Quadratic Survey Interface

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Quadratic Surveys (QS) elicit more accurate individual preferences than traditional surveys, such as Likert-scale surveys. However, the cognitive load associated with QS has hindered its adoption in digital surveys for collective decision-making. We introduce a two-phase "organize-then-vote" QS interface based on decision-making and preference construction theories designed to lessen the cognitive load. Since interface design significantly impacts survey results and accuracy, our design scaffolds survey takers' decision-making while managing the cognitive load imposed by QS. In a 2x2 between-subject in-lab study on public resource allotment, we compared our interface with a traditional text interface across QS with 6 (short) and 24 (long) options. Our interface reduced satisficing behaviors arising from cognitive overload in long QS conditions. Participants using our interface in the long QSs shifted their cognitive effort from mechanical operations to constructing more comprehensive preferences. This research clarifies how human-centered design improves preference elicitation tools for collective decision-making.

CCS Concepts: • **Human-centered computing → Collaborative and social computing systems and tools**; **Collaborative and social computing design and evaluation methods**; User studies; **HCI design and evaluation methods**; **Interactive systems and tools**; **Empirical studies in interaction design**.

Additional Key Words and Phrases: Quadratic Voting; Survey Response Format; Collective decision-making; Preference Construction

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1 Introduction

Designing effective survey interfaces is crucial for accurately capturing respondents' preferences, which directly impact the quality and reliability of the data collected. For instance, voice assistants have been used to gather user feedback [1], and a recent Human-Computer Interaction (HCI) study highlights that certain survey response formats can increase errors [2]. In this paper, we introduce **Quadratic Surveys (QS)**, a survey tool designed to elicit preferences more accurately than traditional methods [3]. Despite the promise of QS, there has been no research on designing interfaces to support its unique quadratic mechanisms [4], where participants must rank and rate items — a task that poses significant cognitive challenges. To popularize QS and ensure high-quality data, this paper addresses the question: *How can we design interfaces to support participants in completing Quadratic Surveys (QS) more effectively?*

We envision an effective interface that navigates participants through the complex mechanism and preference construction process, tailored to the unique challenges of QS. QS improves accuracy in individual preference elicitation compared to traditional methods like Likert scales by requiring participants to make trade-offs using a fixed budget of credits, where purchasing k votes for an option in QS costs k^2 credits [5, 3]. This quadratic cost structure forces respondents to carefully evaluate their preferences, balancing the strength of their support or opposition against the limited budget. While this cost structure forces them to make thoughtful trade-offs, this complexity also increases

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cognitive load, making it mentally taxing to weigh costs, evaluate options, and construct rankings [6]. Moreover, QS, often referred to as Quadratic Voting (QV) in voting scenarios, can involve hundreds of options [7, 8], increasing the risk of cognitive overload and satisficing [9, 10, 11]. We propose that an effective interface tailored to support users through these complex trade-offs can reduce cognitive load and facilitate better preference construction.

To date, existing quadratic mechanism-powered applications simply present options, allow vote adjustments and automatically calculate votes, costs, and budget usage. These designs focused heavily on the mechanism, rather than supporting possible challenges these application users faced. Survey interface literature, while addressing decision-making and usability, most focus on traditional surveys that do not share the unique option-to-option trade-offs that QS introduces [12, 13, 14, 15, 16, 2]. The challenges, in particular, cognitive load [17, 18, 15, 19] and scaffolding challenging tasks [20, 21, 22] like preference construction, are opportunities where user interfaces have shown their promises. As a result, it remains unclear how different interface designs might support QS in reducing cognitive load and aiding preference construction.

After multiple design iterations, we propose a novel interactive two-phase "organize-then-vote" QS interface (two-phase interface, Figure 1) that integrates three key elements. First, the interface scaffolds the preference construction process by having participants initially categorize the survey options into "Positive," "Neutral," or "Negative" This serves as a cognitive warm-up, easing participants into the more complex QS voting task. Second, the interface arranges the options according to these categorizations, providing a structured visual layout. Third, participants can refine the positions of these options using drag-and-drop functionality, giving them greater control and agency in the preference-construction process. These design features are aligned with preference construction theory and build upon prior research in interface design to reduce cognitive load and enhance user engagement.

To explore how these interface elements mitigate the cognitive load and support preference construction in Quadratic Surveys, we pose the following research questions:

- RQ1. How does the number of options in Quadratic Surveys impact respondents' cognitive load?
- RQ2a. How does the two-phase interface impact respondents' cognitive load compared to a text interface?
- RQ2b. What are the similarities and differences in sources of cognitive load across the two interfaces?
- RQ3. What are the differences in Quadratic Survey respondents' behaviors when coping with long lists of options across the two-phase interface and the text interface?

We invited 41 participants to a lab study comparing our two-phase interface with a baseline to understand how different interface designs and option lengths (6 options or 24 options) impact cognitive load. Qualitative findings, measured using the NASA Task Load Index (NASA-TLX) and semi-structured interviews, revealed that participants using the two-phase interface experienced cognitive demand more from strategic, holistic thinking compared to personal relevance and operational tasks, particularly in longer surveys. Quantitative results showed that, although participants spent more time per option, they made faster decisions during the voting phase, suggesting a more efficient distribution of cognitive effort. We concluded that the two-phase interface prevented cognitive overload in long QS surveys and shifted mental load toward more strategic thinking, reducing reliance on mental shortcuts like satisficing [9].

Contributions. We contribute to the HCI community by proposing the first interface specifically designed for QS and QV-like applications, aimed at reducing cognitive challenges and scaffolding preference construction through a two-phase interface with direct manipulation. Before our work, no research had explored QS interfaces, particularly for long surveys prone to cognitive overload. Few studies in HCI address interfaces for surveys and questionnaires. Our study demonstrated how user interfaces can facilitate preference construction in situ and reduce satisficing behaviors

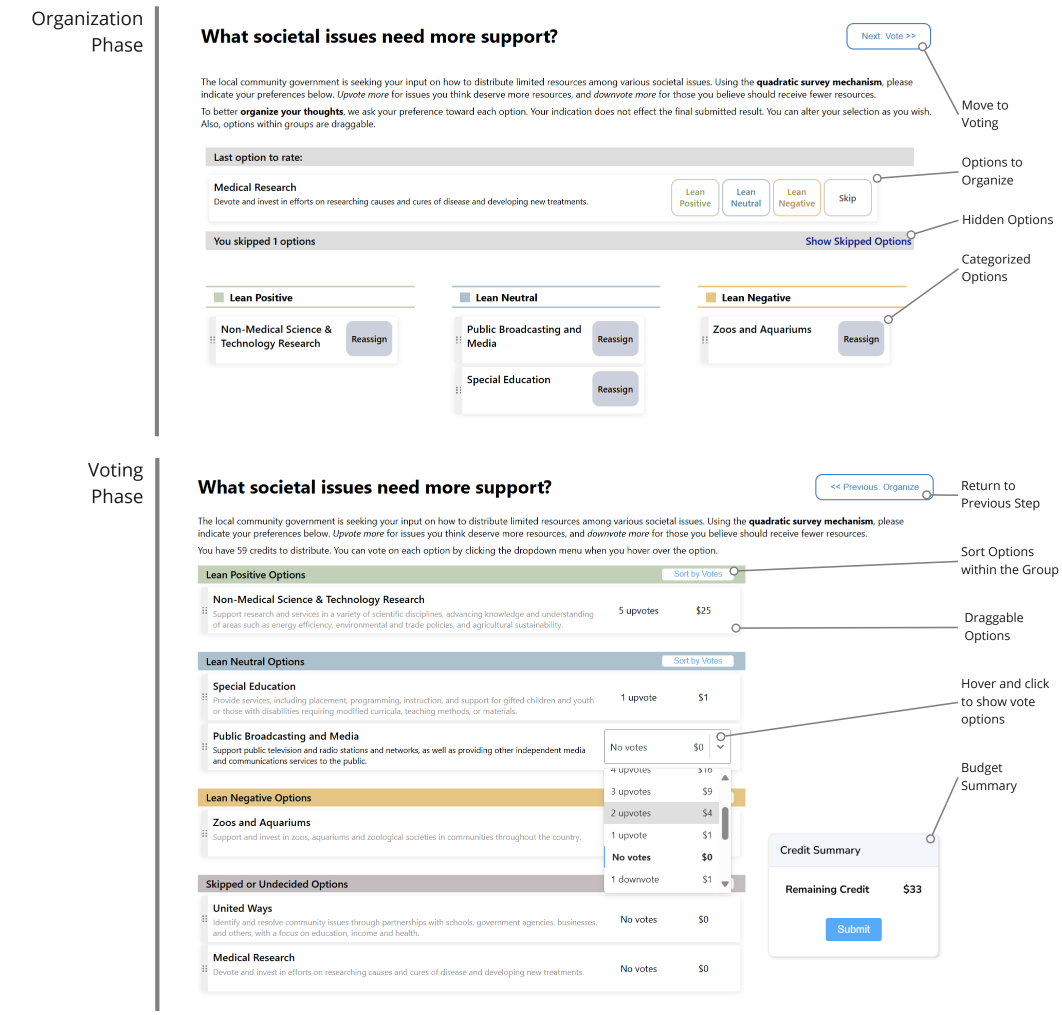


Fig. 1. The Two-Phase Interface: The interface consists of two phases. Survey respondents can navigate between phases using the top right button. In the organization phase, the interface presented one option at a time to the respondents where they choose among four choices: “Lean Positive”, “Lean Neutral”, “Lean Negative”, or “Skip”. Skipped options are hidden and can be evaluated later. The chosen options will be listed below. Items can be dragged and dropped across categories or returned to the stack. In the voting phase, options are listed in the order of the four categories. When hovering over each option, respondents can select a vote for that option using the dropdown. Each dropdown contains the cost associated with the vote. A sort button allows ascending sorting within each category. A summary box tracks the remaining credit balance.

by promoting incremental updates and deeper engagement with survey items through interface elements. Additionally, our interview is also the first in-depth qualitative analysis of user experiences with Quadratic Mechanism applications, identifying key factors contributing to cognitive load. The impact of our contribution extends beyond QS, offering design implications for other preference-elicitation tools in complex scenarios. By making QS easier to use and more accurate, our design also encourages wider adoption among researchers and practitioners. Finally, our work lays the groundwork for future studies on qualitative insights and future interface designs of quadratic mechanisms, supporting decision-makers in eliciting accurate respondents' preferences.

2 Related Work

This research lies at the intersection of three core areas: quadratic surveys, survey and voting interface design, and choice overload along with cognitive challenges. In this section, we review the related works in each of these areas.

2.1 Quadratic Survey and the Quadratic Mechanism

We introduce the term **Quadratic Survey (QS)** to describe surveys that utilize the quadratic mechanism to collect individual attitudes. The **quadratic mechanism** is a theoretical framework designed to encourage the truthful revelation of individual preferences through a quadratic cost function [4]. This framework gained popularity through **Quadratic Voting (QV)**, also known as plural voting, which uses a quadratic cost function in a voting framework to facilitate collective decision-making [23].

To illustrate how QS works, we formally define the mechanism: each survey respondent is allocated a fixed budget, denoted by B, to distribute among various options. Participants can cast n votes for or against option k. The cost c_k for each option k is derived as:

$$c_k = n_k^2 \quad \text{where} \quad n_k \in \mathbb{Z}$$

The total cost of all votes must not exceed the participant's budget:

$$\sum_k c_k \leq B$$

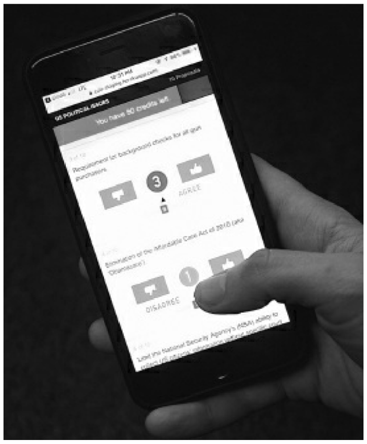
Survey results are determined by summing the total votes for each option:

$$\text{Total Votes for Option } k = \sum_{i=1}^{S} n_{i,k}$$

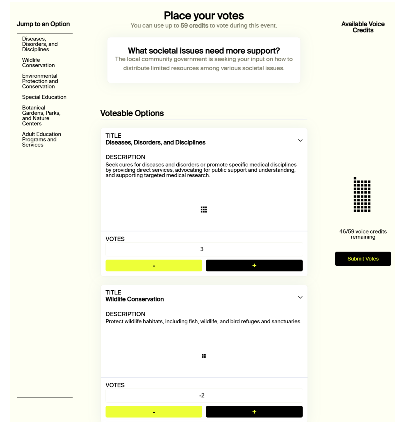
where S represents the total number of participants, and $n_{i,k}$ is the number of votes cast by participant i for option k. Each additional vote for each option increases the marginal cost linearly, encouraging participants to vote proportionally to their level of concern for an issue [24].

QS adapts these strengths of the quadratic mechanism in *voting* to encourage truthful expression of preferences in *surveys*. Unlike traditional surveys that elicit either rankings *or* ratings, QS allows for *both*, enabling participants to cast multiple votes for or against options, incurring a quadratic cost. Cheng et al. [3] showed that this mechanism aligns individual preferences with behaviors more accurately than Likert Scale surveys, particularly in resource-constrained scenarios like prioritizing user feedback on user experiences.

