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SERIAL POSITION EFFECT IN GROUP DECISION-MAKING

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Purpose: The paper investigates the presence of the serial position effect in group decision-making. The aim is to explore how this cognitive phenomenon, known for enhanced recall of items at the beginning (primacy) and end (recency) of a sequence, may affect outcomes in collective evaluations.
Design/methodology/approach: The study examines voting methods commonly employed in classical music competitions, sports, and project evaluations, some of which are specifically designed to reduce manipulation or the influence of outliers. An experimental procedure was implemented in which participants ranked an identical set of alternatives twice, with the order of presentation systematically varied between rounds. Statistical analyses, including Kendall tau, swap distance, and transposition distance, were used to compare voting outcomes between rounds. The research is situated within the fields of behavioral economics and social choice theory.
Findings: The results demonstrate that the serial position effect influences the tested voting methods, although the impact is not consistent across all methods.
Research limitations/implications: The primary limitation of the study is the exclusive use of economics students as participants. Future research should include individuals with backgrounds in music or sports to provide a broader perspective.
Practical implications: The findings provide practical guidance for designing equitable and robust voting systems in contexts such as classical music and sports competitions.
Originality/value: This study introduces a novel perspective by examining the serial position effect in group decision-making. The analysis is relevant both to researchers in social choice theory and behavioral economics and to practitioners involved in developing voting rules for competitions.
Keywords: serial position effect, group decision-making, voting methods, experiment.
Category of the paper: Research paper.

1. Introduction

A wide variety of voting methods exist, each with its own characteristics and theoretical justifications. Arrow (1951) famously demonstrated that no voting system can satisfy all desirable criteria for a collective decision-making procedure — a result known as the impossibility theorem. Since then, numerous additional impossibility results have been developed, highlighting the need to investigate both the strengths and weaknesses of specific voting procedures.

This paper focuses on one such potential weakness: the serial position effect, a cognitive bias in which the order of presented options influences how individuals evaluate or remember them.

In cognitive psychology, the serial position effect refers to the tendency to recall the first (primacy effect) and last (recency effect) items in a sequence more accurately than those in the middle. First described by Ebbinghaus (1908), this phenomenon has since been extensively studied and replicated (e.g., Jahnke, 1965; Neath, 2003; Gerig, Zimbardo, 2010).

Three classic studies help to illustrate the serial position effect:

- *Word recall* (Jahnke, 1965): Participants listened to word lists of varying lengths and were later asked to recall the words either immediately or after a delay. Words at the beginning and end were recalled more reliably than those in the middle. A delay before recall weakened the recency effect but strengthened the primacy effect.
- *Judicial decisions* (Miller, Campbell, 1959): Participants acted as jurors in a simulated courtroom setting. Depending on the order of arguments and the delay before making a judgement, either the primacy or recency effect was observed. When a substantial delay was introduced before evaluation, the serial position effect disappeared.
- *Personality evaluation* (Asch, 1946): Participants formed impressions of a person named Steve based on a list of traits. Even though all participants received the same traits, those who encountered "smart" first formed more favourable impressions than those who began with "jealous", demonstrating a primacy effect in social judgment.

This study examines whether the serial position effect can also influence collective decisions made under formal evaluation procedures—particularly in classical music competitions. In such contexts, contestants typically appear in a fixed order determined by a random draw, and the same jury evaluates all participants across several rounds. As a result, certain contestants may consistently appear at the beginning or end of each stage.

Previous research supports the concern that such ordering could bias evaluations. Manturzewska (1970) analysed the 6th International Chopin Piano Competition (1960) and found evidence of position effects, later revisited by Chmurzyńska (2006, 2015). Although Manturzewska's work remains little known outside Poland, it is consistent with other studies (e.g., Ginsburgh, Ours, 2003; Flores, Ginsburgh, 1996; Fiske, 1977; Wapnick et al., 1993).

Similar effects have also been reported in sports judging. Tyszka and Wielochowski (1991), studying boxing competitions, recommended rotating judges between rounds — an approach that may be unfeasible in music competitions with large juries. Other studies (e.g., Boen et al., 2013; Gambarelli et al., 2019; Bertini et al., 2010) have examined psychological biases and collusion in evaluative settings.

It is well known that different voting methods can produce different outcomes, even when the underlying preferences remain constant (Nurmi, 2010). This paper investigates whether some of these methods are more vulnerable to the serial position effect than others.

To this end, we conduct controlled experiments in which participants rank the same set of alternatives twice, with the order of presentation altered between rounds. We apply a range of voting methods commonly used in classical music competitions, including methods designed to reduce the influence of outliers or to guard against strategic manipulation.

The remainder of the paper is structured as follows: Section 2 presents the voting methods under study. Section 3 outlines our hypotheses regarding their vulnerability to the serial position effect. Section 4 describes the experimental design. Section 5 presents the results and statistical analysis. Section 6 discusses the findings, their implications, and limitations. An appendix contains the raw data from the experiments.

2. Voting methods

This section outlines the voting methods analysed in the study. These include both traditional procedures and more advanced approaches designed to reduce bias, outlier influence, or strategic manipulation. Many of the methods are widely used in classical music competitions.

2.1. Plurality voting

In plurality voting, each voter selects their single most preferred alternative. The alternative receiving the greatest number of votes is declared the winner. This is the simplest form of voting and was implicitly used in the examples described in the Introduction. In our context, we computed the percentage of participants who supported each alternative.

2.2. Scoring methods

In scoring methods, voters assign numerical scores to all alternatives. The scores are then aggregated by summing across voters. The alternative with the highest total score is selected as the winner. This approach is widely applied in both academic and competitive settings.

2.3. Borda Count

The Borda Count is a ranking-based scoring system in which each voter ranks all n alternatives from best to worst, with no ties permitted. Several variants of the method exist, differing only in the point assignment scheme:

– *Standard Borda (version 1):* The top-ranked alternative receives n points, the next $n-1$ points, and so on down to 1 point for the lowest-ranked alternative.
– *Modified Borda (version 2):* The top-ranked alternative receives $n-1$ points, the next $n-2$ points, and so on down to 0 points. This version produces the same ranking outcome as version 1.
– *Inverse Borda (version 3):* The top-ranked alternative receives 1 point, the next 2, and so on, with the lowest-ranked receiving n points. The alternative with the lowest total score is the winner. This version is often used in classical music competitions because the resulting rankings are intuitive (e.g., 1st place = 1 point).

The Borda Count is sensitive to strategic behaviour and is typically used only in the final stages of competitions with a small number of contestants. It was, for instance, applied in the final of the 2016 International Henryk Wieniawski Violin Competition (see Gaertner, 2013).

2.4. Trimmed mean methods

Trimmed mean methods originate from statistical practice and aim to reduce the influence of extreme scores. They eliminate a subset of the highest and lowest values before computing the mean.

– *20% Trimmed Mean:* For each contestant, the top and bottom 20% of scores are excluded. This threshold is standard in statistical analyses.
– *Olympic Mean (Olimp):* For each contestant, the single highest and lowest scores are removed. This method is commonly used in sports and music competitions, including the 2022 International Henryk Wieniawski Violin Competition. While less aggressive than the 20% method, it still limits the influence of extreme values.

2.5. Correction to the Mean (CMEAN)

The CMEAN method adjusts scores based on their deviation from the average. The procedure is as follows:

1. Compute the mean score for each contestant.
2. Define a symmetric threshold parameter α (e.g., ± 1).
3. For each score, if it exceeds the mean $+\alpha$, it is capped at that upper bound; if it falls below the mean $-\alpha$, it is raised to the lower bound.

The same α is applied to all contestants, although it may vary across competition stages. This method aims to suppress outlier influence while preserving the overall ranking structure. Variants of CMEAN have been used in the Queen Elisabeth International Music Competition and the International Fryderyk Chopin Piano Competition (see Sosnowska, 2013, 2017).

2.6. Anti-manipulation methods

These methods were developed to reduce the impact of strategic or collusive voting by identifying and excluding unreliable jurors.

2.6.1. Kontek–Sosnowska method (K-S)

The K-S method, introduced by Kontek and Sosnowska (2020), was developed in response to evidence of strategic voting during the XVI Wieniawski Competition, where jurors reportedly formed coalitions to favour specific candidates.

The procedure involves the following steps:

1. Each juror submits scores or rankings (e.g., via the Borda Count).
2. Compute the average score vector across all jurors.
3. Calculate the Manhattan distance between each juror's score vector and the average vector.
4. Identify and exclude the 20% of jurors whose scores deviate the most from the mean (rounded down to the nearest integer).
5. Recompute the average scores based on the remaining jurors. If ties occur at the cutoff point, fractional weights are applied to those jurors' scores.

Unlike trimmed mean methods, which remove individual scores, the K-S method excludes entire jurors. The method always produces a result, though it does not necessarily yield the Condorcet winner (see Ramsza, Sosnowska, 2020; Sosnowska, 2022).

2.6.2. Kontek-Kenner method (K-K)

The K-K method builds upon the K-S approach by refining the elimination criterion. Rather than focusing solely on the magnitude of deviation, it targets jurors whose scores are weakly correlated with the collective mean or median, as measured by statistical correlation.

This allows for a more selective and principled exclusion of outlier jurors, particularly in cases where deviations are not extreme in magnitude but inconsistent in pattern. Although the final version of the method has not yet been formally published (first draft: Kontek, 2025), it has already been implemented in real-world competitions in Poland, Japan, and the United States. The version applied in this paper reflects the most recent formulation.

Table 1.
Comparison of Voting Methods

Method	**Type**	**Input**	**Outlier Handling**	**Manipulation Resistance**	**Use in Practice**
Plurality	Ranking / Single choice	Single top choice	None	Very low	Basic elections; rarely used in juried evaluations
Scoring	Scoring	Point allocation	None	Low	General-purpose voting systems
Borda Count	Ranking → Points	Full ranking	None	Low (strategic voting possible)	Classical music competitions (e.g., Wieniawski 2016 Final)
Trimmed Mean (20%)	Scoring	Point allocation	Strong (±20% extremes removed)	Medium	Statistical analyses; some sports and music competitions
Olympic Mean	Scoring	Point allocation	Moderate (min/max values removed)	Low-Medium	Olympic sports; music competitions (e.g., Wieniawski 2022)
CMEAN (α correction)	Scoring	Point allocation	Soft (scores adjusted beyond α threshold)	Medium	Queen Elisabeth and Chopin Competitions
K-S Method	Scoring	Full ranking or scores	Removes entire outlier jurors	High	Developed after Wieniawski XVI; applied in both theory and practice
K-K Method	Scoring	Full ranking or scores	Selective juror elimination (low correlation)	Very high	Used experimentally in Poland, Japan, and the United States

Note: *Input:* The type of data provided by voters (ranking or numeric scores). *Outlier Handling:* The method's approach to reducing the influence of extreme scores or voters. *Manipulation Resistance:* The method's robustness against strategic or collusive behaviour. *Use in Practice:* Examples of real-world implementation or typical application contexts.

Source: Own calculations.

3. Hypotheses

As illustrated by the examples discussed in the Introduction, the plurality voting method—particularly in its simplest form—is clearly susceptible to the serial position effect. This observation prompts the question of whether more sophisticated voting procedures may also be vulnerable to this type of cognitive bias.

