

Researcher : First, you chose option A, but then you ended up choosing answer E. Can you explain why?

Subject 4 : **When I chose that answer, I used the formula as I wrote it down and calculated it in my book. After that, I thought that since the probability was ⅖, there could be 2 blue or 2 orange, and the rest would be 3. From choices A to D, I was still confused about the order, so I chose E.**

Researcher : Are you sure you chose answer E? What made you sure to choose that?

Subject 4 : **Actually, it's 50-50. Then in these four answers, the order is the same, there are 2 blue and 2 orange.** In my opinion, **they are almost the same, the important thing is that the numbers are different.**

Researcher : Okay, so you're doing this based on a formula and not randomly

choosing answers?

Subject 4 : **Yes, ma'am, I did it using a formula.**

Interview 5. Subject 4's Reason for Choosing the Answer

Based on the interview results, Subject 4 showed an effort to use a rational approach in solving the probability problem. Initially, the subject was hesitant and not entirely sure of the answer, but tried to calculate it using the formula they had learned. The subject realized that all options had almost the same probability, but was still confused in determining the order of the colors' appearance. Although they considered answers A and B because the order made sense logically, the subject finally chose answer E after trying to use the formula, even though their confidence was only about 50%. This shows that Subject 4 tried to link conceptual knowledge with intuition, but still experienced confusion in technical application, especially regarding the order of events.

3.2. Discussion

The findings of this study reveal that most of the tenth-grade students who were the subjects experienced a random similarity effect in solving probability problems, particularly in the context of the sequence of bird color hatching events. This phenomenon aligns with recent studies indicating that students often rely on intuitive reasoning and heuristic patterns rather than formal probabilistic analysis, leading to misconceptions about randomness and sequence similarity (Erbas & Ocal, 2024; Ingram, 2024). Such reasoning is typically unstructured and guided by surface familiarity or perceptual salience, rather than conceptual understanding of probability laws (Kaplar, Lužanin, & Verbić, 2021). Intuitive thinkers often reach conclusions through affective or impulsive cognitive routes, producing a sense of correctness even in the absence of analytical verification (Manjunath, 2025; Nabbout-Cheiban, 2017). These findings confirm that probability misconceptions rooted in intuitive similarity judgments persist among secondary learners across diverse educational contexts (Prameswari et al., 2023).

Based on the results of interviews and the random similarity effect achievement indicator rubric, it was found that students had varying levels of understanding that reflected the existence of the random similarity effect (RSE) in their thinking. This aligns with recent cognitive research indicating that individuals often exhibit bias toward perceived randomness or diversity in event sequences, rather than relying on probabilistic equivalence (Gronchi, et al., 2021; Stojanoski & Cusimano, 2022). People tend to choose sequences with more apparent variation—a phenomenon known as the random similarity effect bias—which emerges from heuristic-driven and intuitive reasoning processes rather than analytical computation (Fusco, et al., 2023; Zhang, 2024).

To map students' understanding of probability concepts and their susceptibility to the RSE, an achievement rubric was implemented with three hierarchical levels. At Level 0, students understand that all event sequences possess equal probability and can articulate logical reasoning (Kahneman & Sibony, 2021). At Level 1, students recognize the equal probability but fail to justify their reasoning correctly, often blending intuitive and formal elements (Batanero & Chernoff, 2022). Meanwhile, at Level 2, students fail to recognize probabilistic equality and select answers based on intuition, perceptual salience,

or visual similarity—a pattern consistent with heuristic bias theories in probability education (Erbas & Ocal, 2024).