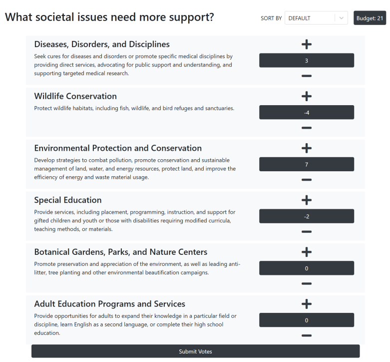
In recent years, empirical studies on QV have expanded into various domains [25, 26]. Applications based on the quadratic mechanism have also grown, including Quadratic Funding, which redistributes funds based on outcomes from consensus made using the quadratic mechanism [27, 28]. Recent work by South et al. [29] applies the quadratic mechanism to networked authority management, later used in Gov4git [30]. Despite the increasing breadth and depth of applications utilizing the quadratic mechanism, little attention has been paid to user experience and interface design, which support individuals in expressing their preference intensity. Our work aims to address this by designing interfaces supporting quadratic mechanisms.



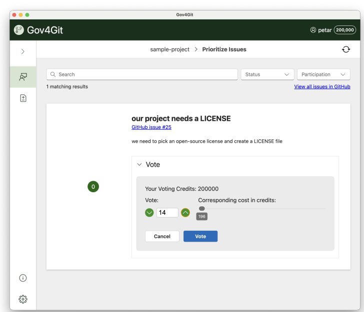
(a) Software by WeDesign, used in the first empirical QV research [5]. Little information is available about the software, except for an image from Posner and Weyl [24]. In the image, each prompt has thumbs up and down icons to update the vote in the center. The remaining budget appears as a progress bar at the top.



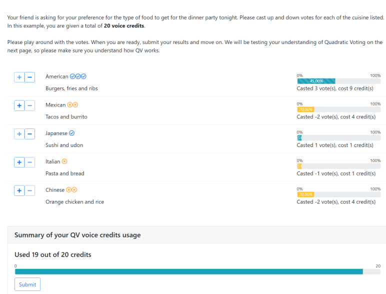
(b) An open-sourced QV interface [31] forked from GitCoin [32], used by the RadicalxChange community [33]. This interface presents total credits as small blocks. Votes are updated using plus and minus buttons, with numerical counts shown under each option and surface area as costs.



(c) An open-source QV interface [34] offers a publicly available service. Options show only the current number of votes, with credits displayed in the top right corner. This interface does not show the costs of votes but supports sorting options.



(d) The interface designed for gov4git [30] updates votes using arrows under each option, with the associated cost shown as a percentage bar to the right. A search bar exists for searching specific pull requests or issues.



(e) The interface used in the research by Cheng et al. [3] employs the most visual components. Icons depict the current number of votes, with progress bars signifying the current spending.

Fig. 2. Recent interface for applications using the quadratic mechanism.

2.2 Design Implications from Surveys and Voting Interfaces

We began by examining existing QV applications, which share the same mechanism as QS, and identifying shared interface components. All QV interfaces generally include:

- Option list: A list of options for voting.
- Vote controls: Buttons to increase or decrease votes for each option.
- Individual vote tally: A display of the votes cast per option.
- Summary: An auto-generated summary of costs and the remaining budget.

These components present options, calculate costs, and allow vote adjustments. However, these interfaces focus purely on mechanics without little understanding of voter's usability needs or offering cognitive support to help them complete the task effectively. In addition, the HCI community conducted few research [35, 36] on survey and questionnaire interfaces components, with more work focusing more on alternative input modalities like bots, voice, and virtual reality [37, 38, 39, 40]. Thus, we turn to marketing and research literature for insights into how digital survey interface elements can impact user behavior and usability.

Research in the marketing and research communities focusing on survey and questionnaire design, usability, and interactions examines the influence of presentation styles and 'response format.' Weijters et al. [41] demonstrated that horizontal distances between options are more influential than vertical distances, with the latter recommended for reduced bias. Slider bars, which operate on a drag-and-drop principle, show lower mean scores and higher nonresponse rates compared to buttons, indicating they are more prone to bias and difficult to use. In contrast, visual analog scales that operate on a point-and-click principle perform better [42]. These studies show how even small design changes can have a large impact on usability, highlighting the importance of designing interfaces that prioritize human-centered interaction rather than focusing solely on functionality.

Voting interfaces are a specialized type of survey interface that not only elicit individual choices but often have consequential impacts. For example, the butterfly ballot, an atypical design, may have influenced the outcome of the 2000 U.S. Presidential Election [43]. Research has shown that ballot interfaces can significantly influence democratic processes [12, 44, 45]. Several studies also highlighted how voting interface designs shift voter decisions [12], reduce usability errors [46, 47], or improve interaction [48, 49, 50, 51, 52]. We provide more details to these voting interfaces in the Appendix C.

From the QV implementations, response format literature, and voting interfaces, we identified how interfaces significantly influence respondent behavior, decision accuracy, and cognitive load. While these systems are functional, they lack the human-centered design needed to reduce cognitive load and make them truly usable, rather than simply operable. These burdens are especially problematic for complex systems like QS, where high cognitive demands may deter researchers and users alike. Developing effective, human-centered interfaces for QS could enhance usability, reduce cognitive overload, and increase adoption in both research and practical applications.

2.3 Cognitive Challenges and Choice Overload

The challenge of respondents making difficult decisions using quadratic mechanisms remains unexplored in the literature. Lichtenstein and Slovic [6] identified three key elements that make decisions difficult. These elements include making decisions in unfamiliar contexts, being forced to make tradeoffs due to conflicting choices, and quantifying the value of one's opinions. QS fits all three elements: participants may encounter unfamiliar options set by the decision maker, are constrained by budgets that require tradeoffs, and cast final votes as numerical values. Thus, we believe QS introduces high cognitive load.

Cognitive overload can adversely affect performance, leading individuals to rely on heuristics rather than deliberate, logical decision-making [53]. When presented with excessive information, such as too many options, individuals 'satisfice', settling for a 'good enough' solution rather than an optimal one [9, 10, 11]. Subsequently, too many options can overwhelm individuals, resulting in decision paralysis, demotivation, and dissatisfaction [54].

Additionally, Alwin and Krosnick [55] highlighted that the use of ranking techniques in surveys can be time-consuming and potentially more costly to administer. These challenges are compounded when ranking numerous items, requiring substantial cognitive sophistication and concentration from survey respondents [56].

Notable applications of Quadratic Voting include the 2019 Colorado House, which considered 107 bills [57], and the 2019 Taiwan Presidential Hackathon, which featured 136 proposals [58]; both used a single QV question with hundreds of options. Psychological and behavioral research highlights the importance of understanding how individuals navigate and benefit from new interfaces under long-list QS conditions. These empirical applications of QV suggest QS's potential to elicit individual preferences, emphasizing the need to study cognitive load and interface design.

3 Quadratic Survey Interface Design

In this section, we present the QS interface. Using components identified in current QV interfaces, together with prior literature, we iterated over paper prototypes and three design iterations based on each pre-test result. During our initial paper prototyping iterations, two challenges emerged: identifying relative preferences among options and deciding the degree of trade-offs between options. In this study, we focus on the first challenge to inform our interface design iterations. For coherence and brevity, we provide detailed descriptions of these iterations and additional design considerations in Appendix D.

3.1 The Two-Phase Interface

3.1.1 Justifying a two-phase approach. The main objective for the two-phase interface is to facilitate preference construction and reduce cognitive load. The two-phase interface, shown in Figure 1 consists of two steps: An organization phase and a voting phase. Throughout both phases, survey respondents can drag-and-drop options across the presented option list.

A two-phase approach. If preferences are constructed, by nature, they consist of a series of constructed decision-making processes [6]. Two major decision-making theories informed this two-step interaction interface design: Montgomery [59]'s Search for a Dominance Structure Theory (Dominance Theory) and Svenson [60]'s Differentiation and Consolidation Theory (Diff-Con Theory). The former suggested that decision-makers prioritize creating dominant choices to minimize cognitive effort by focusing on evidently superior options [59]. The latter described a two-phase process where decisions are formed by initially *differentiating* among alternatives and then *consolidating* these distinctions to form a stable preference [60]. Both theories supported the design decision to reduce the dimensions during the initial decision process and help emphasize relatively important options to form decisions. Hence, the two-phase design – organize then vote – aimed to facilitate this cognitive journey explicitly. The first phase focused on differentiating and identifying dominant options, enabling survey respondents to preliminarily categorize and prioritize their choices. The second phase presented these categorized options in a comparable manner, with drag-and-drop functionality, enhancing one's ability to consolidate preferences. This structured approach aimed to construct a clear decision-making procedure that reduced cognitive load and enhanced clarity and confidence in the decisions made.

Phase 1: Organization Phase. The goal of the organization phase was to support participants in identifying dominating options or partitioning options into differentiable groups. In this section, we first describe how the interaction worked, then we detail the reasons for the implemented design decisions.

The organizing interface, depicted on the top half of Figure 1, sequentially presented each survey option. Participants selected a response among three ordinal categories – "lean positive", "lean negative", or "lean neutral". Once selected, the system moved that option to the respective category. Participants could skip the option if they did not want to indicate a preference. Options within the groups were draggable and rearrangeable to other groups should the participants wish.

Strack and Martin [61]'s research showed that upon understanding a survey question, respondents either recalled a prior judgment or constructed a new one when completing an attitude survey. In addition, revealing one option at a time gated the amount of information presented to the survey respondent and thereby reduced the extraneous load [62]. This process allowed participants to form or express opinions on individual options incrementally. This design also mitigated the original concern from early prototypes where participants accidentally treated the organizing task as a ranking task.

The three possible options, positive, neutral, and negative, aimed to scaffold participants in constructing their own choice architecture [63, 64], which strategically segmented options into diverse and alternative choice presentations while avoiding the biases from defaults. We believed that these three categories were sufficient for participants to segment the options. However, we chose not to limit the number of options one could place into a category to prevent restricting user agency, a core user interface design principle [18].

Immediate feedback displaying the placement of options and allowing participants to rearrange them via drag-and-drop adhered to key interface design principles [18]. At the same time, it allowed finer grain control for individuals to surface dominating options and create differentiating groups of options.

Phase 2: Interactive Voting Phase. The objective of the voting phase was to facilitate the consolidation of differentiated options through interactive elements while reinforcing the differentiation across options constructed by participants from the previous phase. This facilitation was achieved by retaining the drag-and-drop functionality for direct manipulation of position and enabling sorting within each category.

Options were displayed as they were categorized within each category from the previous step and in the following section orders – lean positive, lean neutral, lean negative, and skipped or undecided as detailed on the bottom half of Figure 1. The Skipped or Undecided category contained options left in the organization queue, possibly because survey respondents had a pre-existing preference or chose not to organize their thoughts further. The original order within these categories was preserved to maintain and reinforce the differentiated options. This new ordering sequence mitigated the concern from prototype 3 where options without a category are left at the top of the voting interface. Respondents had the flexibility to return to the organization interface at any point during the survey to revise their choices.

In the voting interface, options remained draggable, enabling participants to modify or reinforce their preference decisions as needed. Each category featured a sort-by-vote function that enabled reordering within the same category. Although these interactions did not influence the final voting outcome, they were designed to support consolidation and positional proximity in information organization. This design aimed to automate the grouping of similar options while providing an intuitive drag-and-drop mechanism, thereby facilitating decision-making by placing similar options near each other. This echoed the principles of the proximity compatibility principle, particularly emphasizing spatial proximity and mental compatibility [65]. The interface design anticipated that participants would find it easier to consolidate their choices when similar options were positioned close together, thereby reducing cognitive load.

While multiple interaction mechanisms exist, drag-and-drop has been extensively explored in rank-based surveys. For instance, Krosnick et al. [66] demonstrated that replacing drag-and-drop with traditional number-filling rank-based questions improved participants' satisfaction with little trade-off in their time. Similarly, Timbrook [67] found that integrating drag-and-drop into the ranking process, despite potentially reducing outcome stability, was justified by the increased satisfaction and ease of use reported by respondents. The trade-off was deemed worthwhile as QS did not use the final position of options as part of the outcome if it significantly enhanced user satisfaction and usability [68].

Together, these design decisions led to our belief that a two-phase interface with direct interface manipulation could reduce the cognitive load for survey respondents to form preference decisions when completing QS.

3.1.2 Aesthetic Design Decisions. We made three aesthetic design decisions. First, we decided to remove all visual elements. Prior literature suggested that the use of emojis might influence the interpretations of surveys [69] and decrease user satisfaction [15]. Prior literature also noted that not all data visualization elements reduce cognitive demand [70]. Even though effective visualization can aid decision-making, it remains an open question that this study does not aim to address. Thus, we also removed all visualization elements, such as blocks, progress bars, and percentage indicators.

Second, the final interface has all options presented on the screen at the same time, intentionally. Unlike all the prototypes and existing interfaces, prior literature emphasized the importance of placing all the options on the same digital ballot screen to avoid losing votes. This echoes the proverb "out of sight, out of mind," where individuals might be biased toward options that are shown to them, and additional effort is required for individuals to retrieve specific information if options are hidden.