In this study, we propose a generalised definition of the serial position effect as applied to group decision-making. A voting method is considered vulnerable to the serial position effect if there exists at least one configuration of voter preferences under which the final ranking is significantly influenced by the order in which alternatives are presented. This vulnerability may not be uniform across all preference profiles and may depend on specific input patterns.

Within this general framework, the traditional primacy and recency effects are treated as special cases.

Based on this definition, we formulate the following hypotheses:

- *H1:* The Borda Count is vulnerable to the serial position effect.
- *H2:* Trimmed mean methods (including the 20% trimmed mean and the Olympic mean) are vulnerable to the serial position effect.
- *H3:* The CMEAN method is vulnerable to the serial position effect.
- *H4:* Anti-manipulation methods (K-S and K-K) are vulnerable to the serial position effect.

These hypotheses will be tested through controlled experiments. In the experimental design, participants are asked to rank the same set of alternatives twice, with the order of presentation altered between the two rounds. By comparing the results of each voting method across the two conditions, we aim to detect and quantify the presence of serial position effects.

To assess similarity between rankings, we employ the following measures:

- *Kendall's tau* rank correlation coefficient, a non-parametric statistic introduced by Kendall (1938), used to evaluate the strength and direction of association between two rankings. The null hypothesis is that the rankings are uncorrelated ($\tau = 0$). Significance levels of 0.05 and 0.1 are used to evaluate the results.
- *Swap distance* and *transposition distance*, as discussed by Boehmer et al. (2022), are also computed to quantify the magnitude of rank-order changes between the two voting rounds.

A combination of significantly low correlation and large rank distances would indicate the presence of the serial position effect for a given method. Additional analysis will explore whether any observed effects correspond more strongly to primacy or recency.

4. Experiment

4.1. Objectives and general design

The experimental method was designed to investigate whether the outcomes of various voting methods are influenced by the serial position effect. A series of experiments was conducted, of which three are presented here as representative cases illustrating the key features of the study.

Each experiment consisted of two stages in which participants ranked a set of visual alternatives (landscapes) using a selection of voting methods. The only difference between the two stages was the order in which the alternatives were presented.

4.2. Experimental procedure

In the first stage, participants received evaluation sheets listing letters A to H, each corresponding to a landscape. They were instructed to assign a score from 1 (worst) to 8 (best) to each landscape, with no ties allowed. Space was also provided for optional comments.

Subsequently, eight landscapes labelled A to H were shown to participants, each displayed for 30 seconds. Scores were recorded only after the final image had been shown. Sheets were collected immediately upon completion.

After a break (either short or extended), the second stage was conducted. It replicated the first in all respects except for the order and labels of the landscapes. The same images were relabelled P to W and presented in the following sequence (parentheses indicate the corresponding image from the first stage):

$$[P(D), Q(C), R(B), S(A), T(H), U(G), V(F), W(E)].$$

The Kendall's tau correlation between the two presentation orders is 0.14 (p-value is 0.61), indicating no statistically significant association.

The experiment was designed to approximate the conditions of a classical music competition:

- The number of participants was similar to that of a typical jury in a competition final.
- The number of alternatives approximated the number of finalists.
- The layout of scoring sheets mirrored real-life evaluation formats.

One key distinction lies in expertise: whereas jurors in music or sports competitions are domain specialists, participants in this study assessed landscapes—a domain where aesthetic judgement is more subjective. However, to ensure baseline quality, all images were preselected by a professional photo editor and were aesthetically appealing.

4.3. Voting methods applied

Each participant's rankings from both stages were processed using six different voting methods:

1. Borda Count.
2. Trimmed mean – 20%.
3. Trimmed mean – Olympic.
4. CMEAN method (with threshold $\alpha = 1$).
5. Kontek-Sosnowska method (K-S).
6. Kontek-Kenner method (K-K).

The experiment followed a 6 (methods) × 2 (stages) within-subjects design. The manipulation of presentation order was applied identically across all participants.

4.4. Experimental groups

All participants were undergraduate students at the Warsaw School of Economics, aged 20-23, with an approximately equal gender distribution. Students were selected to ensure a minimum level of academic literacy and experience in working with abstract visual information.

- *Experiment 1.* Conducted in Spring 2022 with 19 students majoring in quantitative methods. Participants were familiarised with the voting methods prior to the experiment. A 40-minute break between stages was used to administer a test on social choice theory.
- *Experiment 2.* Conducted in Autumn 2024 with 19 first-year students from the same institution. Participants received a brief introduction to the voting methods. The 40-minute break included a calculus exercise.
- *Experiment 3.* Conducted in Winter 2025 with 11 students majoring in quantitative methods. Participants were already acquainted with the voting methods. A five-week break separated the two stages, during which students attended lectures on social choice theory. They had no exposure to the experimental materials in the interim.

4.5. Comparison with previous research

Unlike most studies discussed in the Introduction, this experiment applies complex voting methods. To our knowledge, no prior empirical research has directly examined the interaction between the serial position effect and such aggregation procedures.

The most comparable study is Example 3 (Asch, 1946), in which the order of presented attributes influenced personality judgements. A key difference lies in the experimental design: whereas Asch used different groups for each condition, our study employs a within-subjects design, thereby enhancing internal validity.

Additionally, the inclusion of a break between stages aims to minimise memory effects and ensure that any observed serial position effects result from presentation order rather than recall. The break durations in Experiments 1 and 2 are consistent with the conditions in Example 2 (Miller, Campbell, 1959), where no serial position effects were detected.

If the serial position effect does emerge in our results, its origin may lie not in memory biases but in the structural features of complex voting methods or in differences in cognitive processing driven by task complexity.

5. Results

5.1. Methodology

For each experiment, we computed the outcomes of six voting methods: Borda Count, Olympic Mean, 20% Trimmed Mean, CMEAN, and the two anti-manipulation methods (K-S and K-K). For each method, results from both stages of the experiment were compared using the following measures:

- Swap distance.
- Transposition distance.
- Kendall's tau rank correlation.

Note that the null hypothesis in the Kendall's tau test posits no correlation between the rankings obtained in the first and second stages. A statistically significant deviation from this assumption would indicate a potential serial position effect.

5.1.1. Data structures

There were eight alternatives in each experiment, labelled A through H. We employed two principal data structures for analysis.

- *Type 1: Score-based table.* This structure records the total number of points received by each alternative under a given voting method. For simple methods such as the Borda Count or Olympic Mean, these scores are integers. However, for methods involving juror exclusion or fractional weighting (e.g. K-K), scores may be real numbers.
- *Type 2: Ranking matrix* This matrix captures individual juror rankings of the alternatives. The first column identifies the juror, while the remaining columns list the ranking positions assigned to each alternative. For instance, in Table 2, Juror 1 assigned alternative A to position 2, B to position 3, and so forth.

Table 2.
Typical data structure – Type 2: Juror rankings

Person	A	B	C	D	E	F	G	H
1	2	3	4	5	6	7	1	8
2	6	4	1	2	7	3	8	5
3	1	3	5	7	8	2	4	6
4	1	3	4	5	7	6	2	8

Note: Sample structure shown below; actual data follows in subsequent tables.

Source: Own calculations.

From Table 2, it is straightforward to derive the number of points awarded to any alternative by a juror. For example, alternative A was placed sixth by the second juror; assuming the *Inverse Borda Count* is applied (where 1st place receives 8 points, 2nd place receives 7 points, etc.), sixth place corresponds to 3 points.

In our analysis:

– *Kendall's tau* and the corresponding significance tests are based on the final scores (point totals) derived for each alternative under a given voting method.
– *Swap distance* and *transposition distance* are based on the **rank order** of alternatives, not the scores themselves. For these measures, a sequence of rankings is generated for each voting round.

For example, based on the rankings assigned by Juror 1 in Table 2, the ordered sequence is: (G, D, A, B, F, C, H, E).

Which corresponds to:
(7, 1, 2, 3, 4, 5, 6, 8).

Meaning:

– Alternative G (7th) was ranked 1st.
– Alternative D (4th) was ranked 2nd.
– Alternative A (1st) was ranked 3rd ... and so on.

This representation allows us to compare entire ranking orders between the two rounds of voting using positional distance metrics.

Table 3.
Typical data structure – Type 1: Aggregate point totals for each alternative

A	B	C	D	E	F	G	H	Label
4.364	3.545	5.182	3.091	4.455	3.909	4.545	6.445	k-k I round
4.545	4.273	4.545	5.000	3.545	5.273	3.455	5.818	k-k II round
5.125	4.438	5.625	3.500	5.188	4.438	4.563	7.000	k-s I round
4.111	5.000	4.778	5.000	3.556	4.889	3.778	5.444	k-s II round

Note: Sample structure shown; actual values will be provided in subsequent sections.

Source: Own calculations.

The label describes the voting method and the algorithm used to produce the results. Accordingly, we conduct two types of comparisons in our analysis:

– *Type 1 – Individual-level comparison*: Compares the rankings submitted by a given juror between the two rounds.
– *Type 2 – Aggregate-level comparison*: Compares the overall voting outcomes (i.e. the final rankings) produced by each method between the two rounds.

For both types and for each experiment, we compute the following metrics:

– Kendall's tau rank correlation coefficient.
– p-value for the null hypothesis that $\tau = 0$ (no correlation).
– Transformation distance.
– Swap distance.

5.2. Distance measures

5.2.1. Transformation distance

The transformation distance measures the number of adjacent swaps (inversions) required to convert one ranking into another. It assumes full, tie-free permutations. In cases where ties occur, we generate all possible permutations consistent with the tied rankings and compute the transformation distances for each. The final value is the average of all these permutations.

Example. Consider two rank vectors for eight alternatives (A–H), where → denotes the position:

- Round 1: ("A"→5, "B"→7, "C"→2, "D"→8, "E"→4, "F"→6, "G"→3, "H"→1) → Sequence: (8, 3, 7, 5, 1, 6, 2, 4)
- Round 2: ("A"→4, "B"→6, "C"→4, "D"→3, "E"→7, "F"→2, "G"→8, "H"→1) → Two consistent permutations due to a tie between A and C:
  - (8, 6, 4, 1, 3, 2, 5, 7),
  - (8, 6, 4, 3, 1, 2, 5, 7).

We compute the transformation distance for both permutations and average the results: $(5 + 4)/2 = 4.5$.

5.2.2. Swap distance

The swap distance, as defined by Boehmer et al. (2022), counts the number of discordant pairs between two rankings. As with transformation distance, in the presence of ties, we consider all consistent permutations and compute the mean value.

Importantly, our approach differs from the treatment of ties in Kendall's tau-b, which uses a correction factor. We intentionally apply a consistent procedure across both distance metrics to maintain comparability.