The results show that most students did not explicitly calculate probabilities but relied on their intuition regarding the sequence or pattern of color appearances. This is because visual intuition became dominant (Baumanns, et al., 2024). This can be seen in subjects 1 and 3, who were at level 2. They chose answers based on patterns that were considered more random visually without realizing that all sequences had the same probability. These findings are in line with the results of research by Gronchi, et al., (2021), which shows that visual representations that are considered more random often mislead students' probabilistic reasoning because they rely on the representativeness heuristic. This bias arises because two sequences that appear visually similar or balanced tend to trigger the perception that the pattern better represents "natural randomness." This condition causes students to prefer patterns that are visually apparent over other patterns that probabilistically have the same odds. Cognitively, the similarity of these patterns causes interference in working memory, making it difficult for students to distinguish between actual probability values and their visual perceptions. As a result, decision-making is based more on intuitive perceptions than on mathematical analysis in line with the concept of probability. Intuition often dominates probabilistic reasoning (Faure, 2019). However, in subject 3, decision-making was not based on an understanding of probability concepts but was influenced by intuition and following visual patterns. This reflects the characteristic of the random similarity effect, which is the tendency to choose patterns that appear random, balanced, or intuitive without considering the actual probability value (Tversky, et al., 1990). Subjects' difficulty in understanding the questions was also caused by the habit of memorizing without understanding the mathematical concepts (Yulfiana, 2016; Anggraini et al., 2022).

Subject 2 is at level 1 because they were able to choose the correct answer—that all sequences have the same probability—but could not provide the correct conceptual reasoning. The explanation they gave tended to be illogical or emotionally grounded, relying on feelings or guesswork rather than analytical justification, indicating the dominance of System 1 intuitive processing over System 2 analytical reasoning (Shye & Viale, 2025; De Neys, 2022). Cognitively, this shows that the student has not yet constructed a stable conceptual framework in probability reasoning, so the decision-making process is guided more by fast, associative thought patterns than by deliberate computation (Evans & Stanovich, 2023).

Although the student achieved the correct answer, their underlying cognitive structure remains weak because they do not yet understand why all sequences have the same probability. This aligns with findings that correct responses do not always reflect conceptual mastery, particularly when intuitive heuristics override reflective reasoning (Morsanyi & Szűcs, 2022; Krajbich, 2024). Such conditions allow the random similarity effect and related biases to reappear in varied contexts due to insufficient conceptual inhibition of intuitive dominance (Kahneman & Sibony, 2021). Hence, accuracy in answers does not necessarily indicate cognitive maturity—a principle central to the cognitivist approach, which emphasizes the process of thought construction rather than merely its outcomes (Kartikasari, 2022).

On the other hand, subject 4 successfully achieved level 0, which indicates a high level of conceptual understanding in addressing probability questions. This subject not only chose the mathematically correct answer but also demonstrated reflective thinking by providing a logical justification that each sequence has the same probability. This reasoning is in line with the basic principle of equiprobability, which states that in a uniform sample space, each outcome has the same probability (Jones, et al., 2007). This difference shows that when students have a strong conceptual representation, the analytical system will inhibit the influence of the similarity heuristic, so that RSE does not appear. In the context of this study, subject 4 represents how learning that emphasizes understanding probabilistic structures rather than merely mechanical problem-solving exercises can help students avoid the random similarity effect bias.

4. CONCLUSION

The results of this study reveal that the Random Similarity Effect (RSE) remains a significant cognitive challenge in probability learning at the high school level. Students' tendency to judge randomness based on visual similarity shows that representativeness bias influences their decision-making process. Based on in-depth interviews with four subjects, it was found that only one student demonstrated mature conceptual understanding (Level 0), while the rest showed varying degrees of influence by bias (Levels 1 and 2). This reflects that even though students can give the correct answer, they do not necessarily have a strong probabilistic basis for their thinking. There were students who answered correctly but copied their friends' answers. Through interviews and in-depth independent explanations, it was still found that students experienced RSE. This proves the importance of evaluating not only the final result but also the underlying thought process. Using a cognitivism approach, this study emphasizes the importance of exploring students' thought processes, not just the final results of their answers. This study affirms the need for more reflective and conceptual teaching strategies so that students can build a more accurate probabilistic thinking framework and avoid intuitive biases such as RSE.

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