Last, we decided to use a dropdown positioned to the right of the option such that control of votes and the budget summary are placed near one another. The layout of the votes and cost was inspired by online shopping cart checkout interfaces where quantities are supplied next to the itemized costs followed by the total checkout amount. We chose a dropdown after iterating with two alternative input methods (Figure 3): the original click-based buttons and a wheel-based implementation. The former design requires survey respondents to click multiple times to reach their desired vote values. Thus, we wanted to look for a solution to aid respondents in reaching their intended value faster. A wheel-based approach allows intuitive control of the votes by using the wheel on the mouse and clicking to fine-tune the values. However, in our early pilot studies, not all participants were familiar with wheel control. Thus, we opted for a dropdown menu for vote selection.

3.2 Baseline Interface: Text-based Interface

To compare how the designed interactive components influenced participants' cognitive load and behavior, we designed the text-based interface as our control condition. The text-based interface shares the other functionalities of the two-phase interface without the two-phase interactive design and the drag-and-drop (Figure 4.) The interface contained the question prompt at the top of the screen. The options were presented in a list underneath the prompt. Survey respondents could update the votes by selecting from a dropdown that provided all possible voting options and costs given the number of credits available. A small summary box to the right of the interface showed the current total cost and the remaining credits for the respondent. The interface randomly presented options to avoid ordering bias [71, 72].

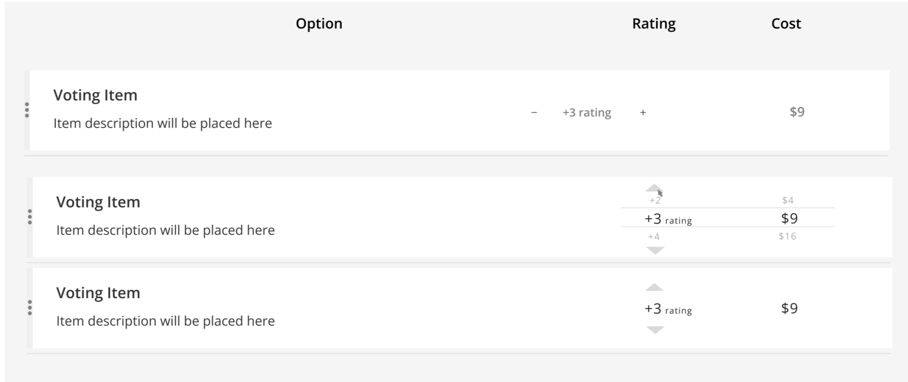


Fig. 3. Alternative vote control. The click-based design (upper) mirrors traditional vote control used in other QV interfaces, where each click controls one vote. The wheel-based design (the latter two) allows control through both clicks and mouse wheel rotation.

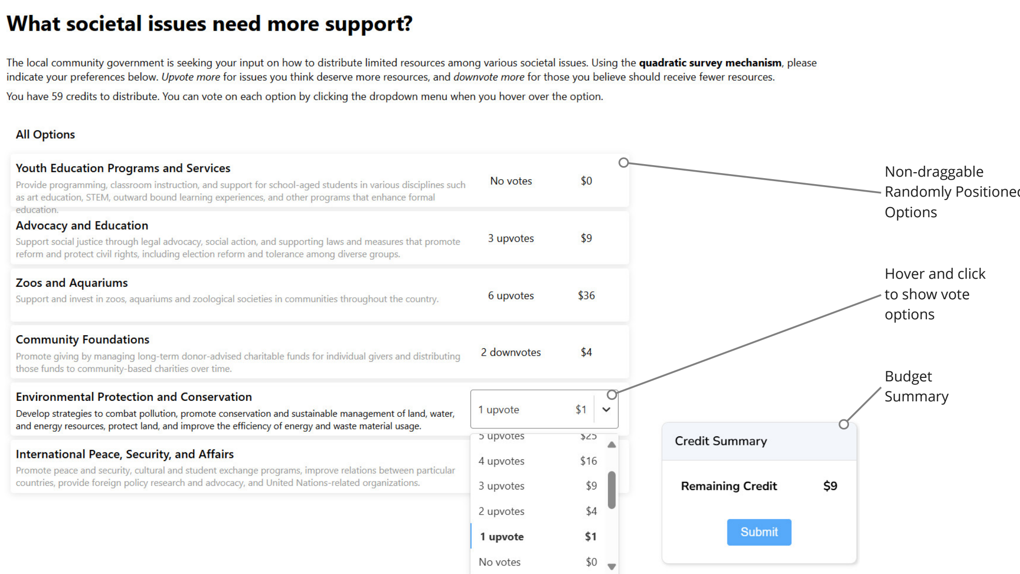


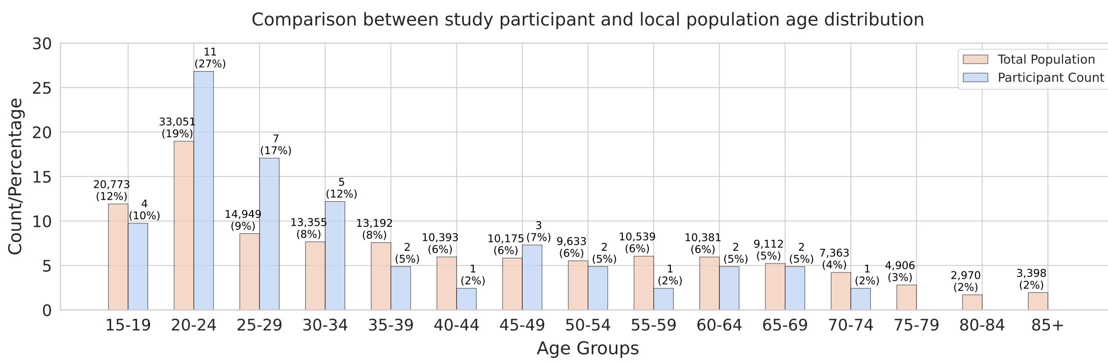
Fig. 4. The text-based interface: This interface is based on the interactive version but does not include the two-phase interactive support and lacks the drag-and-drop functionality. Options are randomly positioned.

Both experiment interfaces are developed with a React.js frontend and a Next.js backend powered on MongoDB. We open-sourced both interfaces.[1]

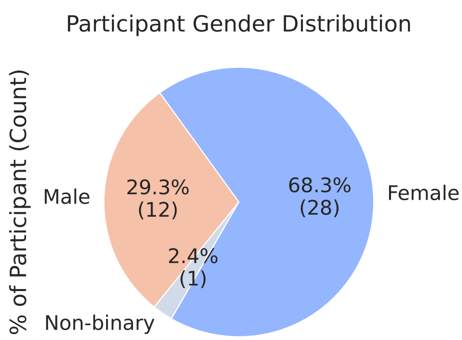
[1] link-to-github

4 Experiment Design

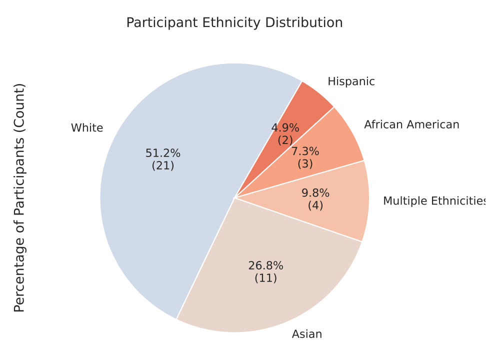
We recruited 41 participants, with one excluded[2] due to data quality concerns, from a United States college town using online ads, digital bulletins, social media posts, online newsletters, and physical flyers in public spaces beyond campus. To ensure participant diversity, we prioritized non-students by selectively accepting them as we monitored demographics. Study participants' mean age was 34.63 years old, with an age distribution similar to the county's demographic profile (Figure 5a) albeit a slightly higher representation of younger adults. Gender and race demographics are aggregated in Figure 5b and 5c. The study was framed as focusing on societal attitudes to avoid response bias. The university's Institutional Review Board reviewed and approved this study.



(a) Age distribution of the participants skewed slightly younger despite following similar trends as the county population.



(b) Gender distribution of our participants skewed towards female participants.



(c) Ethnicity distribution remains diverse with less Hispanic and African American participants.

Fig. 5. Demographic distributions: Age, Gender, and Ethnicity

Figure 6 visually represents the study protocol. Participants completed the study in the lab to control for external influences. Participants used a 32-inch vertical monitor displaying all options on the survey to prevent hidden information during decision-making. After consenting, participants watched a video explaining the quadratic mechanism without

[2]The participant reported not completing the survey seriously because they believed the experiment was fake.

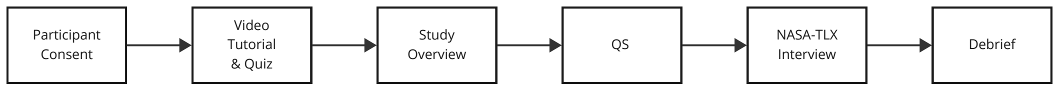


Fig. 6. Study protocol: Participants are asked to learn about the mechanism of QS after consenting to the study. The researcher explained the study overview and asked participants to complete the QS. A NASA-TLX survey followed by interviews to understand participants' cognitive load. We debriefed participants after the study.

hints of interface operation followed by a quiz to ensure understanding. Participants rewatched the video or consulted the researcher until they could select the correct answers. The participant's screen was captured throughout the study. The researcher primed the participant that the study aimed to help local community organizers understand preferences on societal issues to better allocate resources. Participants were randomly assigned to one of four groups:

- Short Text (ST): A text interface with 6 options. ($N = 10$)
- Short Interactive (SI): A two-phase interface 6 options. ($N = 10$)
- Long Text (LT): A text-based interface 24 options. ($N = 10$)
- Long Interactive (LI): A two-phase interface with 24 options. ($N = 10$)

Participants completed the survey independently, without the researcher's presence. They then contacted the researcher for the NASA-TLX survey, followed by a short audio-recorded semi-structured interview. The session concluded with a debriefing and a $15 cash compensation, during which participants were informed of the study goal on cognitive load and interface design.

We made several experimental design choices. First, we selected a between-subject design to minimize study fatigue, considering the complexity of QS, and avoiding the learning effect that could influence how participants evaluated the options. Second, we chose the context of public resource allotment, where participants expressed their preferences regarding their preference across 6 or 24 societal issue options, following the methodology of Cheng et al. [3]. These issues are relevant to all citizens and effectively demonstrate the need to prioritize limited public resources. We curated 26 societal issues used by Charity Navigator [73] which evaluates over 20,000 charities in the United States. The interface randomly presents options from this list to participants. Appendix E contains the full list.

We relied on prior literature to test 6 and 24 options, representing short and long lists, as identifying the 'breaking point' for cognitive overload would require impractical time and resource commitments which we detail below. Constant sum surveys and the Analytic Hierarchy Process (AHP) recommend fewer than ten and seven options, respectively [74, 75, 76]. Miller [77]'s classic work on cognitive processing capacity and Saaty and Ozdemir [78]'s theoretical proof supported the use of 7 ± 2 items. A meta-analysis by Chernev et al. [79] identified 6 and 24 as common values for short and long lists in choice overload studies, rooted in the original experiment by Iyengar and Lepper [54].

Finally, we deployed self-report subjective surveys and analytical measures (i.e., time and clickstream data). We adopted the paper-based weighted NASA Task Load Index (NASA TLX), a widely used multidimensional tool that averages six subscale scores to represent overall workload after completing a task [80, 81, 82]. NASA-TLX is favored for its low cost and ease of administration [83], with less variability compared to one-dimensional workload scores [84], making it suitable for our study. While cognitive load can be measured through performance measures, psychophysiological measures, subjective measures, and analytical measures [83], given the extended nature of QS we chose not to adopt them.

5 Cognitive Load and Sources across Experiment Conditions

This section presents cognitive load across experiment groups and the sources contributing to each cognitive load dimension. Due to the smaller sample size, we focus on descriptive statistics and qualitative assessments. We present quantitative data from survey tasks and qualitative insights from post-survey interviews.

To analyze the qualitative data, the first author conducted an inductive thematic analysis process [85] after transcribing the interview. They coded snippets from each transcript based on specific research questions and topics of interest for the qualitative analysis. Similar codes were merged within each research question or topic to form relevant themes. When differences were hypothesized, they applied a deductive coding process to text snippets related to a specific research question or topic of interest.

The results for this section are organized as follows: We first provide an overview of our cognitive load findings. Of the six dimensions used in the NASA-TLX survey, we report mental demand, physical demand, and frustration in detail and summarize our findings for the temporal demand, performance, and effort for brevity.

5.1 Overall Cognitive Load

To answer **RQ1** and **RQ2a**, we derive the weighted NASA-TLX scores across the four experiment conditions. We show these results in Figure 7. Weighted NASA-TLX uses a continuous 0-100 score, with higher values indicating greater cognitive load. We use predefined mappings of NASA-TLX scores to cognitive levels: low, medium, somewhat high, high, and very high, as listed by Hart and Staveland [80]. We show value interpretations in Figure 7b.

Surprisingly, the long text interface had lower mean ($\mu = 34.60$) and median ($\tilde{x} = 33.85$) cognitive load scores than both the short text ($\mu = 43.23$, $\tilde{x} = 39.00$) and long interactive interfaces ($\mu = 42.02$, $\tilde{x} = 42.70$). Additionally, the two-phase interface decreased cognitive load for the short survey but increased it for the long survey. Notably, the short text interface had the most participants ($N = 8$) reporting somewhat high or higher cognitive loads, whereas the other conditions had a more balanced distribution, with about half reporting medium to high loads.