Table 4.
Results of Experiment 1. First stage

landscape	**k-k**	**k-s**	**Olimp**	**20%**	**CMEAN**	**Borda**
A	3.778 *7*	4.267 *7*	3.588 *7*	3.308 *8*	3.507 *8*	3.684 *7*
B	4.944 *2*	4.533 *2*	5.118 *2*	5.077 *2*	5.047 *2*	5.053 *2*
C	4.722 *3*	4.333 *6*	4.706 *5*	4.846 *4*	4.715 *5*	4.684 *5*
D	4.722 *3*	4.467 *5*	4.824 *3*	5.000 *3*	4.931 *3*	4.789 *4*
E	4.222 *6*	4.533 *2*	4.000 *6*	3.923 *6*	3.989 *6*	4.053 *6*
F	4.667 *5*	4.533 *2*	4.824 *3*	4.846 *4*	4.867 *4*	4.842 *3*
G	3.667 *8*	3.800 *8*	3.529 *8*	3.538 *7*	3.648 *7*	3.632 *8*
H	5.278 *1*	5.533 *1*	5.294 *1*	5.308 *1*	5.310 *1*	5.263 *1*

Note: In each cell, points are written with three numbers after a dot, and the position is written in italic.

Source: Own calculations.

5.3. Results of Experiment 1

The application of each voting method to the results from both stages of Experiment 1 is presented in:

- Table 4 – Results from Stage 1.
- Table 5 – Results from Stage 2.

Each table reports the total scores for each alternative under the six methods discussed. In the following subsections, we present comparative analyses of the rankings, including Kendall's tau values, p-values, and distance measures between stages.

Table 5.
Results of Experiment 1. Second stage

landscape	k-k	k-s	Olimp	20%	CMEAN	Borda
A	4.000 *7*	4.333 *6*	3.941 *7*	3.846 *7*	3.895 *7*	4.000 *7*
B	4.579 *4*	3.933 *7*	4.588 *4*	4.692 *4*	4.637 *4*	4.579 *4*
C	5.211 *1*	4.867 *2*	5.294 *1*	5.615 *1*	5.449 *1*	5.211 *1*
D	4.368 *5*	4.733 *3*	4.353 *5*	4.308 *5*	4.429 *5*	4.368 *5*
E	3.632 *8*	3.933 *7*	3.529 *8*	3.231 *8*	3.380 *8*	3.632 *8*
F	5.000 *2*	4.600 *4*	5.059 *2*	5.154 *2*	4.947 *3*	5.000 *2*
G	4.263 *6*	4.467 *5*	4.294 *6*	4.231 *6*	4.244 *6*	4.263 *6*
H	4.947 *3*	5.133 *1*	5.000 *3*	5.077 *3*	5.014 *2*	4.947 *3*

Note: In each cell, points are written with three numbers after a dot, and the position is written in italic.

Source: Own calculations.

Comparing positions across both stages, we observe that the sequences of positions differ for every voting method. This may indicate the presence of a serial position effect. To verify this, we apply statistical methods. Table 6 presents a comparison between the stages, including the transformation distance, swap distance, and Kendall's tau coefficient with corresponding p-values.

Table 6.
Results of Experiment 1. Comparing stages

Voting method	Transformation Distance	Swap distance	Kendall tau	Kendall tau p-value
k-k	5	9	0.400	0.170
k-s	6	12	0.327	0.261
Olimp	5	9	0.327	0.261
20%	5	9	0.400	0.170
CMEAN	6	8	0.428	0.137
Borda	5	9	0.357	0.216

Source: Own calculations.

The highest distances are observed for the K-S method, while the other distances are of moderate magnitude. All p-values exceed 0.1, which means that the null hypothesis cannot be rejected, and the results from both stages are not significantly correlated. This indicates the presence of a serial position effect. The methods, ordered by Kendall's tau from highest to lowest, are as follows: CMEAN > K-K = 20% > K-S = Olympic = Borda.

In what follows, we present Figures 1–6, which display column charts illustrating the results of each method for both stages and all landscapes. The height of each column corresponds to the mean score taken from the relevant table for this experiment.

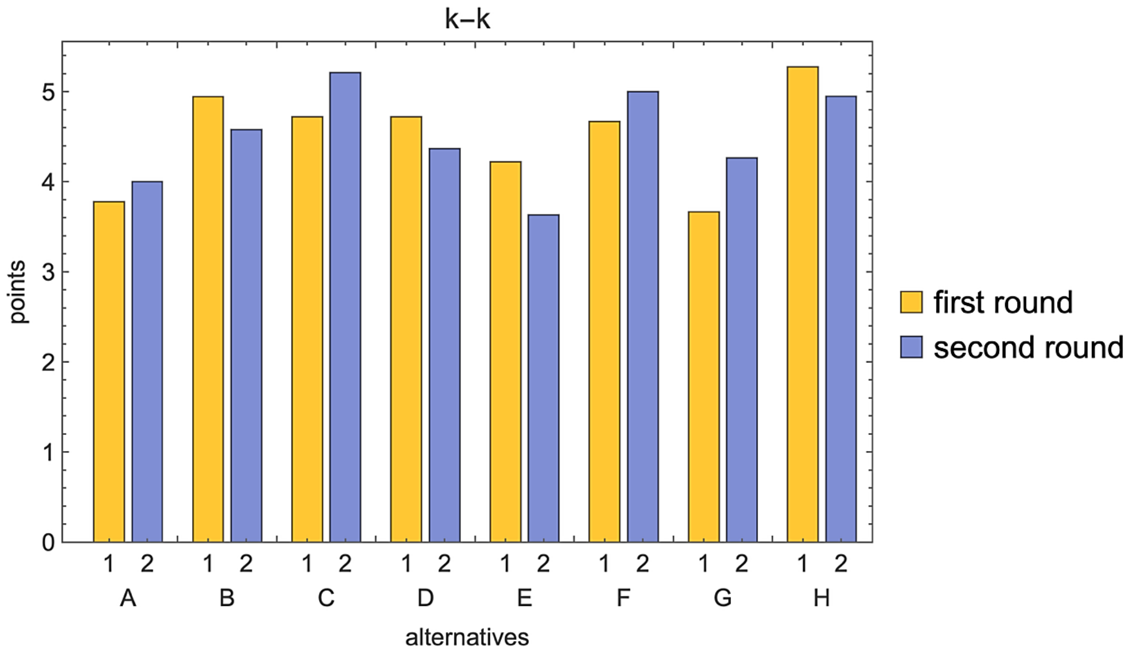

Figure 1. Experiment 1, method k-k.

Source: Own calculations.

It is worth noting that in Figure 1, the columns for landscapes A and H are similar in height, indicating that the landscapes shown at the beginning and end of the sequence were better remembered. This suggests the presence of primacy and recency effects. For the remaining landscapes, the differences in column height are either modest (in the case of two landscapes) or more pronounced (in four cases). The position effect is partially observed, as the final landscape, H, is rated highly, whereas this is not the case for the first landscape, A.

A similar pattern can be observed in Figure 2. The columns for landscapes A and H again show comparable height, suggesting that items presented at the beginning and end of the sequence were more memorable. The primacy and recency effects are therefore present. Among the remaining landscapes, two show minor differences in column height, while four exhibit more substantial differences. The position effect is partially evident, with the final landscape H receiving a high evaluation, unlike the first landscape A.

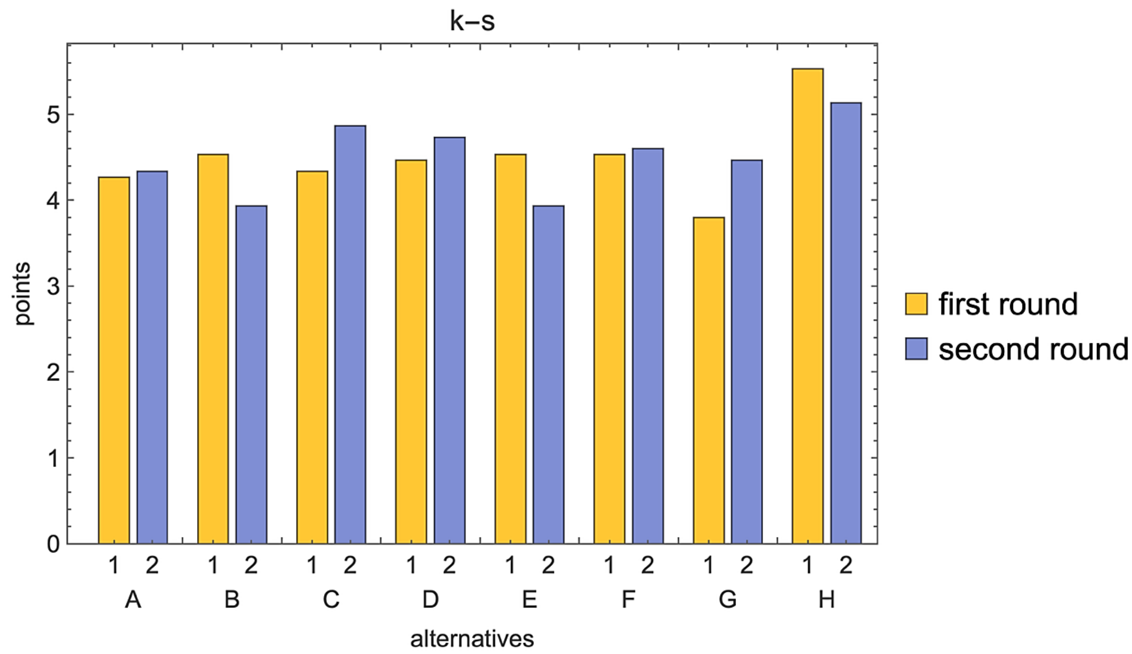

Figure 2. Experiment 1, k-s method.

Source: Own calculations.

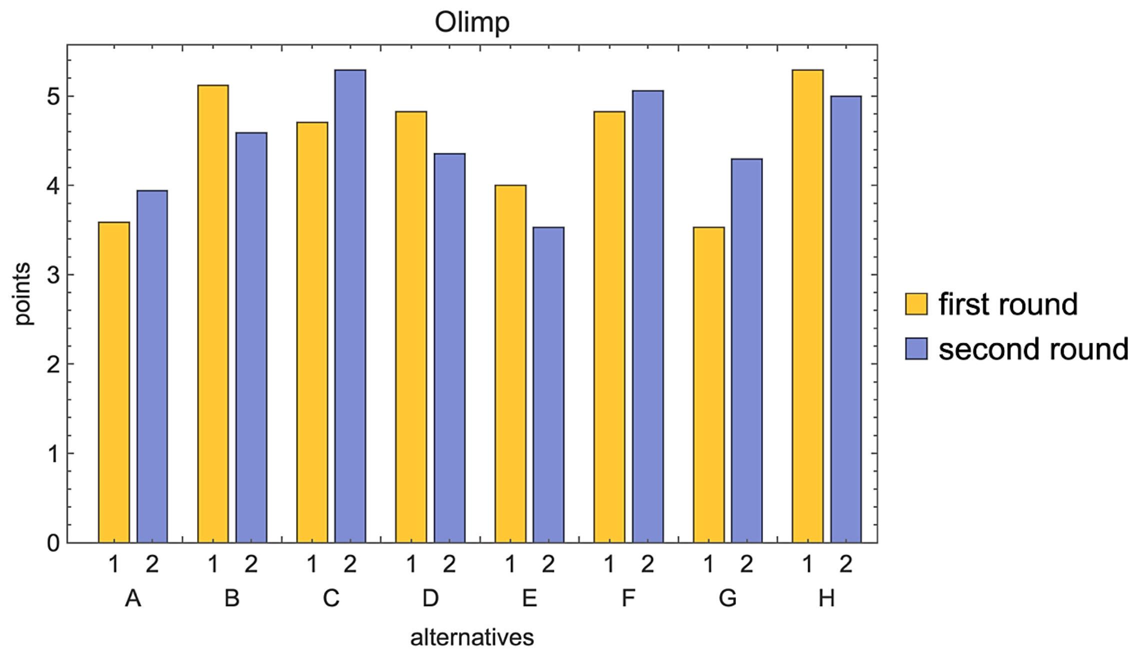

Figure 3. Experiment 1, Olimp method.

Source: Own calculations.

In Figure 3, the columns for landscapes A and H are similar in height, indicating that the landscapes presented at the beginning and end of the sequence were better remembered. This suggests the presence of primacy and recency effects. The differences in column height for the remaining landscapes are more pronounced. Additionally, the differences between the first and second stages are larger than those observed for the K-K and K-S methods (see Figures 1 and 2). The position effect is partially observed, as the final landscape H receives a high evaluation, while this is not the case for the first landscape A.

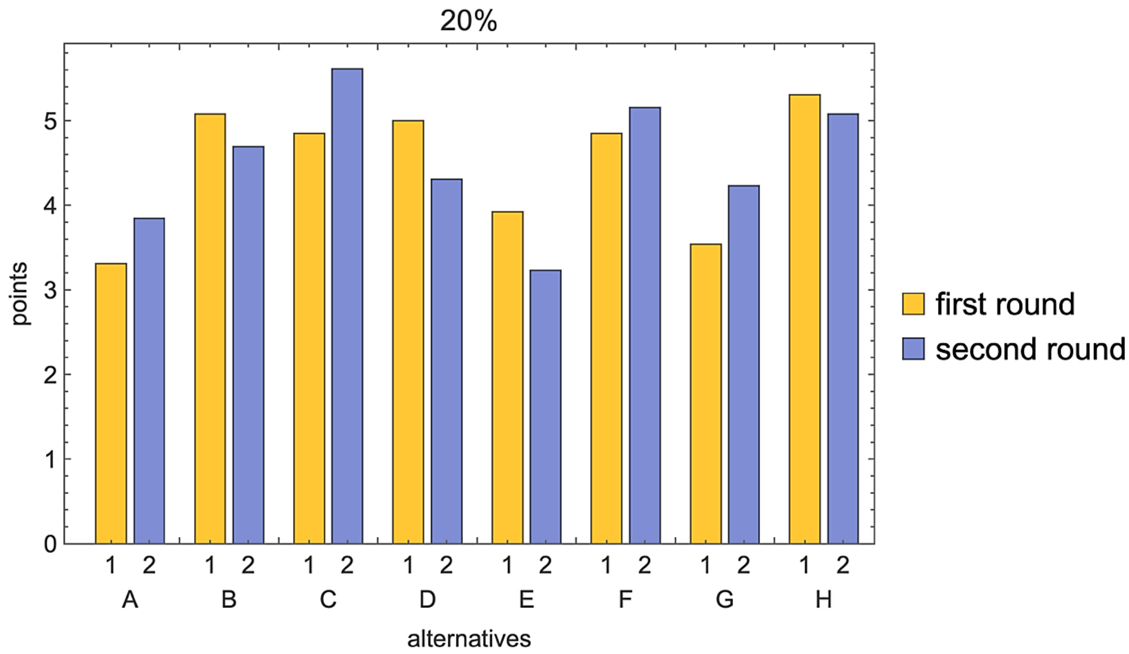

Figure 4. Experiment 1, method 20%.

Source: Own calculations.

In Figure 4, the columns for landscape H are similar in height across both stages, whereas the difference for landscape A is more pronounced. This indicates that the landscape presented at the end of the sequence was better remembered, suggesting a recency effect. For the remaining landscapes, differences in column height are generally larger (in four cases) or similar (in two cases). The differences between stages are greater than those observed for the K-K and K-S methods (see Figures 1 and 2). The position effect is partially observed: the final landscape H receives a high evaluation, while this is not the case for the first landscape A.

In Figure 5, the columns for landscape H are again similar in height, while the difference for landscape A is more substantial. This suggests that the end-of-sequence landscape was better remembered, confirming a recency effect. For the other landscapes, the differences in column height are mostly larger (in five cases) or similar (in one). The stage-to-stage differences are greater than those observed for the K-K and K-S methods (see Figures 1 and 2). The position effect is partially present: the last landscape H is highly evaluated, unlike the first landscape A.

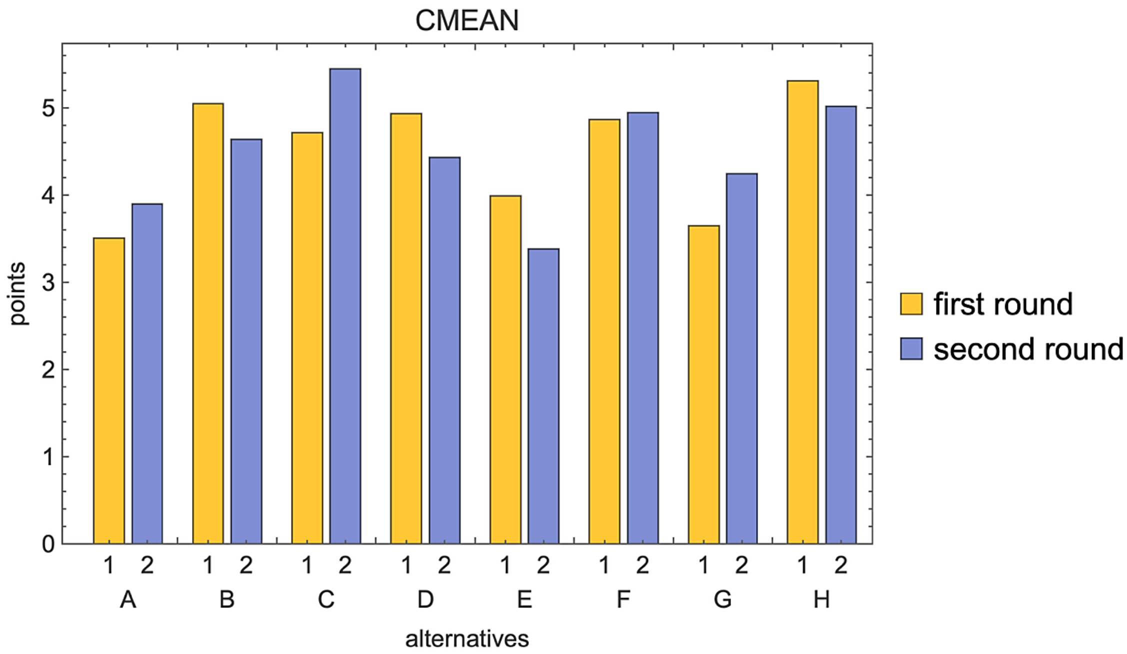

Figure 5. Experiment 1, method CMEAN.

Source: Own calculations.

In Figure 6, the columns for landscape H are similar in height across both stages, while the difference for landscape A is slightly larger. This suggests that the landscape presented at the end of the sequence was better remembered, indicating a recency effect. For the remaining landscapes, differences in column height are generally larger (in five cases) or similar (in one). The differences between stages are greater than those observed for the K-K and K-S methods (see Figures 1 and 2). The position effect is partially observed: the final landscape H receives a high evaluation, whereas this is not the case for the first landscape A.

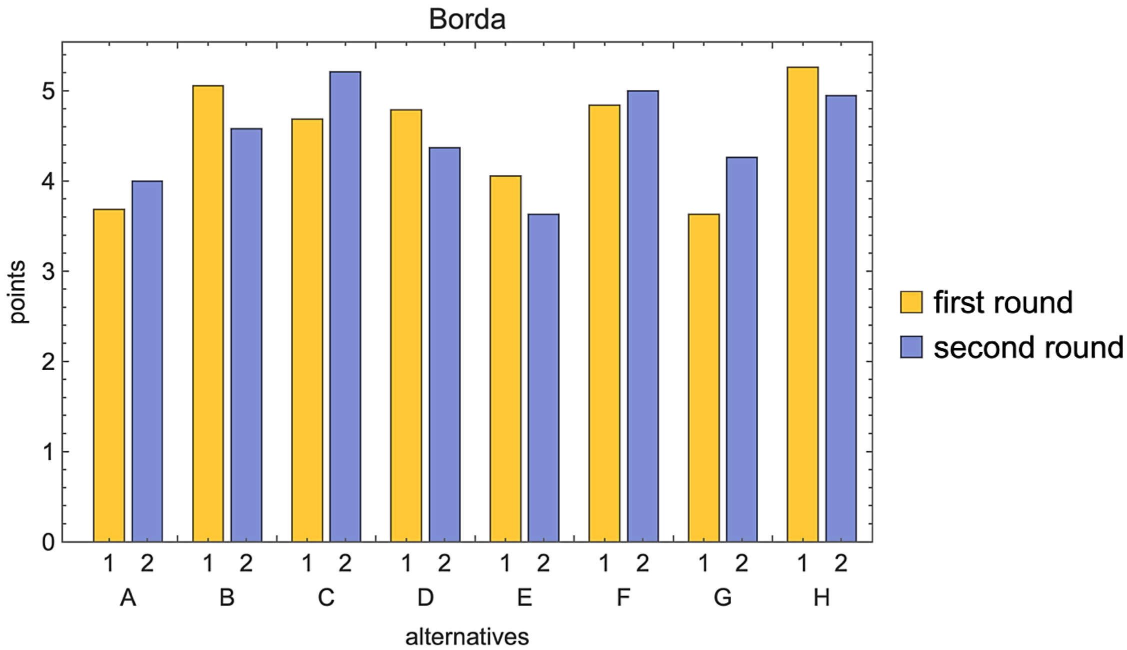

Figure 6. Experiment 1, method Borda.

Source: Own calculations.

In summary, both primacy (weaker) and recency (stronger) effects are observed. The position effect is evident only for the last landscape. The results of both stages are most closely aligned for the K-S and K-K methods.

5.4. Results of Experiment 2

Tables 7 (first stage) and 8 (second stage) present the application of voting methods to the voting results in both stages.

Table 7.
Results of Experiment 2. First stage

Landscape	k-k	k-s	Olimp	20%	CMEAN	Borda
A	4.263 *5*	4.333 *4*	4.176 *5*	4.077 *5*	4.141 *5*	4.263 *5*
B	3.526 *7*	3.600 *7*	3.412 *7*	3.154 *7*	3.416 *7*	3.526 *7*
C	5.842 *2*	6.400 *1*	6.000 *2*	6.231 *2*	6.042 *2*	5.842 *2*
D	4.842 *3*	5.200 *3*	4.882 *3*	4.923 *3*	4.920 *3*	4.842 *3*
E	3.000 *8*	2.533 *8*	2.941 *8*	2.846 *8*	2.947 *8*	3.000 *8*
F	4.368 *4*	4.067 *5*	4.353 *4*	4.308 *4*	4.324 *4*	4.368 *4*
G	4.105 *6*	3.667 *6*	4.118 *6*	4.077 *5*	4.072 *6*	4.105 *6*
H	6.105 1	6.267 *2*	6.235 *1*	6.385 *1*	6.183 *1*	6.105 *1*

Note: In each cell, points are written with three numbers after a dot, and the position is written in italic.

Source: Own calculations.