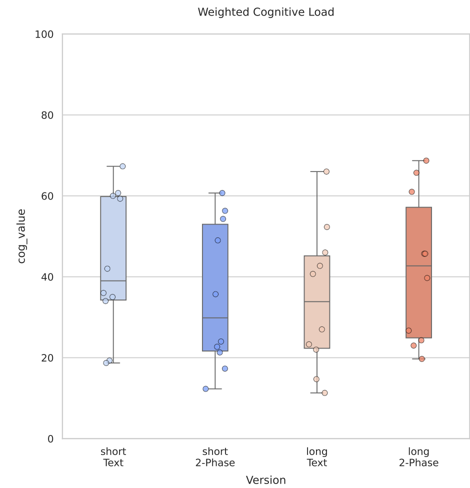
We acknowledge that these results may not fully reflect actual cognitive load due to noise from factors like small sample size, task nature, or participants' interpretation of the cognitive load scale. To explore these possibilities further, we turn to qualitative insights from post-task interviews.

5.2 Sources of Mental Demand

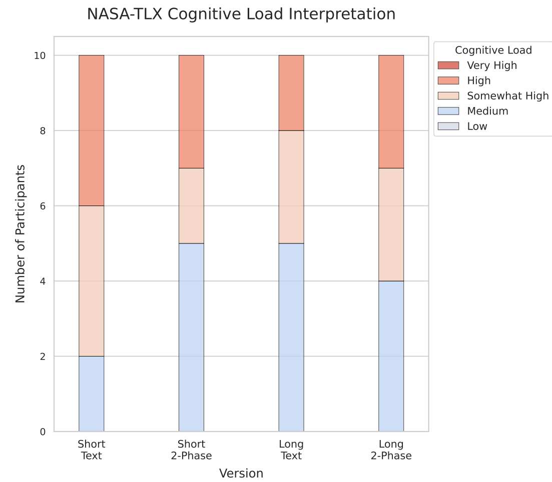
> **Key Differences:** First, slightly more participants using the text interface reported mental demand from precisely determining the number of votes for options compared to the two-phase interface. Second, when it comes to long QS, participants using the long two-phase interface considered broader societal impacts and evaluated options holistically, while those in the long text interface focused on personal relevance and individual issues.

Mental demand refers to the degree of mental and perceptual activity required to complete a task. Interview results showed primary drivers of participants' mental demand were *Budget management* and *Preference construction* [3].

[3] The full table is in Appendix F.1.



(a) NASA-TLX Weight Score: The Long Two-Phase Interface exhibits the highest weighted cognitive load with a median of 42.70, a mean of 42.02. This is higher than the Long Text Interface, which has a median cognitive load of 33.85, a mean of 34.60. However, the Short Text Interface demonstrates a higher cognitive load with a median of 39.00, a mean of 43.23, compared to the Short Two-Phase Interface which has a median of 29.85, a mean of 35.36. Standard deviation are similar across groups at around 18.



(b) NASA-TLX Cognitive Interpretation: More participants in the Short Text Interface, totaling 8, reported a somewhat high or above cognitive load, which is significantly higher compared to the 5 participants who reported similarly for the Short Two-Phase Interface. However, the Long Two-Phase Interface saw slightly more participants, 6 in total, reporting somewhat high or above cognitive load compared to the Long Text Interface.

Fig. 7. This figure shows the box plot results for weighted NASA-TLX scores across experiment groups and participant counts based on individual score interpretations. In 7a, we observe a downward trend in cognitive load for the short QS, while the long QS shows an upward trend. Interestingly, there is a counterintuitive downward trend between short and long text interfaces. In 7b, these trends are clearer when NASA-TLX scores are grouped into five tiers.

5.2.1 Mental Demand Source #1: Budget management. 14 participants expressed demand from budgeting within limited credit (S032 *[. . .] for certain societal issues you had to . . . take away from other societal issues that you could support.* , $N = 5$), tracking remaining credits (S006 *[. . .] looking at the remaining credits, I'm trying to mentally divide that up before I start allocating* , $N = 10$), and maximizing credit use (S032 *[. . .] I used all the credit that I had available* , $N = 8$).

We categorized budget management-induced mental demand as operational (single interface-level action, e.g., using the last remaining credit) or strategic (higher-level goal, e.g., evenly distributing credits across options). Long survey participants more often report operational causes suggesting that more survey options induced short-term thinking.

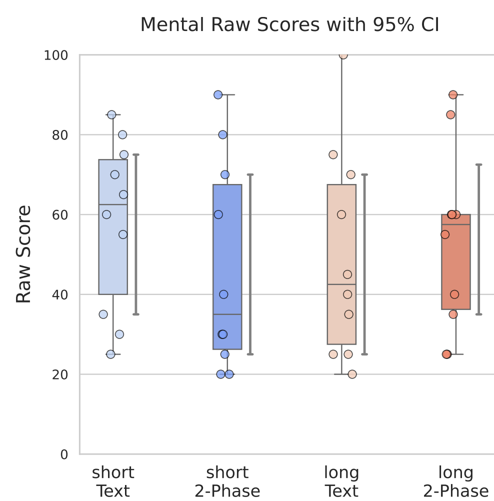


Fig. 8. Mental Demand Raw Score: Across all four experiment groups, participants' reported mental demand is spread across a wide range with many participants experiencing high mental demand.

5.2.2 Mental Demand Source #2: Preference construction. All but one participant reported increased mental demand due to preference construction. We further break it down into three sources: comparative preference evaluation (i.e., evaluating relative importance between options; S002 *Figuring out ... how much I prioritize option 1 over option 2* , $N = 16$), resource-constraint prioritization (i.e., trading off between options due to resource constraints, S005 *[...] very hard to take decisions ... because I felt that multiple options deserve equal amount of credit ... but you have given very limited amount of credit.* , $N = 17$), and precise resource allocation (S023 *[...] having to pick how many upvotes would go to each one* , $N = 30$).

Almost all participants mentioned preference construction as a source of mental demand, supporting the theory that preference construction is a difficult and mentally demanding task. Notably, more participants using the text interface reported mental demand from precise resource allocation compared to the two-phase interface (18 vs. 12). We conjecture that the first pass on the survey items in the organization phase helped participants reduce their mental demands in this area once they got around to vote allocation.

In addition, when categorizing preference construction-induced mental demand, participants ($N = 8$) in the long text interface tend to consider a smaller scope that focuses on personal relevance. Conversely, participants ($N = 9$) in the long two-phase interface considered the broader societal impact and evaluated options more comprehensively. Compare the following two quotes, where one focused on adjusting credits between two options and the other reflecting across broader societal values:

> *Trying to figure out what upvotes I should give [...] I kind of went back and forth between those two. [...] So it was very mentally tasking for me.* S015 (LT)

> *[...] really having to think, especially with so many different societal issues. How do I personally prioritize them? And to what extent do I prioritize them?* S009 (LI)

Inspecting both causes, while we did not notice significant differences in mental demand raw values (Figure 8) across the four experiment groups, especially between the interfaces across long QS, they exhibited different sources contributing to their mental demand.

5.3 Sources of Temporal Demand

> **Key Differences:** First, participants using the short text interface wanted to complete the task quickly and reported the highest temporal demand. The two-phase interface lowered the temporal demand for short QS. Second, participants using the long text interface showed the lowest temporal demand score. The two-phase interface increased the temporal demand for long QS.

Temporal demand measures the time pressure participants feel during a task. Lower demand indicates participants felt comfortable taking a more leisurely pace. We categorize the main sources of increased temporal demand as the time pressure on *Decision Making* (S024 *maybe I should just hurry up and make a decision.* , $N = 15$) and *Operational Tasks* (S032 *to be able to move through this quickly and efficiently* , $N = 16$) (Table 5). *Budget* also came up occasionally (S034 *as the money decreases I felt kind of rushed* , $N = 4$).

5.3.1 Two-phase Interface Reduced Temporal Demand on Short QS. The raw NASA-TLX values in Fig 9 show that participants in the Short Text Interface condition reported the highest temporal demand among all. They framed concerns as time spent on making decisions. Five participants felt they invested more time and effort than anticipated, prompting them to rush. The two-phase interface reduced this, with only one participant in the short survey group reporting similar concerns.

5.3.2 Long QS on Text Interface Showed the Lowest Temporal Demand. Based on the raw NASA-TLX values in Fig 9, participants in the long text interface exhibited the lowest temporal demand, explaining why this group had the lowest overall cognitive load as discussed in Section 5.1. This is counter-intuitive since participants in this condition made more decisions and operations compared to the short text group. There are two potential explanations. First, we noticed that more participants who experienced a short survey expressed a desire to complete the task efficiently ($N = 7$) than those in the long survey groups ($N = 1$). They often expressed things like:

> *I wanna get through things in an efficient manner [...] to move through this quickly and efficiently.* S032 (ST)

A second possible explanation for the unexpectedly low temporal demand in the Long Text condition was the participants' satisficing behaviors.

> *I didn't really do the math, so I was like $2 is not that much left so I tried my best to use up most of it.*
> S035 (LT)

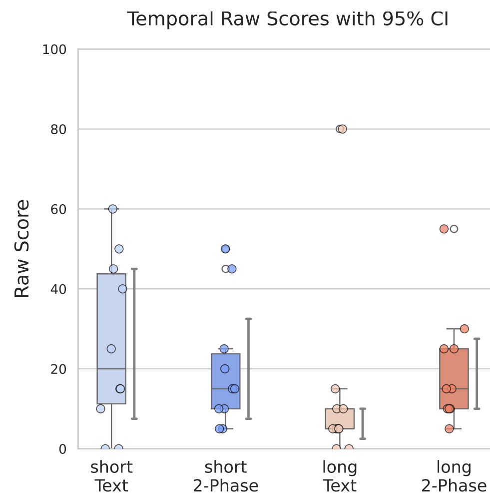


Fig. 9. Temporal Demand Raw Score: The short text interface results in the highest temporal demand, while the long text interface is the lowest. Two-phase interfaces, show moderate temporal demand, suggesting that interactive elements allowed participants to pace themselves better.

Due to cognitive overload from the long list of options, participants may have spent less time than they expected on the decisions. We will discuss this possibility in-depth in Section 7.1.

5.3.3 Two-phase Interface Increased Temporal Demand in Long QS. Despite the unexpectedly low temporal demand in long QS with a text interface, completing the long QS with our two-phase interface raised the temporal demand to the level of short QS groups. All five participants who mentioned a feeling of time pressure on decision-making in the Long Two-phase group described the pressure affirmatively. This means their pressure stemmed from having too many remaining decisions to make (S022 *So it didn't take too much time. but obviously there was a lot of things to consider, so there was some temporal demand.*), not from the time they have already spent (i.e., framed negatively) as that in the Short Text group.

5.4 Source of Frustration

> **Key differences:** We observed evidence that participants in the long text interface showed the least amount of frustration from operational causes compared to other experiment conditions.

Frustration refers to the extent to which the participant is annoyed, irritated, or discouraged during the task.

Sources of frustration were generally related to either *Operational Actions* (e.g., credit management ($N = 6$) and managing quadratic vote costs ($N = 5$)), or *Societal Concerns* (e.g., regretful tradeoffs ($N = 8$) or pessimism about other's vote ($N = 6$)). We provide the full table in Appendix F.5.

In general, the frustration derived from societal concerns did not seem strongly affected by any of the experimental conditions. With respect to operational action-driven frustration, however, we saw some discrepancies. The long text interface condition had the fewest participants expressing operational frustration, with half expressing no frustration, mirroring the trends in the actual scores (Figure 10). Similar to the finding that the long text group has the lowest temporal demand, this is counter-intuitive as more options and dense text are known to lead to more frustration in interface design. Participants engaging in satisficing behaviors in the long text interface may explain this phenomenon – prior literature [86, 87] indicates that satisficers tend to be less frustrated and happier than maximizers.

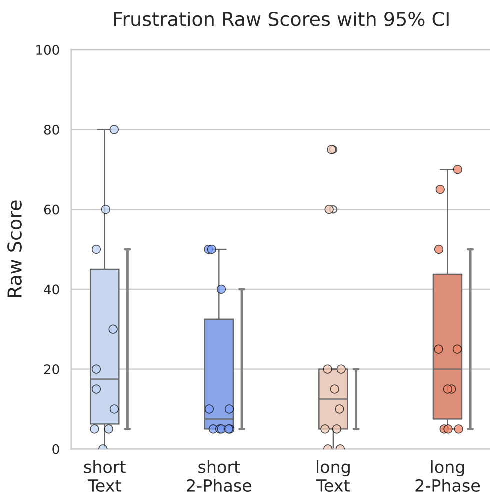


Fig. 10. Fustration Raw Score: Participants other than the long text interface highlighted seversl operational tasks that led to fustration. All groups share causes from strategic planning.

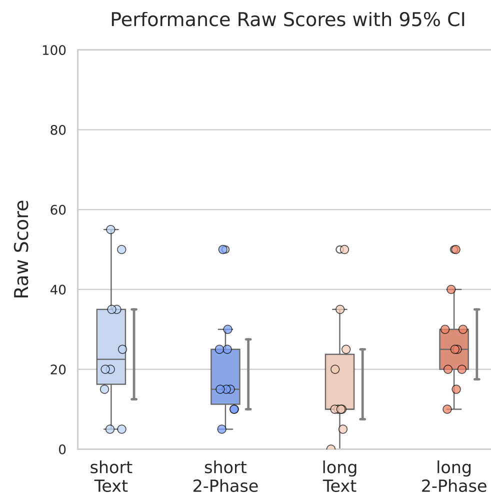


Fig. 11. Performance Demand Raw Score: Participants showed indifferent performance raw scores across experiment conditions, all trending toward satisfactory.