Table 8.
Results of Experiment 2. Second stage

Landscape	k-k	k-s	Olimp	20%	CMEAN	Borda
A	4.421 *4*	3.867 *6*	4.412 *4*	4.308 *4*	4.371 *4*	4.421 4
B	3.632 *7*	3.467 *7*	3.529 *7*	3.308 *7*	3.465 *7*	3.632 *7*
C	4.895 *3*	4.800 *3*	4.941 *3*	5.154 *3*	4.981 *3*	4.895 *3*
D	5.368 *2*	5.933 *2*	5.471 *2*	5.615 *2*	5.562 *2*	5.368 *2*
E	3.105 *8*	2.733 *8*	2.941 *8*	2.615 *8*	2.878 *8*	3.105 *8*
F	4.263 *5*	4.267 *4*	4.235 *5*	4.308 *4*	4.285 *5*	4.263 *5*
G	4.105 *6*	4.000 *5*	4.059 *6*	3.923 *6*	3.967 *6*	4.105 *6*
H	6.211 *1*	6.933 *1*	6.294 *1*	6.538 *1*	6.366 *1*	6.211 *1*

Note: In each cell, points are written with three numbers after a dot, and the position is written in italic.

Source: Own calculations.

There are noticeable differences between the sequences of positions in both stages. To assess these differences, we compare the stages using distance measures and Kendall's tau. The results of this comparison are presented in Table 8.

Table 9.
Results of Experiment 2. Comparing stages

Method	Transformation distance	Swap distance	Kendall tau	Kendall tau p-value
k-k	2	2	0.857	0.002
k-s	4	4	0.714	0.013
Olimp	2	2	0.857	0.002
20%	2	2	0.888	0.002
CMEAN	2	2	0.857	0.002
Borda	2	2	0.857	0.003

Source: Own calculations.

Note that the distances are low, Kendall's tau values are high, and the p-values are below 0.05. The null hypothesis is therefore rejected, indicating that the results of both stages are highly correlated across all voting methods. Consequently, the serial position effect does not appear. The methods, ordered by Kendall's tau from highest to lowest, are as follows: 20% > k-k = Olympic = CMEAN = Borda > k-s.

In what follows, we analyse the column charts in the same manner as in Experiment 1. Figures 7-12 exhibit similar properties and will therefore be presented jointly.

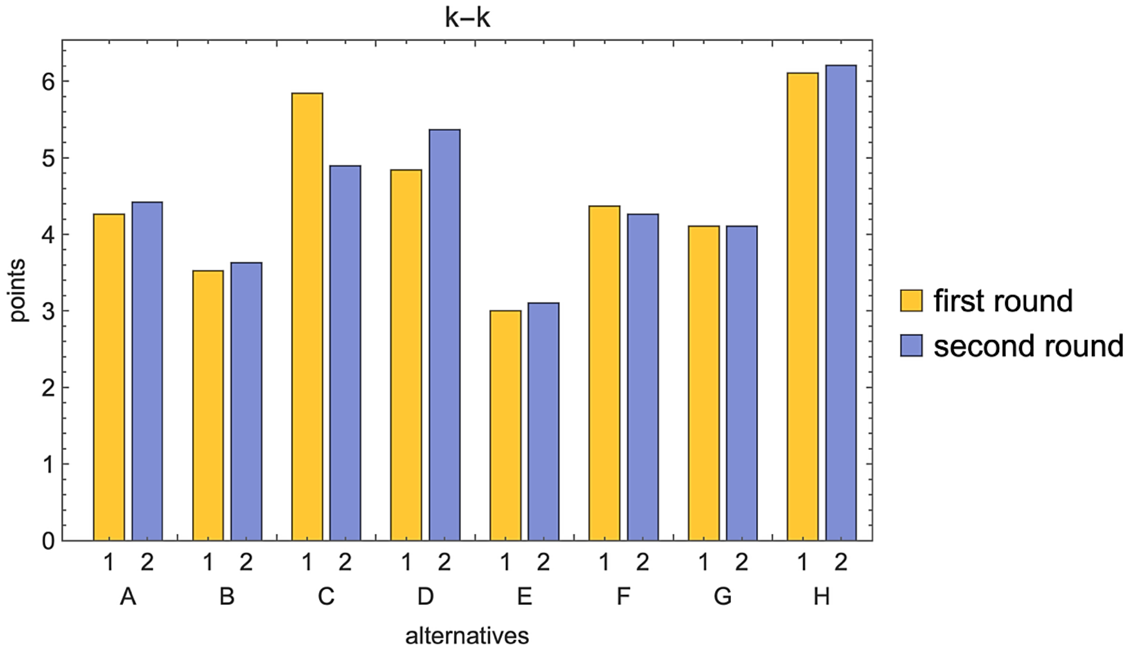

Figure 7. Experiment 2. Method k-k.

Source: Own calculations.

For all methods, the evaluations of landscapes A and H are similar across both stages, indicating that the assessments from the first stage were well remembered in the second. Similar consistency is also observed for four other landscapes. Therefore, primacy and recency effects are not present, as such effects would be expected only if the similarities for landscapes other than the first and last were rare. The position effect is observed only for the final landscape, H.

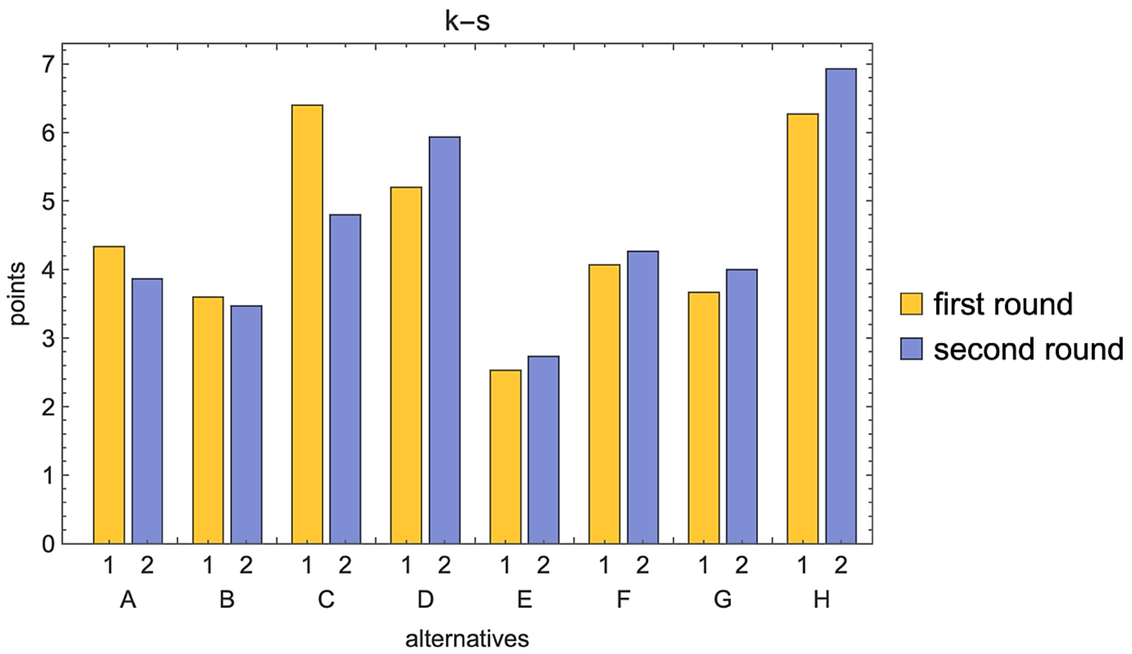

Figure 9. Experiment 2. Method k-s.

Source: Own calculations.

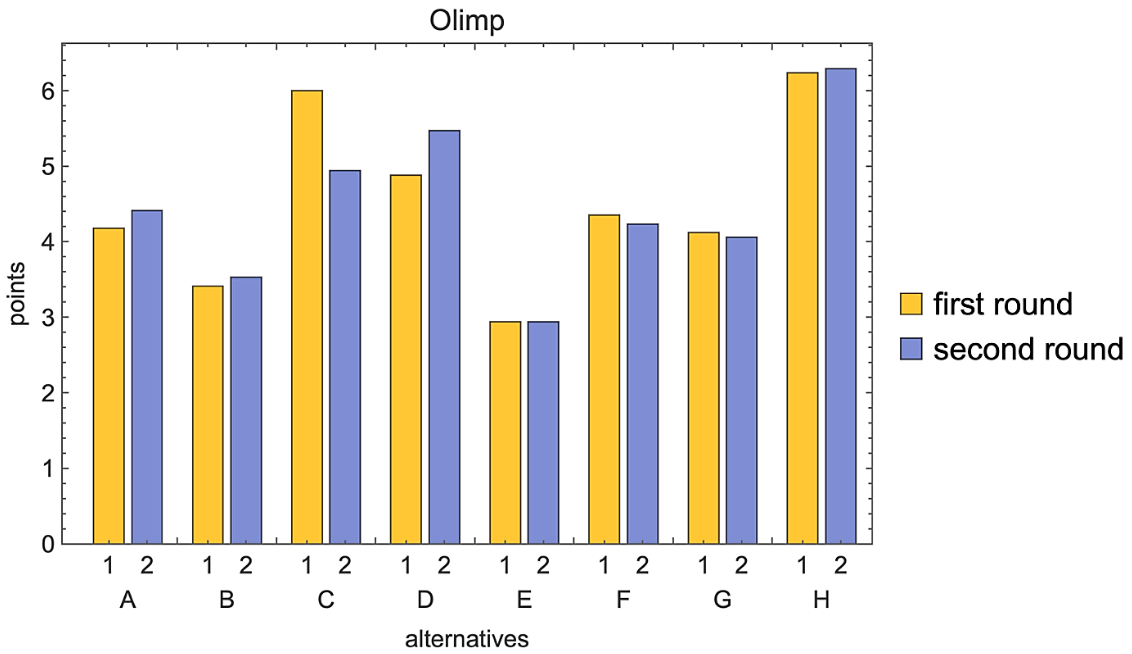

Figure 9. Experiment 2. Method Olimp.

Source: Own calculations.

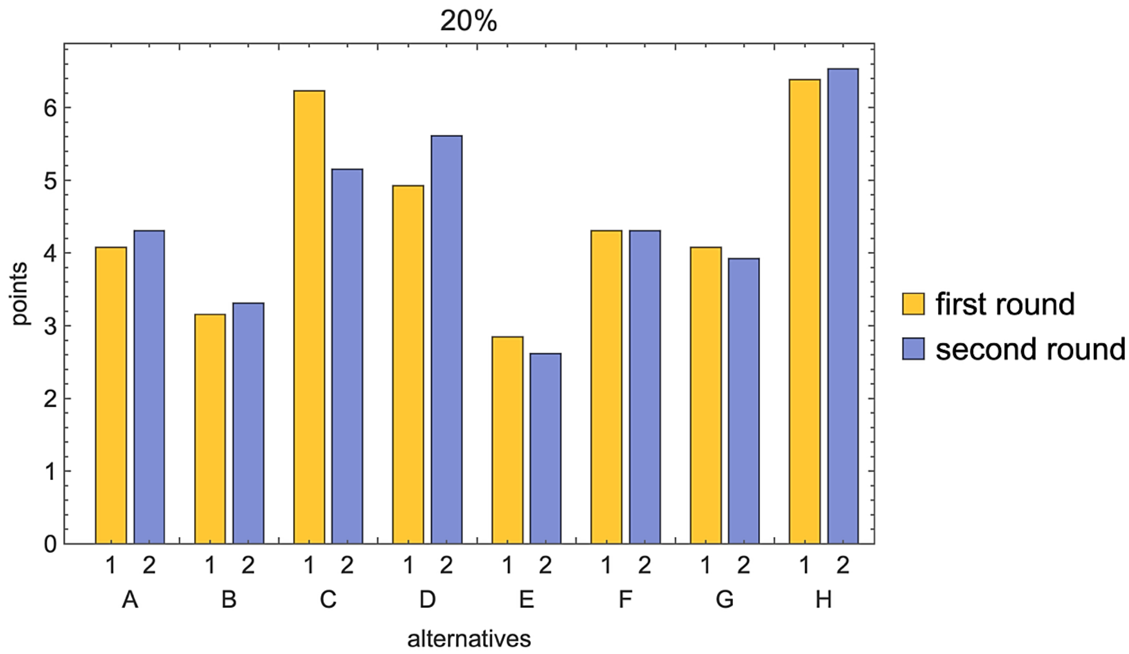

Figure 10. Experiment 2. Method 20%.

Source: Own calculations.

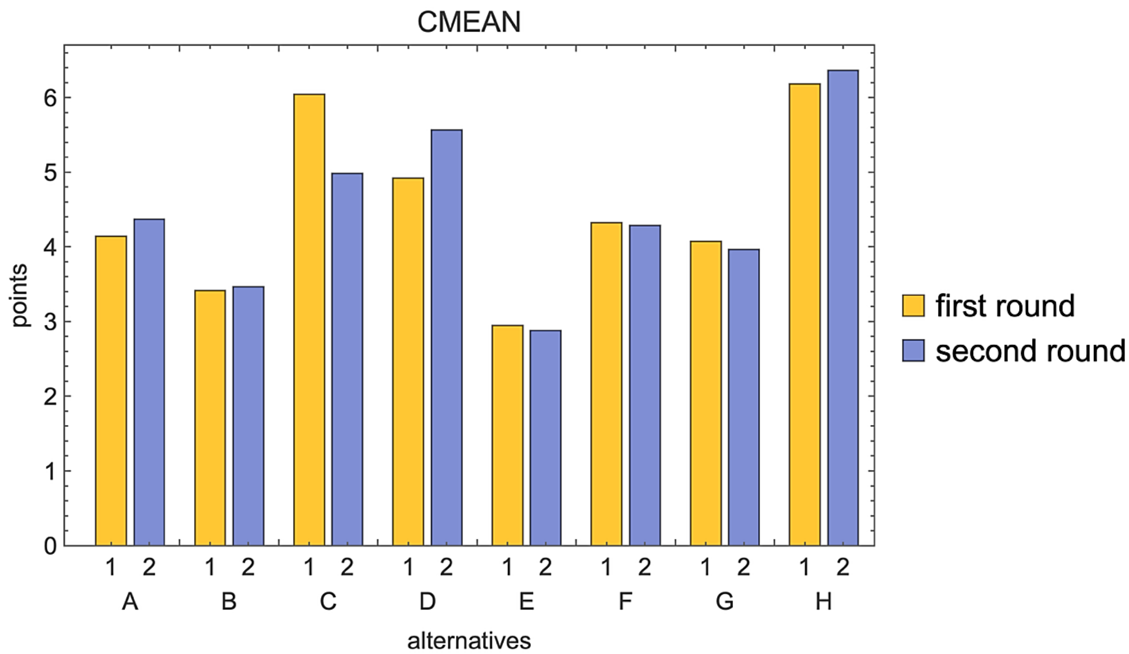

Figure 11. Experiment 2. Method CMEAN.

Source: Own calculations.

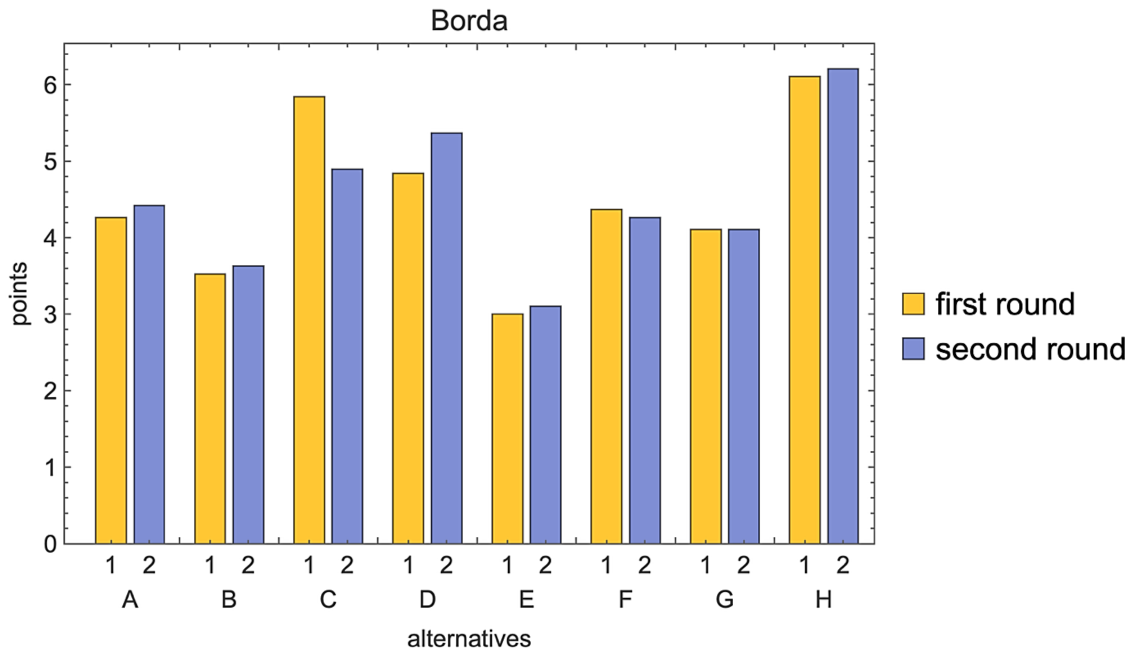

Figure 12. Experiment 2. Method Borda.

Source: Own calculations.

5.5. Results of Experiment 3

Table 10 (first stage) and Table 11 (second stage) present the application of voting methods to the results from both stages. This experiment differs from the previous two in one key respect: the break between stages was significantly longer—five weeks instead of 40 minutes. The choice of a long break was intended to test the influence of long-term memory, which is generally less accurate than short-term memory. We hypothesised that the serial position effect would be more likely to appear under these conditions.

Table 10.
Results of Experiment 3. First stage

Landscape	**k-k**	**k-s**	**Olimp**	**20%**	**CMEAN**	**Borda**
A	4.364 *5*	5.125 *4*	4.222 *5*	4.143 *5*	4.256 *5*	4.364 *5*
B	3.545 *7*	4.438 *6*	3.333 *7*	3.143 *7*	3.397 *7*	3.545 *7*
C	5.182 *2*	5.625 *2*	5.222 *2*	5.571 *2*	5.430 *2*	5.182 *2*
D	3.091 *8*	3.500 *8*	2.889 *8*	2.857 *8*	2.950 *8*	3.091 *8*
E	4.455 *4*	5.188 *3*	4.444 *4*	4.429 *4*	4.421 *4*	4.455 *4*
F	3.909 *6*	4.438 *5*	4.000 *6*	4.000 *6*	3.942 *6*	3.909 *6*
G	4.545 *3*	4.563 *5*	4.556 *3*	4.571 *3*	4.579 *3*	4.454 *3*
H	6.455 *1*	7.000 *1*	6.778 *1*	7.000 *1*	6.702 *1*	6.455 *1*

Note: In each cell, points are written with three numbers after a dot, and the position is written in italic.

Source: Own calculations.

Table 11.
Results of Experiment 3. Second stage

Landscape	k-k	k-s	Olimp	20%	CMEAN	Borda
A	4.545 *4*	4.111 *6*	4.556 *4*	4.571 *4*	4.628 *4*	4.545 *4*
B	4.273 *6*	5.000 *2*	4.333 *6*	4.429 *5*	4.248 *6*	4.273 *6*
C	4.545 *4*	4.778 *5*	4.444 *5*	4.429 *5*	4.446 *5*	4.545 *4*
D	5.000 *3*	5.000 *2*	5.111 *3*	5.143 *3*	5.091 *3*	5.000 *3*
E	3.545 *7*	3.556 *8*	3.333 *8*	3.000 *8*	3.397 *8*	3.545 *7*
F	5.273 *2*	4.889 *4*	5.333 *2*	5.286 *2*	5.198 *2*	5.273 *2*
G	3.455 *8*	3.778 *7*	3.556 *7*	3.571 *7*	3.512 *7*	3.455 *8*
H	5.818 *1*	5.444 *1*	6.111 *1*	6.571 *1*	6.273 *1*	5.818 *1*

Note: In each cell, points are written with three numbers after a dot, and the position is written in italic.

Source: Own calculations.

Let us compare the results of both stages based on the positions. Landscape H ranks first in both stages across all voting methods. However, differences are observed for other positions. For example, Landscape C holds second place in all voting methods during the first stage, while Landscape F occupies that position in the second stage. This suggests the presence of a serial position effect. To confirm this, we compute distance measures and Kendall's tau for this experiment.

Table 12.
Results of Experiment 3. Comparing stages

Method	Transformation distance	Swap distance	Kendall tau	Kendall tau *p*-value
k-k	4.500	14.500	-0.036	1.000
k-s	5	16	-0.148	0.615
Olimp	6	14	0.000	1.000
20%	5.500	14.500	-0.036	0.901
CMEAN	6	14	0.000	1.000
Borda	4	14	-0.036	0.900

Source: Own calculations.

Distances are high, especially when compared with Experiment 2. Kendall's tau is zero or close to zero, and the p-values are significantly greater than 0.1. Therefore, the null hypothesis cannot be rejected, providing strong evidence that the results of both stages are not correlated. Compared to Experiment 1, this experiment yields lower values of Kendall's tau and higher p-values. This supports the hypothesis that a longer interval between stages leads to lower correlation. The methods are ordered from the highest to the lowest Kendall's tau as follows: CMEAN = Olympic > K-K = 20% = Borda > K-S.

Following the approach used in the analysis of Experiments 1 and 2, we now examine the column charts. In Figures 13 and 15–18, for all methods except K-S, landscapes A and H are evaluated similarly across both stages, while the remaining landscapes show larger differences in evaluations. This indicates the presence of both primacy and recency effects. The position effect is observed only for landscape H, which appeared last in the first sequence. In contrast, Figure 14, corresponding to the K-S method, shows substantial differences between the paired evaluations of all landscapes. In this case, neither primacy nor recency effects are observed, and the position effect is again visible only for landscape H.