5.5 others

Effort refers to how hard participants felt they worked to achieve the level of performance they did. Qualitative analysis showed participants using the two-phase interface regardless of length considered options more comprehensively and felt less effort on completing operational tasks. Almost all participants ($N = 9$) from the long two-phase interface spent effort planning a strategy to complete tasks with many ($N = 7$) considered options comprehensively and beyond the immediate task (i.e., considering broader community impact of their choices).

Performance refers to a person's perception of their success in completing a task. An interesting element that contributed to their cognitive load comes from concerning social responsibility. They wonder how their final vote counts would be perceived by others (`S041` *I don't want people to think that I just like don't care about <ethnicity> people at all*) or influence real-world decision-making (`S027` *Some of these things might . . . have outcomes that I didn't foresee*). In addition, when analyzing how participants' describe their performance, we categorize them into indications of satisficing behaviors("good enough"), exhausting their effort (i.e., "done their best,") or feeling positive (i.e., "feeling good.") We observed twice as many participants using the two-phase interface to report the positive feeling about their final submission ($N = 11$ v.s. $N = 6$).

physical Physical demand refers to the physical effort required to complete a task, such as physical exertion or movement. Two-phase interface experienced higher physical demand from increased mouse usage.

5.6 Summary across all cognitive load dimensions

In this subsection, we gathered differences across dimensions and synthesized them into a list.

- **Mental Demand:** Participants using the text interface reported higher mental demand from determining the number of votes for options. Those using the long two-phase interface considered broader societal impacts and evaluated options holistically.
- **Physical Demand:** Physical demand was higher for participants using the two-phase interface due to increased mouse usage.
- **Effort:** Effort sources varied, with text interface participants focusing more on operational tasks, and two-phase interface participants engaging more in strategic planning, reflecting deeper, more comprehensive consideration of options.
- **Temporal Demand:** Temporal demand was highest in the short text interface, where participants aimed to complete tasks quickly, while the long text interface showed the lowest temporal demand.
- **Frustration:** Frustration levels from operational causes were lowest in the long text interface.
- **Performance:** Participants using the two-phase interface felt more positive about their performance, being twice as likely to report "feeling good" about their results compared to the text interface users.

Overall, participants using the two-phase interface tend to think more comprehensively and critically, while those using the text interface focus more narrowly on operational tasks. In addition, we suspect that participants who completed the long QS on a text interface engaged in satisficing behaviors based on the counter-intuitive results that they had the lowest temporal demand and frustration level. We will interpret these results in the discussion section. To better understand participants' behavior, we analyze click-stream data across experiment conditions in the next section.

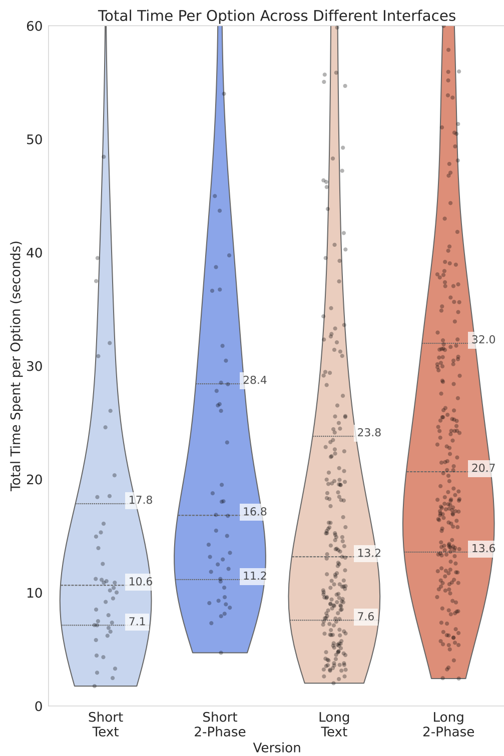
6 Behavior Results

To answer RQ3, we investigate time-to-action and remaining credit differences across experiment conditions. Time-to-action is a widely used metric in decision sciences, where longer decision time often indicates more complex cognitive processing [88]. Additionally, resource allocation strongly influences decision making. Cheng et al. [3] showed that the number of given credits influences the validity of QV. Decision science studies like Shah et al. [89] and [90] showed how scarcity influences decisions, increases risk aversion, and adds cognitive load. These measures serve as proxies for participant behavior, and all analyzed data is publicly available[4] for transparency and to facilitate further research.

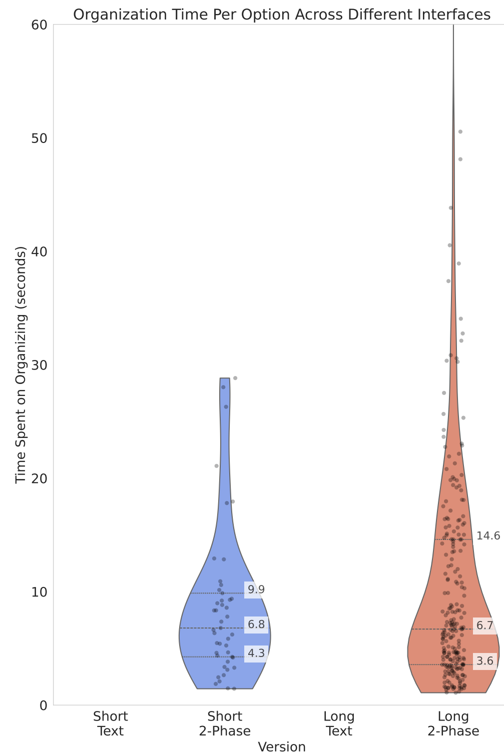
6.1 Time Spent per Option

Our first analysis focuses on understanding how much time participants spent per option across different stages and experiment conditions. Based on the QS system log, we can derive the following detailed logs of participant actions: *the*

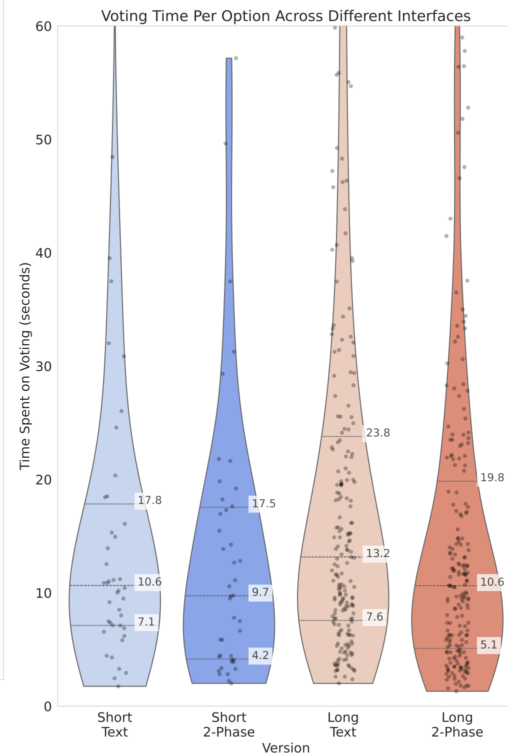
[4]link-to-github



(a) Total Time per option: We identified that two-phase interface skewed slightly higher than the text interface. This is reasonable since participants in these two conditions requires additional time to complete the organizing steps.



(b) Organization Time per option: Since only two-phase interfaces has an organization phase, the other two experiment groups does not have any accumulated time.



(c) Voting Time per option: We see a slight downward trend between the short QS, and a statistical faster voting time for the long two-phase interface.

Fig. 12. Time per option across all experiment conditions. In each of these violin plots, a dot represents the total time a participant spent on that option. Fig 12a one dot represents the total time a person spent for one option. Figure 12b and Figure 12c are decomposition of the total time.

option involved in the interaction, *the type of interaction* (such as updating a certain number of votes), and *the time* between this interaction and the previous one.

We aggregate all the time spent on each option as the total time spent for that option. Organization time covers both placing options into categories and the drag-and-drop time during the organization phase. Voting time strictly refers to the time participants took to update vote values for each option. To minimize noise, we intentionally drop all the time participants spent on the first option in the organization phase or voting phase. The goal is to exclude time spent on reading the prompt, forming their preference, or understanding the interface.

Figure 12 each dot represents one option for one participant. Figure 12a shows total time, figure 12b shows organization time, and figure 12c shows voting time. The violin plot shows the distribution of the dots and the three horizontal lines represent the median, 25th percentile, and 75th percentile of the time spent for that interface. We limited the y-axis to 1 minute to improve visualization clarity.

Participants spent slightly more time per option on the two-phase interface than the text interface. A non-parametric Mann-Whitney U test showed a small effect size (long QS: $p < 0.0000001$, Rank-biserial: -0.304, Cohen's d: -0.030; short QS: $p = 0.01$, Rank-biserial: -0.37, Cohen's d: -0.082). This is expected as the two-phase interface has an additional step of organizing the options. We break down the total time spent into organization time and voting time in Figure 12b and Figure 12c.

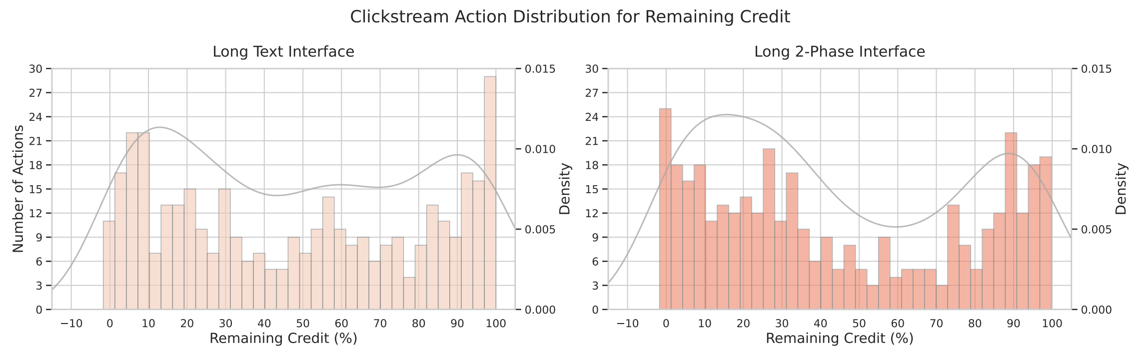
We observed minimal difference in organization time per option (Figure 12b) between short and long surveys, as options are shown one at a time for drag-and-drop. In terms of the voting time (Figure 12c), participants spent significantly less time voting on the two-phase interface than on the text interface with a small effect size in the long QS ($U = 24053$, $p < 0.005$, Rank-biserial: 0.167, Cohen's d: 0.017), but not in the short survey ($p > 0.4$, Power=0.051). This supports our hypothesis that the two-step design in the two-phase interface facilitates more efficient decision-making, especially in longer surveys.

6.2 Budget and Voting Behaviors

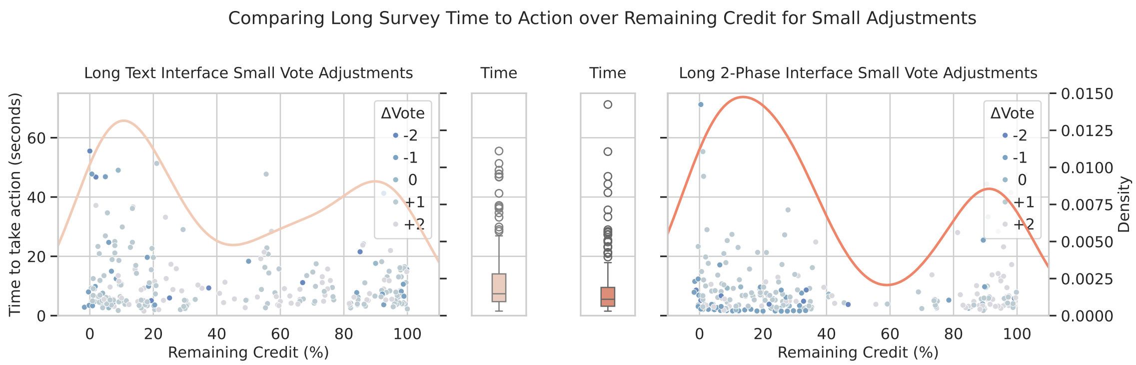
We further breakdown and highlight key differences of how long QS participant's voting behaviors when credits changed their voting behaviors with detailed analysis in Appendix B. Figure 13a first shows the number of vote adjustments at a given remaining budget across the two interface. We then plotted the vote adjustments of two or fewer votes, which is 10% of the possible values one can choose among the maximum of 21 votes in Figure 13b. A kernel density estimate (KDE) plot is provided to visualize the trends and compared how it changed when we plotted only small vote adjustments.

In long surveys, participants exhibited more actions both when the budget was abundant and when it began to run out This pattern was more pronounced with the long two-phase interface. In fact, the bimodal distribution is more pronounced in the two-phase interface. This suggests that participants make small adjustments both at the beginning and toward the end of the QS. However, the two-phase interface shows more frequent and faster edits towards the end. Visually, dots are more clustered in the long two-phase interface for small vote adjustments compared to the long text interface. The Mann-Whitney U Test on the time spent on small vote adjustments showed significant differences ($U = 13037$, $p < 0.001$), with a small effect size (Rank-biserial: 0.227, Cohen's d: 0.195) and a power of 0.381. This indicates that participants had a clearer idea of how to distribute their credits across the options.