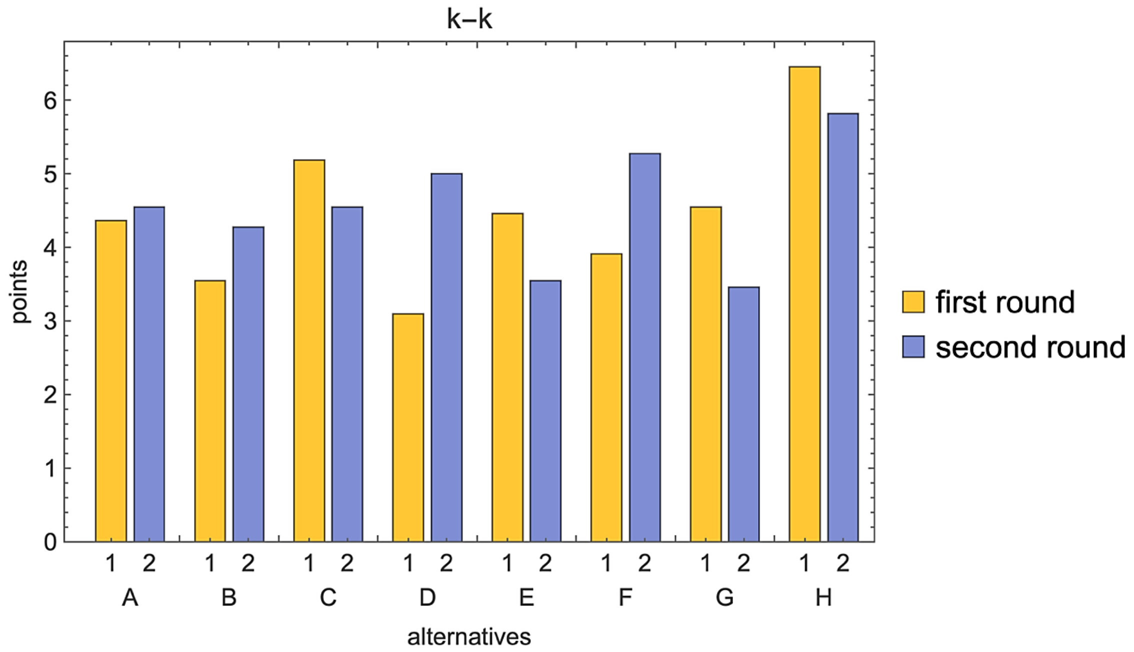

Figure 13. Experiment 3, method k-k.

Source: Own calculations.

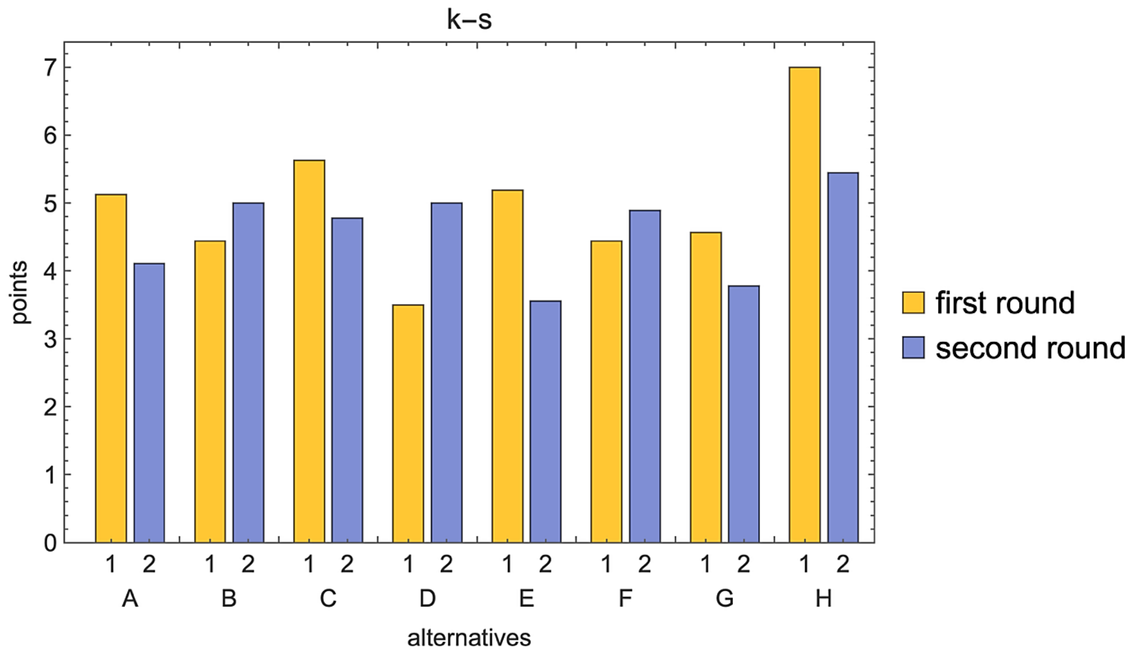

Figure 14. Experiment 3. Method k-s.

Source: Own calculations.

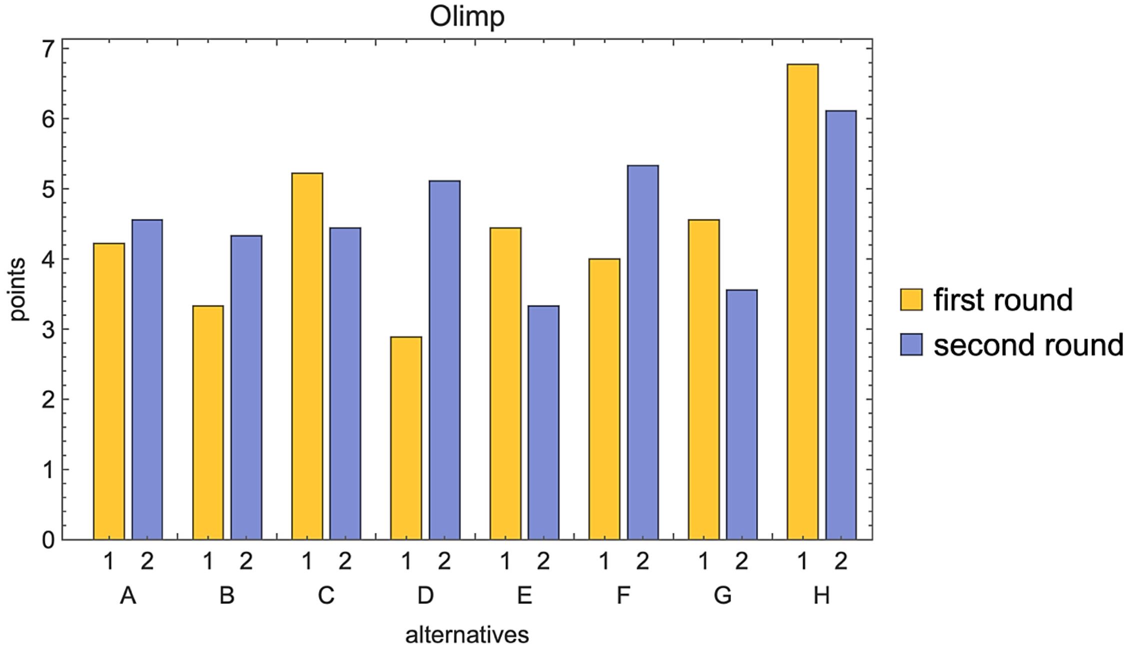

Figure 15. Experiment 3, method Olimp.

Source: Own calculations.

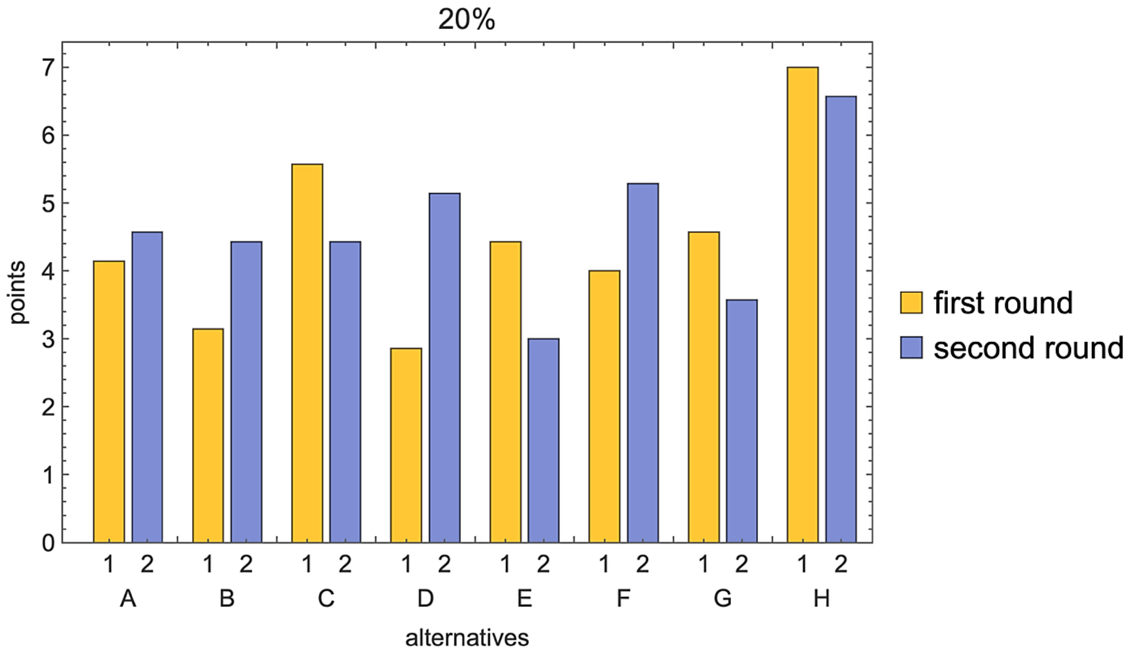

Figure 16. Experiment 3, method 20%.

Source: Own calculations.

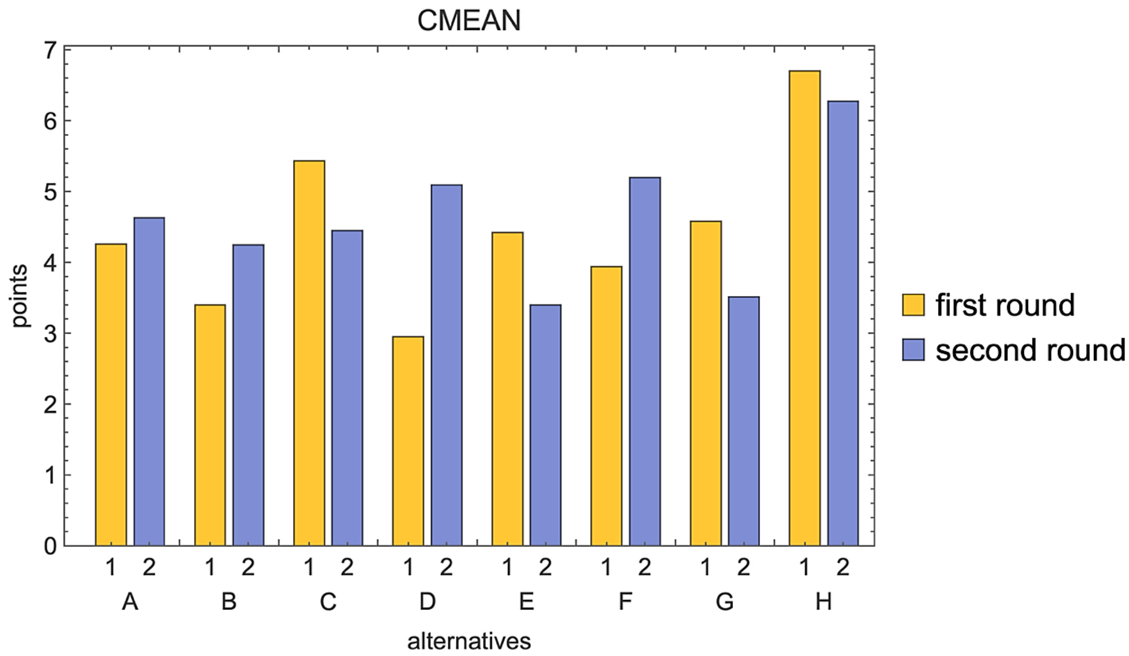

Figure 17. Experiment 3, method CMEAN.

Source: Own calculations.

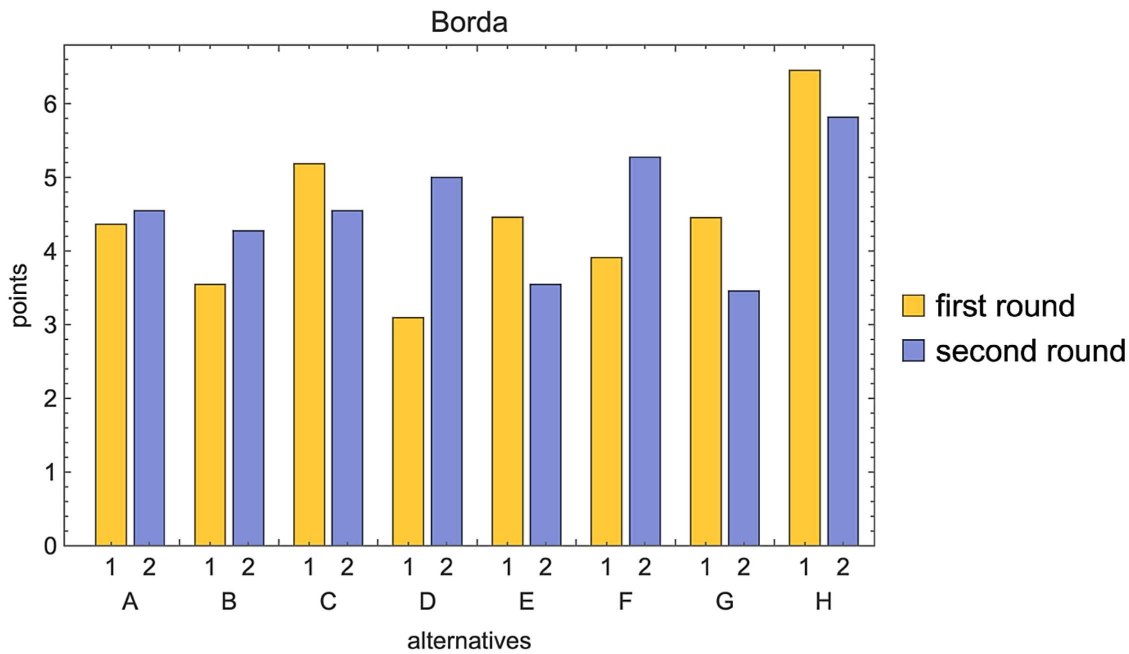

Figure 18. Experiment 3. Method Borda.

Source: Own calculations.

5.6. Summary

In summary, the serial position effect is observed in Experiments 1 and 3, but it is not a universal phenomenon, as shown by Experiment 2. Hypotheses H1–H4 are confirmed. Both primacy and recency effects are present. However, the position effect appears consistently only for the last landscape, H. Longer breaks between the stages result in lower values of Kendall's tau and higher distance measures, indicating reduced correlation.

6. Conclusions

Our study demonstrates that specific voting methods may be susceptible to serial position effects, particularly primacy and recency effects. One might question whether a group of students familiar with voting procedures could resist such influences or might have guessed the purpose of the study. However, post-experiment conversations revealed that the participants had not considered the study's purpose and were not immune to the serial position effect.

The number of voters and alternatives was chosen to resemble the conditions of the final rounds in classical music competitions. It is also worth emphasising that these voting methods — especially the Borda Count and its variations — are commonly used in sports and music competitions.

Therefore, we recommend introducing procedural safeguards to ensure that different contestants appear at the beginning and end of each stage. This measure should be applied not only in music competitions but also in other multi-stage contests judged by a fixed jury. Such a practice was implemented at the National Chopin Competition in Miami in 2025. The experience from that competition indicated that the choice of starting letters should better match the distribution of contestants' names.

A limitation of this study lies in the choice of voters. We selected students because we sought to work with educated individuals who understood that voting outcomes depend on the voting method. This condition was met by students of the Warsaw School of Economics. In the conducted experiments, landscape H — most often the highest-scoring image — was consistently placed at the end of the sequence. A different order of alternatives in the first stage could potentially lead to different conclusions regarding the position effect.

To prevent such bias, we suggest conducting a preliminary experiment to identify the most highly rated alternatives. This pretest, conducted with a similar group of participants, would determine which images receive the highest scores. Those alternatives should then be excluded from the initial and final positions in the main experiment.

Acknowledgements

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Appendix

The following tables present the experiment's raw data and the first and second voting. Voters ordered landscapes from the best to the worst. The best landscape got 8 points, the next 7, and so on. The worst landscape got 1 point. Points are in the cells of the tables.

Table 13.
Raw data of Experiment 1. First stage

landscape→ voter ↓	A	B	C	D	E	F	G	H
1	2	3	4	5	6	7	1	8
2	6	4	1	2	7	3	8	5
3	1	3	5	7	8	2	4	6
4	1	3	4	5	7	6	2	8
5	7	6	3	8	1	5	4	2
6	5	4	3	1	2	7	6	8
7	2	5	7	8	4	3	1	6
8	2	8	7	5	1	4	6	3
9	1	8	7	5	2	6	4	3
10	1	8	6	5	2	7	4	3
11	8	7	1	5	6	2	3	4
12	3	7	8	1	5	6	4	2
13	1	3	7	6	2	4	5	8
14	2	3	6	4	5	8	1	7
15	6	7	8	4	3	2	1	5
16	4	7	5	1	8	2	3	6
17	8	2	1	6	3	7	4	5
18	2	7	4	6	1	8	3	5
19	8	1	2	7	4	3	5	6

Source: Own calculations.

Table 14.
Raw data of Experiment 1. Second stage

landscape→ voter↓	A	B	C	D	E	F	G	H
1	8	2	1	6	3	7	4	5
2	4	7	6	5	1	8	3	2
3	6	1	7	8	3	2	4	5
4	3	1	6	5	2	8	7	4
5	5	2	1	6	3	8	4	7
6	3	5	4	2	8	1	7	6
7	3	1	6	5	2	8	7	4
8	5	4	7	2	8	3	1	6
9	7	6	1	2	3	4	5	8
10	2	5	7	8	3	6	4	1
11	5	7	8	2	3	6	4	1
12	2	7	6	4	1	8	5	3
13	3	6	5	4	1	8	2	7
14	8	6	2	7	3	1	5	4
15	3	8	7	1	5	6	4	2
16	1	3	8	6	2	4	5	7
17	1	4	5	7	8	2	3	6

Cont. table 14.

18	1	8	7	2	5	4	3	6
19	6	4	5	1	7	3	2	8

Source: Own calculations.

Table 15.
Raw data of Experiment 2. First stag.

Landscape → **voter↓**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	4	1	7	2	5	8	3	6
2	5	4	6	7	3	2	1	8
3	3	1	8	7	6	2	5	4
4	3	8	6	5	1	4	7	2
5	4	5	1	8	2	6	3	8
6	2	3	5	8	1	4	7	6
7	2	6	8	3	4	7	1	5
8	6	1	8	3	5	2	4	7
9	3	1	6	4	2	5	7	8
10	6	2	7	5	1	3	4	8
11	5	7	4	6	1	3	2	8
12	6	1	8	7	3	2	4	5
13	3	2	4	8	6	1	7	5
14	8	1	6	2	4	7	5	3
15	3	2	4	1	5	7	6	8
16	2	8	1	3	4	7	5	6
17	5	4	7	6	1	3	2	8
18	8	6	7	1	2	5	3	4
19	3	4	8	6	1	5	2	7

Source: Own calculations.

Table 16.
Raw data of Experiment 2. Second stage

landscape→ **voter↓**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	4	1	5	2	7	8	3	6
2	6	3	5	7	1	2	4	8
3	5	1	8	6	4	2	7	3
4	2	8	4	7	1	6	3	5
5	4	5	1	7	2	6	3	8
6	2	3	5	8	1	4	7	6
7	3	7	6	5	1	4	2	8
8	7	2	6	5	8	1	4	3
9	2	1	4	5	3	6	7	8
10	5	2	7	6	1	3	4	8
11	5	7	3	6	4	1	2	8
12	7	1	5	8	2	3	4	6
13	1	2	3	8	5	6	4	7
14	8	1	7	2	6	4	5	3
15	4	3	1	2	7	5	6	8
16	3	8	1	5	2	7	6	4
17	5	4	7	6	1	3	2	8
18	8	6	7	1	2	5	3	4
19	3	4	8	6	1	5	2	7

Source: Own calculations.

Table 17.
Raw data of Experiment 3. First stage

landscape→ voter↓	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	8	5	2	1	4	3	7	6
2	2	3	6	1	7	5	4	8
3	4	7	8	3	5	2	1	6
4	7	8	2	3	1	6	5	4
5	4	3	5	7	8	6	1	2
6	3	1	4	2	7	6	5	8
7	4	5	6	3	8	1	2	7
8	5	1	6	3	4	2	7	8
9	5	2	6	3	1	4	8	7
10	4	3	6	3	1	4	2	8
11	2	1	6	5	3	4	8	7

Source: Own calculations.

Table 18.
Raw data of Experiment 3. Second stage

landscape→ voter↓	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	6	7	2	8	4	3	5	1
2	3	6	2	1	7	4	5	8
3	2	4	7	3	1	6	5	8
4	2	6	5	4	1	8	3	7
5	6	7	3	5	1	4	2	8
6	7	1	4	5	3	6	2	8
7	7	6	3	5	8	4	1	7
8	6	1	3	5	4	8	2	7
9	4	3	7	6	1	8	5	2
10	2	3	6	7	8	5	4	1
11	5	3	8	6	1	2	4	7

Source: Own calculations.

Table 19.
Raw data of Experiment 3. Second stage

landscape→ voter↓	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	6	7	2	8	4	3	5	1
2	3	6	2	1	7	4	5	8
3	2	4	7	3	1	6	5	8
4	2	6	5	4	1	8	3	7
5	6	7	3	5	1	4	2	8
6	7	1	4	5	3	6	2	8
7	7	6	3	5	8	4	1	7
8	6	1	3	5	4	8	2	7
9	4	3	7	6	1	8	5	2
10	2	3	6	7	8	5	4	1
11	5	3	8	6	1	2	4	7

Source: Own calculations.