Five participants highlighted how the interface supported their incremental iterative approach during the interview whom all used the two-phase interface. As one participant pointed out:



(a) This plot counts the number of voting actions when there are x percentages of credits remaining. A KDE plot is provided to help better understand the action distribution.



(b) This plot further separates participants' interaction behavior based on the number of votes participants adjusted. We observed a bimodal interaction pattern across long QS when small vote adjustments are made.

Fig. 13. Comparison of voting actions and participant behavior in different survey interfaces. Subplot (a) shows the overall distribution of actions based on the remaining credit, while subplot (b) further differentiates the interaction based on the size of vote adjustments.

> *I like the fact that it remembers everything that you know. [...] that's very important is that it's an iterative process.* S019 (LI)

In summary, participants spent more time on the two-phase interface compared to the text interface in both short and long surveys. Across the two-phase interfaces, organization time remained consistent. While voting time did not differ between interfaces for the short survey, participants voted more quickly on the two-phase interface in the long survey, confirming the hypothesis that the two-step design enhances decision-making efficiency. Voting behaviors indicated more frequent actions when the budget was abundant and nearly exhausted, particularly in the long two-phase interface. Additionally, the analysis revealed more frequent and faster small vote adjustments towards the end of the QS in the two-phase interface, demonstrating an iterative and incremental approach.

7 Discussion and Future Works

This study proposed a two-phase interface for QS to study how the number of survey options and interfaces influence cognitive load and behavior in social resource allotment context. Section 5 and 6 revealed that longer surveys did not increase cognitive load, contrary to expectations.

In the discussion section, we interpret results related to cognitive load and survey respondent behaviors. We focus on three key topics: what two-phase interface elements influenced behavior, how these elements supported preference construction, and remaining design challenges. Additionally, we provide recommendations for using QS and suggest design improvements.

We concluded that the two-phase interface prevented satisficing behaviors and promoted more strategic, holistic thinking, unlike the text-based interface, which leans more toward operational tasks. Behavioral analysis showed that long two-phase interface participants made frequent, small updates, shifting their cognitive load focus.

7.1 Interpretation of results: Two-phase interface limits satisficing during cognitive overload

Participants using the long two-phase interface reported slightly higher cognitive load compared to those using the long text interface. In comparison, the short two-phase interface resulted in a lower cognitive load. This suggests that the two-phase interface alone does not inherently increase cognitive load.

One explanation is that the two-phase interface reduces cognitive load in the short QS but not in the longer one. In longer surveys, the interactive nature of the two-phase interface may require participants to perform more operations without significantly altering their decision-making processes. However, our findings suggest that participants using the two-phase interface in longer surveys responded more efficiently. Across both short and long surveys, participants using the two-phase interface demonstrated iterative and efficient fine-tuning preferences, indicating deeper survey engagement. Therefore, we reject the claim that the two-phase interface increases cognitive load in the long survey.

An alternative explanation is that while the two-phase interface limits satisficing during cognitive overload, the complexity of the long QS may have counteracted this effect, preventing a full reduction in cognitive load. This suggests that long QS participants resorted to satisficing behaviors to manage their cognitive overload. Qualitative results support this explanation: participants using the two-phase interface engaged in broader, more strategic considerations, while those using the text interface focused on operational tasks. For instance, participants using the long two-phase interface experienced less cognitive burden from precise voting and managed their time better. Overall, the two-phase interface participants demonstrated deeper and more critical thinking, as they engaged in more strategic decision-making.

In contrast, participants using the long text interface satisficed due to cognitive overload from having to decide and allocate more credits for more options. However, fewer participants in this group reported high cognitive load compared to those in the short-text interface. This group also experienced the least temporal demand and frustration with operational tasks, despite spending a similar amount of time per option as participants using the text interface. These counterintuitive findings pointed to the remaining plausible explanation that long-text interface participants used satisficing to manage the overload.

In summary, the interactive components of the two-phase interface likely prevented mental shortcuts [53, 9, 10, 11], resulting in a cognitive *shift* towards deeper reflection and decision-making. Thus, while QS with many options might lead to satisficing, the two-phase interface redirects participants' attention, facilitating the decision-making process that promotes comprehensive preference construction. In the following section, we examine these specific elements that guided participants to achieve this.

7.2 Bounded rationality and interface design

Bounded rationality emerged as a core theme in participants' responses, highlighting how cognitive limitations lead to sub-optimal decision-making due to their inability to process all available information [9]. This often led to *satisficing* behaviors, where participants settle for *good enough* but not *optimal* decisions [91].

For instance, S036 described making meaningful choices while acknowledging the limits of their effort:

> *[...] you thought of enough things, you know, and so it wasn't the most effort I could put in because again, that would have been diminishing returns. I tried to think of enough things [...] and then move on. [...] I felt like that (the response) was satisfied, but not perfect. Cause perfect is not a reality.* S036 (ST)

This illustrates typical satisficing decision-making, where participants settle for suboptimal choices. In long QS, the significant increase in decision points—due to the numerous vote and credit options—was so overwhelming to some that even features like pre-calculated vote-credit values in drop-down menus provided relief, as they helped avoid the cognitively demanding task of searching for bounds.

Participants often relied on *heuristics* [92] and *defaults* [64], behaviors less common among two-phase interface participants. Presenting one option at a time reduced reliance on defaults and encouraged deeper reflection, as illustrated by S013, who highlighted how the organization phase supported their option preferences construction:

> *[...] it (organization phase) gives you time to just focus on that single thing and rank it based on how you feel at that moment.* S013 (SI)

Conversely, text interface participants, like S003, described how default placements influenced their decisions:

> *Honestly, if medical research [...] was the first one I saw, I think it would automatically give it a lot more.* S003 (ST)

The three key elements of the organization phase—presenting options one at a time, grouping them into categories, and enabling drag-and-drop—worked together to structure participant preferences. These elements aligned with cognitive strategies like *problem decomposition* [93] and *dimension reduction* which reduces cognitive overload. Bounded rationality illuminates the importance of decision-making support interfaces rather than being a critique of human behaviors. One participant explained how the organization phase broke down complex decisions into manageable steps:

> *[...] being able to have a preliminary categorization of all the topics. First, it introduced me to all the topics, [...] to think about and process [...] being able to digest all the information prior to actually allocating the budget or completing the quadratic survey.* S009 (LI)

Participants using the two-phase interface, especially in the long version, organized options along dimensions such as topics (e.g., health vs. humanitarian) and preferences (positive vs. negative) before voting. Others expressed that the upfront introduction of all options and the ability to rank and group them helped manage their cognitive load effectively. In contrast, almost half of the participants using the long text interface, like S028, expressed a desire for features that can help reduce the decision space when responding to the QS, further supporting the importance of these organizational design elements:

> *Because with this many (options), especially when I'm thinking ... Ok, where was (the option) ... Where was (the option) you know? Oh, that's right. Maybe I could give another up another upvote to the, you know whatever [...]* S028 (LT)

This quote reflected participants' need to manually track and revisit options, which occupies cognitive load, without a more structured interface.

In summary, individual's bounded rationality encouraged participants to exhibit *satisficing* behaviors, *heuristics*, and *defaults* when responding to QS. Showing all options upfront, one at a time, and repositioning options based on participants' rough preferences prevented participants from using defaults and heuristics. The two-phase organization actively scaffolds participants' decision-making process, supporting efficiency *problem decomposition* and *dimension reduction*. Together, these elements in the two-phase interface design prevented *satisficing* behaviors and supported participants in making more informed decisions through a more strategic planning and holistic thinking process.

7.3 Construction of Preference on QS

Completing QS is a series of difficult decision tasks Lichtenstein and Slovic [6]. Svenson [60]'s differentiation and consolidation theory helps explain how participants process these decisions. The decision process begins with differentiation, where participants identify differences and eliminate less favorable options, followed by consolidation, which strengthens their commitment to selected choices. This theory aligns with how the two-phase interface helps participants decompose options into categories, effectively reducing decision complexity.

Participants started by constructing preferences in situ, especially regarding options they hadn't previously considered:

> *[. . .] 'Oh, there are other aspects that I never care about.' And actually . . . some people care <an option>. Sure. Why? Why (should) I spend money on that?*
> `S037 (LI)`

Those using the text interface, lacking the interactive tools, found it challenging to facilitate differentiation as `S025` noted:

> *I would like to be able to like, click and drag the categories themselves so I could maybe reorder them to like my priorities. [. . .] make myself categories and subcategories out of this list . . . If I could organize it.* `S025 (LT)`

In contrast, the two-phase interface allowed participants to express at least one dimension of differentiation more easily. The drag-and-drop feature helped blend this differentiation into the consolidation phase. Not only does participants drag-and-drop options post voting to reflect and assure a correct vote allocation, it also enables participants, like `S039`, to make fine-grain comparisons between options:

> *I think the system was actually really helpful because I could just drag them. [. . .] I can really compare them, I can drag this one up here, and then compare it to the top one [. . .]* `S039 (SI)`

The bi-modal behavior observed in the long interactive interface participants provided in the results aligns with the differentiation and consolidation framework. Participants in the two-phase interface began differentiating options earlier allowing them to later adjust fine-grain votes. The faster and smaller vote updates indicated participants consolidating. The less prominent bi-modal behavior from the long text interface participants implied that the interface guided this decision framework as participant `037` explained:

> *I only start from the positive one [. . .] I finish everything . . . and then I move to the second part (the neutral box). [. . .] I want to focus on these and make sure that resources are at least they get the attention they want. And if there's surplus and they can move to the second part.* `S037 (LI)`

These evidences explain how the organization phase and the drag-and-drop features supported differentiation and consolidation, scaffolding a decision-making framework enabling deeper engagement.

In summary, participants construct their preferences as they complete QS. We observed behaviors and qualitative insights that align with the differentiation and consolidation theory in decision-making. Our interface scaffolded many of the differentiation stages through pre-voting organization and some consolidation phases through drag-and-drop, explaining how the two-phase approach supports preference construction to yield effective QS responses.

7.4 Opportunities for better budget management

Budget management is a recurring theme in participant interviews. While they appreciated the automatic calculation feature in modern QV interfaces, we identified three challenges for future QS interfaces: *cognitive load, the cold-start problem*, and *navigating between budget, votes, and outcome.*

7.4.1 Automatic calculation is critical. Over one-third of participants ($N = 14$) from all four experiment conditions emphasized the importance of automated calculation for deriving costs and tracking expenditures. For example:

> *I thought I have [. . .] (to) do all the numbers or calculations myself as a part of checking my ability of doing mathematics. [. . .] I said that credit summary to be very specific. The credit summary section was really wonderful in doing all the calculations on that end.*
> `S005 (LT, keeping track of spent)`

The quotes marked the importance that QS must be facilitated by computer-supported interfaces.

7.4.2 The coldstart problem. We notice from the study that one of the biggest challenges for participants is deciding 'how many votes' to start with. This challenge pertains to the initial vote, not the relative vote. Some participants began by equally distributing their credits to all options and then made adjustments. Others established 1, 2, and 3 votes as starting points. A small handful surprisingly used the tutorial's example of 4 upvotes as their anchor.

This arbitrary voting decision echoes discussions in prior literature about the existence of an absolute value for individuals. Coherent arbitrariness [94], similar to the anchoring effect in marketing, refers to participants' willingness to allocate votes, which can be influenced by an arbitrary value. However, the ordinal utility remains intact among the set of preferences.

7.4.3 Navigating Between Budget, Votes, and Actual Impact. The third challenge is participants' confusion between budget, votes, and outcomes, despite understanding their definitions. One participant stated:

> *[. . .] get rid of the upvote column or just get rid of the word upvote and just really focus on the money column. Listen. You're an organization or your participant. You have X amount of dollars you need to. You can only distribute X amount of dollars to these causes. So you have to figure out which ones get the most, which ones don't get as much. [. . .]*
> *Interviewer: [. . .] Do you feel that the more votes you're giving to a cause you're actually spending more on it?*
> *Yeah.* `S003 (ST)`

Participants like `S003` bypassed the quadratic formulation, directly translating votes to resource allocation. While this does not invalidate the power of the quadratic mechanism, it causes frustration and friction for participants to construct a clear picture of how to make voting decisions. Future interfaces should better communicate these relationships to facilitate respondents' trade-offs.

In summary, while the interface supports budget management through automated cost calculation, participants still face cognitive load from managing the budget. The cold-start problem and the confusion between budget, votes, and actual impact are open questions for future research. These challenges highlight the need for better budget management support to complete the QS interface.

7.5 Quadratic Survey Usage, Design Recommendations and Future Work

With a deeper understanding of how survey respondents interact with QS and the sources of cognitive load, we recognize that while this current interface may not significantly reduce cognitive load, it represents a crucial step toward constructing better interfaces to support individuals responding to QS. In this subsection, we outline usage and design recommendations applicable to all applications using the quadratic mechanism and highlight directions for future work.

7.5.1 Usage Recommendation: QS for Critical Evaluations. Our study highlighted the complex cognitive challenges and in-depth consideration required when ranking and rating options using QS, even in a short survey. Similar to survey respondents needing to make trade-offs across options, researchers and agencies seeking additional insights and alignment with respondent preferences must ensure that survey respondents have the cognitive capacity to complete such surveys rigorously. QS should be designed for critical evaluations, such as investment decisions, or situations where participants have ample time to think and process the survey. For instance, revealing the options ahead of time can aid in preference construction.

7.5.2 Design Recommendations.

Use Organization Phases for Quadratic Mechanism Applications. Our study demonstrated that preference construction can shift from operational to strategic and higher-level causes. An additional organizational phase with direct manipulation capability allows survey respondents to engage in higher-level critical thinking. We believe this approach should extend beyond QS to other ranking-based surveying tools, such as rank-choice voting and constant sum surveys. Further research should examine how implementing such functionality alters survey respondents' mental models.

Facilitate Differentiation through Categorization, Not Ranking. Participants in our study were less inclined to provide a full rank unless necessary. The final 'rank' of option preferences often emerged as a byproduct of their vote allocation, constructed in situ. Therefore, for survey designs to be effective in constructing preferences, it is more important to facilitate differentiation than to focus on direct manipulation solely for fine-tuning. Emphasizing categorization can better support participants in articulating their preferences.

7.5.3 Future Work: Support for Absolute Credit Decision. Deciding the absolute amount of credits in QS is highly demanding. Designing interfaces and interactions that address the cold start challenge and help participants decide the absolute vote value while considering ways to limit direct influences remains an open question. Future research should explore innovative solutions to support participants in making these complex decisions effectively.

By implementing these recommendations and pursuing future research directions, we can improve the usability and effectiveness of QS and other quadratic mechanism-powered applications, ultimately aiding respondents in making more informed and accurate decisions.

8 Limitations

Evaluating the QS interface is challenging due to its novelty. During the study, we identified several limitations that require further research.

Understanding results influence on decision-makers. Further research is required to understand how the QS interface impacts decision-makers and broader societal resource distributions. Since QS is still in its early stages, we prioritize its widespread adoption and usage before attempting a comprehensive assessment of its influence on decision-making. Future studies will examine how decision-makers interpret and use QS data, as well as its broader implications for societal decisions.

Individual differences in cognitive capacity. Variations in individual cognitive capacity influenced participants' cognitive scores. For example, participants with more experience in decision-making might be able to manage multiple options more effectively. A within-subject study could clarify cognitive load shifts, but deconstructing established preferences and altering options further complicates this. Thus, we opted for this in-depth, between-subject study, although the small sample size may introduce noise that distorts the actual cognitive load. Future research should quantify the impact of different QS interfaces.

Limited experience with QS. Participants had no prior experience with the QS interface. Following a tutorial and quiz, participants proceeded to complete tasks using the QS interface. While participants understood the QS mechanics, familiarity with the interface still influences strategies and cognitive load. As quadratic mechanisms become more prevalent, future research can compare novices and experts.

Duration between clicks to represent decision-making. Click duration may include time spent considering other options, so it must be treated as an approximate measure of decision-making time. For instance, deciding between two options may take longer for the first option and less time for the second. Despite its limitations, this approach provides valuable insights into decision-making within our experimental constraints.

9 Conclusion

Surveys enable decision-makers to aggregate crowd opinions. In this study, we use QS to elicit individual responses in the context of social resource allotment. After multiple design iterations, we propose an two-phase interface for QS. We then examined its influence on individuals' cognitive load and behaviors when faced with societal issues of varying lengths. In a 2x2 between-subject study, we had participants experience either a long or short QS using a text-based or two-phase interface. NASA-TLX questionnaires and interviews revealed that participants using the two-phase interface for a long QS demonstrated a more comprehensive and critical evaluation of societal issues, despite not experiencing a lower cognitive load. Participants using the long text interface experienced cognitive overload, which led to satisficing behaviors or mental shortcuts. Analyzing click-stream data, we identified that participants made fine-grain iterations using the long two-phase interface when credits were low. We demonstrate that a two-phase, organize-then-vote interface can scaffold the complex decision-making process, helping individuals express their opinions for collective societal decisions. Through the iterative design process and detailed interviews, we identified future directions and design recommendations for collective decision-making applications using the quadratic mechanism.

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A Cognitive Load remaining

A.1 Sources of Physical Demand

> **Key Differences:** Two-phase interface experienced higher physical demand from increased mouse usage.

Physical demand refers to the physical effort required to complete a task, such as physical exertion or movement. Most participants reported minimal physical demand ($N = 32$), reflected in the low NASA-TLX physical demand scores (Figure 14). Notably, 11 out of 20 participants who used the two-phase interface mentioned physical demand from using the mouse, reflecting their increased interaction with the interface. This is further supported by the raw NASA-TLX physical demand scores (Figure 14), which show a significant visual difference between short and long two-phase interfaces as well as between text and two-phase interfaces in long surveys.

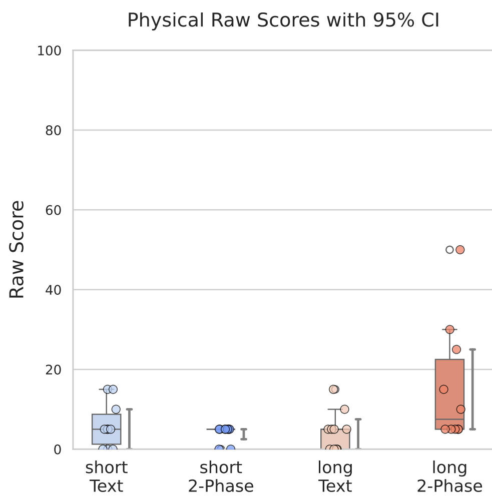


Fig. 14. Physical Demand Raw Score: Participants other than the long two-phase interface reported minimal physical demand. The long two-phase interface had the highest physical demand, likely due to increased mouse clicks and extended time spent looking at the vertical screen.

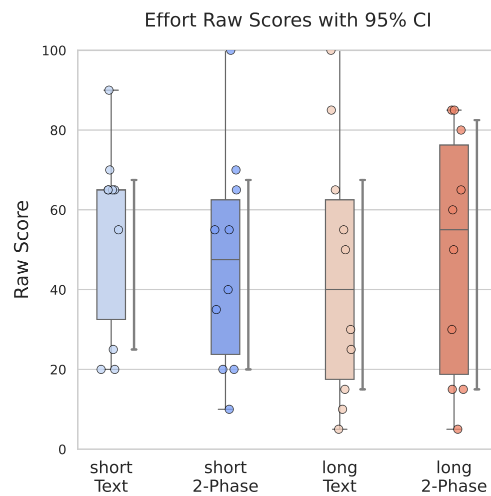


Fig. 15. Effort Raw Score: Effort scores shows indifference across groups.

Table 1. Effort Sources: Participants using the text interface focused more on operational tasks, while those using the two-phase interface focused more on strategic planning.

[Effort]	Total	Version				Experiment Conditions			
		ST	SI	LT	LI	Short	Long	Text	Inter
Operational	21	6	5	8	2	11	10	14	7
Strategic	28	6	8	5	9	14	14	11	17
Personal	22	4	7	5	6	11	11	9	13
Global	11	2	3	2	4	5	6	4	7
None/Little/a bit	9	2	1	3	3	3	6	5	4

A.2 Source of Effort

> **Key Differences:** First, participants in the text interface associated effort with operational tasks more often than participants from the two-phase interface. Conversely, participants in the two-phase interface cited more sources from strategic planning than those in the text interface. We observed that participants experienced effort when considering a comprehensive view while using the two-phase interface.

Effort refers to how hard participants felt they worked to achieve the level of performance they did. Since effort includes both mental and physical resource intensity, refer to Section 5.2 and Appendix A.1 for definitions.

While the raw NASA-TLX effort scores (Figure 15) showed a similar spread across experiment groups, the qualitative analysis showed more distinction that participants using the two-phase interface considered options more comprehensively and felt less effort on completing operational tasks, similar to what we found on mental demands (Section 5.2).

A.2.1 Effort Source #1: Operational Tasks. 14 of the 20 participants using the text interface mentioned Operational Tasks as effort sources, compared to 7 using the two-phase interface, with the lowest mention by the long two-phase interface group ($N = 2$).

A.2.2 Effort Source #2: Strategic Planning. Different from Operational Tasks, 11 participants in the text interface compared to 17 participants described strategic planning as sources of effort, with almost all participants ($N = 9$) from the long two-phase interface. We further categorize strategic planning into *narrow* and *broad* scopes as we did for mental demand section 5.2. Participants using the two-phase interface ($N = 7$) had nearly mentioned double ($N = 4$) times regarding global strategies.

A.3 Source of Performance

> **Key Differences:** Participants who used a two-phase interface were generally more positive about their final outcome – they were twice as likely to report "feeling good" about their final results

Performance refers to a person's perception of their success in completing a task. Lower values mean good perceived performance; higher values mean poor perceived performance. We found minimal qualitative differences between experiment groups regarding factors influencing perceived performance. Two influencing factors emerged: *Operational Actions* and *Social Responsibility* [5]. Despite most participants reporting positively on their performance, nuances exist in how different groups interpret their performance.

A.3.1 Operational Actions. Operational actions, like the theme presented in temporal demand, refer to specific, executable procedures participants perform in the survey. This could involve: pressure to spend all credits or stay within budget ($N = 6$), fears that final vote choices did not reflect true preferences($N = 5$), or concerns that they had finished the task inefficiently ($N = 6$).

A.3.2 Social Responsibility. Social responsibility-based concerns around performance came up when participants reflected on how their final vote counts would be perceived by others (`S041` *I don't want people to think that I just like don't care about <ethnicity> people at all*) or influence real-world decision-making (`S027` *Some of these things might . . . have outcomes that I didn't foresee*).

[5] The full performance table is at Appendix F.3

All groups cited social responsibility as source to evaluate effort. Raw NASA-TLX scores (Figure 11) show participants had indistinguishable performance scores. This aligns with the interview results where most participants felt positive about their final submission.

To dig deeper, we also analyzed participants' language when they described their performance. Expressions like "good enough" may be indicative of satisficing behaviors – our results suggest participants are satisfied at similar rates regardless of the interface. 1/4 of the participants in the text interface expressed "done their best," referring to exhausting their effort. Participants who used a two-phase interface were generally more positive about their final outcome – they were twice as likely to report "feeling good" about their final results ($N = 11$ v.s. $N = 6$).

B Additional behavioral results

To further analyze participant behaviors, we break down the aggregated time from the previous analysis and examine fine-grain interactions. Specifically, we examine if there are differences among behavior across interfaces. As we outlined, credit scarcity might influence decision making. Figure 16 plots the time of voting actions over the remainder of the participant's budget across the text and two-phase interface across all four groups. Each bar shows the number of actions accumulated across participants at specific percentages of remaining credits. A kernel density estimate (KDE) plot is provided to visualize the trends. We did not follow Quarfoot et al. [5] in counting accumulated votes over time due to varying total times across individuals.

Comparing experiment groups, we see fewer differences in the short QS but different interaction distributions between the two interfaces in the long QS. Given the significant differences in voting time between the text and two-phase interface for the long QS, we focus on deciphering the voting action changes between these two conditions in this subsection.

In Figure 16, we see two distinct patterns between the short survey and the long survey in terms of participant behaviors. In long surveys, participants exhibited more actions both when the budget was abundant and when it began to run out. This pattern was more pronounced with the long two-phase interface. We further separated the behaviors where participants made large or small changes to the options, specifically for the long version. In Figure 17, we define an adjustment of four or more votes as large, which we plotted in the first row of the figure. Adjustments of two or fewer votes are considered small, which is 10% of the possible values one can choose among the maximum of 21 votes.

We plotted all actions against the time to complete them. Revisiting the KDE curve in the second row in Figure 16 and the curve of the second row in Figure 17 show a stronger bimodal distribution for small vote adjustments across interfaces. In fact, the bimodal distribution is more pronounced in the two-phase interface. This suggests that participants make small adjustments both at the beginning and toward the end of the QS. However, the two-phase interface shows more frequent and faster edits towards the end. Visually, dots are more clustered in the long two-phase interface for small vote adjustments compared to the long text interface. The Mann-Whitney U Test on the time spent on small vote adjustments showed significant differences ($U = 13037$, $p < 0.001$), with a small effect size (Rank-biserial: 0.227, Cohen's d: 0.195) and a power of 0.381. Based on the KDE plots in the first row of Figure 17, participants also made more large vote adjustments early on that spread more equally compared to the text interface. This indicates that participants had a clearer idea of how to distribute their credits across the options.

In interviews, five participants highlighted the importance of the interface's flexibility and their use of an incremental, iterative approach. All these participants used the two-phase interface. While this doesn't mean participants using the text interface didn't take an iterative approach, it highlights that the two-phase interface encouraged iterative and incremental updates. As one participant pointed out:

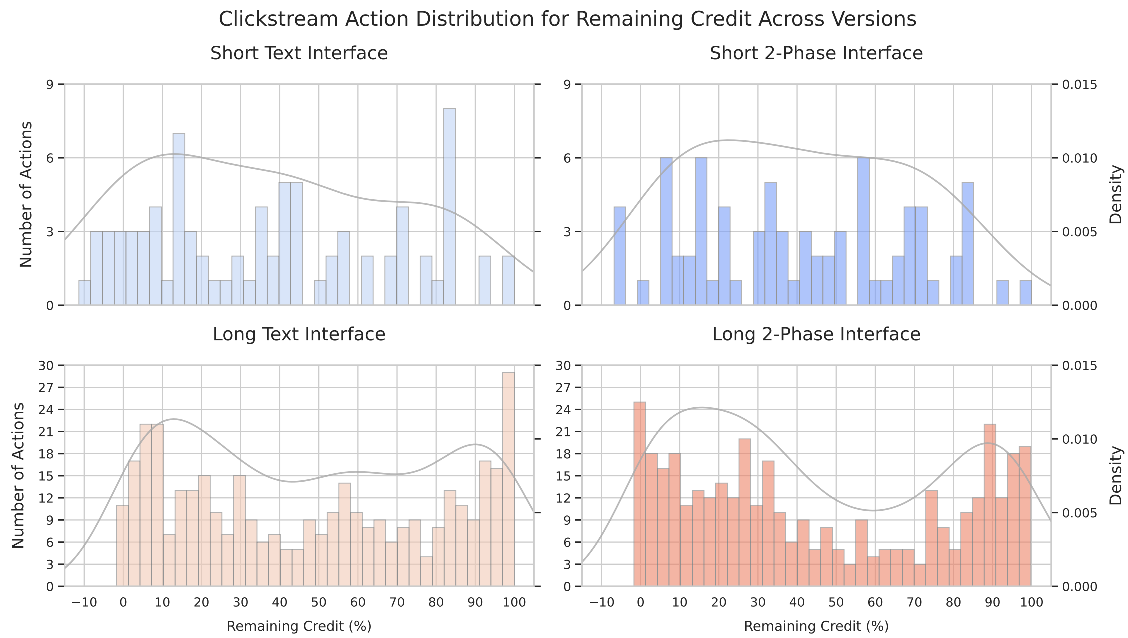


Fig. 16. This plot counts the number of voting actions when there are x percentages of credits remaining. A KDE plot is provided to help better understand the action distribution.

I like the fact that it remembers everything that you know. [...] that's very important is that it's an iterative process. `S019 (LI)`

C Voting Interface Breakdown

Designs that shifted voter decisions: For example, states without straight-party ticket voting (where voters can select all candidates from one party through a single choice) exhibited higher rates of split-ticket voting [12]. Another example from the Australian ballot showing incumbency advantages is where candidates are listed by the office they are running for, with no party labels or boxes.

Designs that influenced errors: Butterfly ballots increased voter errors because voters could not correctly identify the punch hole on the ballot. Splitting contestants across columns increases the chance for voters to overvote [46]. On the other hand, Everett et al. [47] showed the use of incorporating physical voting behaviors, like lever voting, into graphical user interfaces.

Designs that incorporated technologies: Other projects like the Caltech-MIT Voting Technology Project have sparked research to address accessibility challenges, resulting in innovations like EZ Ballot [48], Anywhere Ballot [49], and Prime III [50]. In addition, Gilbert et al. [51] investigated optimal touchpoints on voting interfaces, and Conrad et al. [52] examined zoomable voting interfaces.

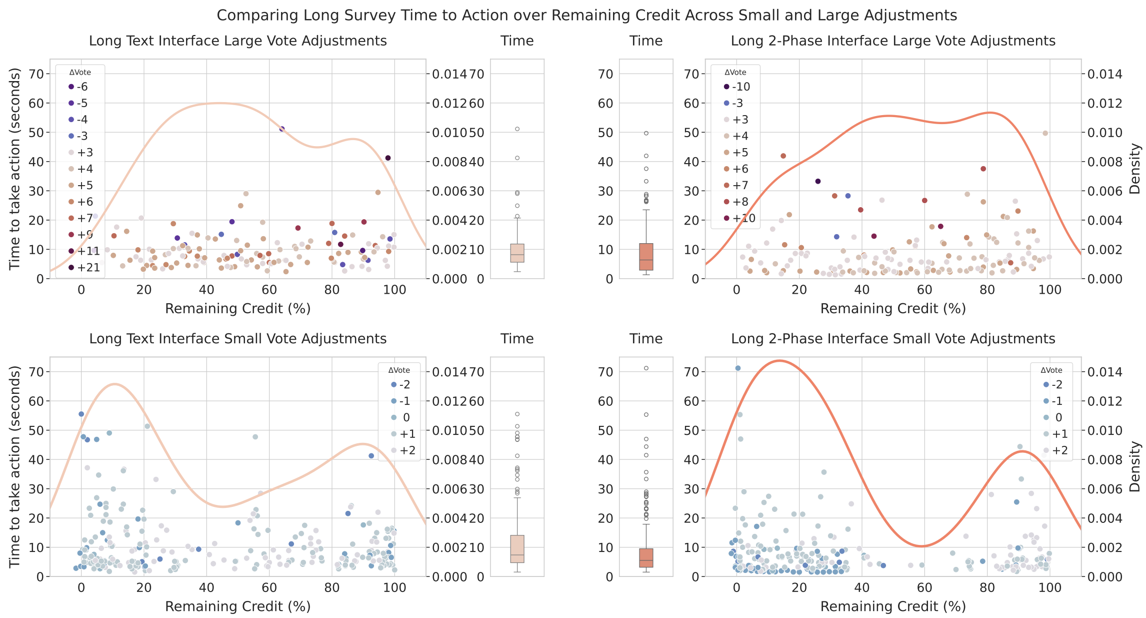
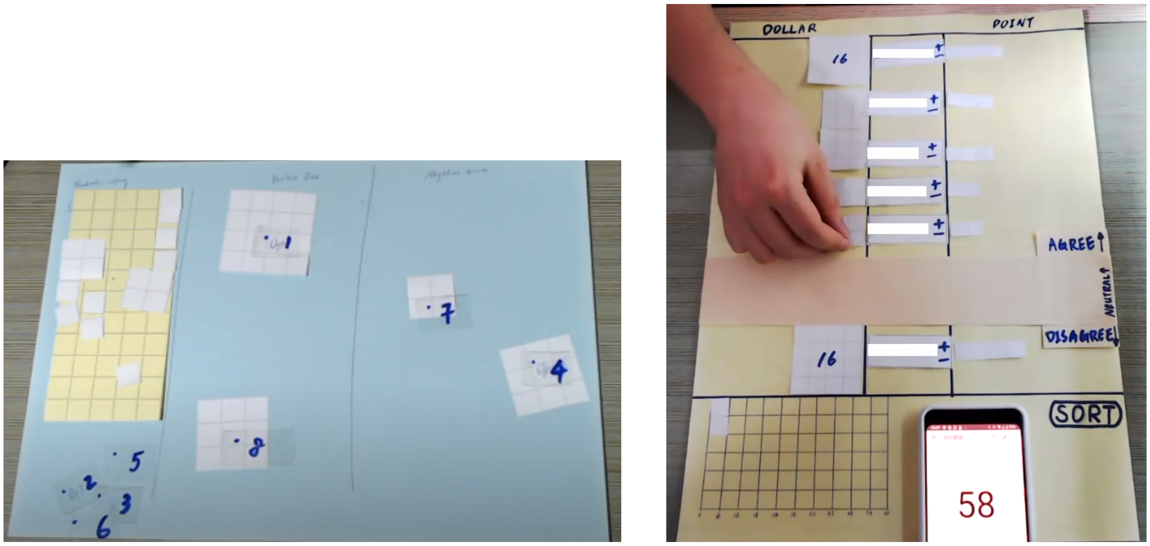


Fig. 17. This plot further separates participants' interaction behavior based on the number of votes participants adjusted. We observed a bimodal interaction pattern across long QS when small vote adjustments are made.

D Interface design process

In this section, we outline the design process leading to our final interface. As mentioned in the paper, our design iteration is based on existing QV applications in the wild.



(a) In this paper prototype, issues are denoted by different numbers that appear on mouseover. Pretest respondents can move options anywhere in the two sections of the interface, one denoting positive and one negative. The blocks represent the cost for each option, with no indication of the number of current votes. The credits are shown in the yellow box on the left.

(b) This paper prototype separates the positive and negative areas with a 'band' at the center. Undecided options are placed inside this band. The cost and the votes on both sides of the interface are denoted by small blocks. The budget is shown in the yellow box below the interface with a numerical counter.

Fig. 18. Initial paper prototypes designed for QS interface

D.0.1 Prototype 1: Ranking-Vote. Considering that relative preference is often through ranking items, we tested whether ranking options before voting would help establish an individual's relative preference in our prototype 1. This prototype allowed respondents to reposition options before voting. Pretests revealed that respondents rarely moved the options and questioned the necessity of full ranking, as it did not influence their QS submission. Additionally, many were unaware that options were draggable until shown. This insight indicates that full ranking is unnecessary for establishing relative preferences. Therefore, we decided to ask respondents to select a subset of options instead of requiring a full rank among all options.

D.0.2 Prototype 2: Select-then-Vote. Based on feedback from Prototype 1, instead of *allowing* individuals to rank options, Prototype 2 implemented a two-phase process that *intentionally* asks respondents to select options to express opinions before voting. As shown in Figure 20, survey respondents selected their preferred options (Figure 20a), and the interface positioned these options at the top of the list for voting (Figure 20b). We identified several issues during the prototype 2 pretest: many respondents marked most options as 'options they care about,' which undermined the design's purpose. Additionally, the lack of clear distinction between selected and unselected options confused respondents about the necessity of Step 1. Thus, we need a clearer distinction and connection between the two phases to effectively construct relative preferences.

D.0.3 Prototype 3: Organize-then-Vote. Figure 21 shows the last prototype where we built on the previous takeaway by providing finer-grain groupings and creating a clear connection between option organization and voting position. Specifically, we provided three categories: Positive, Negative, and Neutral. Initially, respondents see all options under

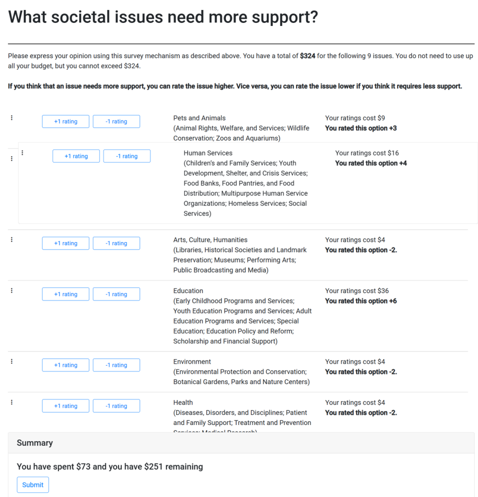
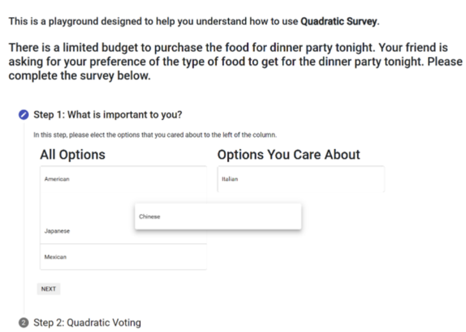


Fig. 19. A Ranking-Vote Prototype: The goal of this prototype is to test whether ranking options prior to voting help establish an individual's relative preferences and reduce effort when voting. Each option is draggable to position in a specific location amongst the full list of options. Votes can be updated using the buttons to the right of the interface with vote count and costs to the right of the interface. A summary box is placed sticky to the bottom of the screen.

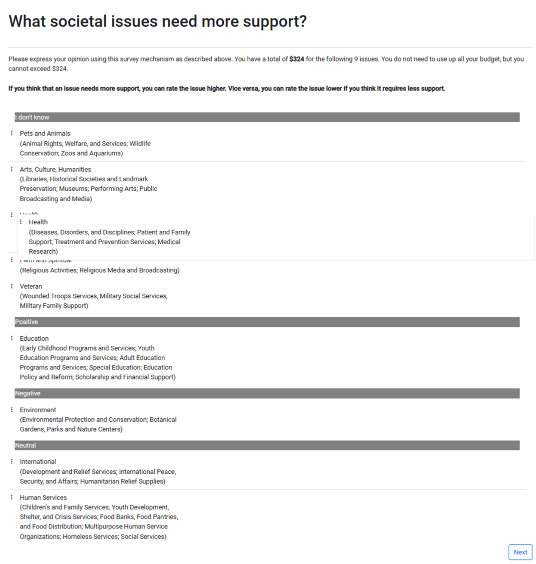


(a) Options are dragged and dropped to the 'Option You Care About' box.

(b) The previous step collapses showing all voting options.

Fig. 20. A Select-then-Vote Prototype: The goal of this prototype is to nudge participants to focus on a subset of options to vote, rather than ranking all of them. This prototype introduces a two-step voting process. As shown in Fig. 20a, the first step involves selecting options for further consideration. Important options are placed at the top of the list for voting shown in Fig. 20b, but options can be placed anywhere on the list if desired. The rest of the controls remain the same as the previous prototype.

the section labeled 'I don't know,' which includes only the option descriptions. We ask respondents to move these options into the categories below. Voting controls and information appear on each option once respondents move to the subsequent page, forming a clear connection between option groups, positions, and voting controls.



(a) The Organization Interface: Options are shown initially in the first bin labeled as 'I don't know.' Survey respondents can then drag and drop these options into the latter bins: Positive, Neutral, or Negative. Only the details of each option are shown on this interface.

(b) The Voting Interface: Voting controls appear on the left side of each option, showing the current votes and associated costs on the right. A budget summary is stuck at the bottom of the screen.

Fig. 21. Organize-then-Vote Prototype: The goal of this prototype is to encourage participants at deriving finer grain categories among options before voting. Survey respondents first organize their thoughts into categories, then vote on the options.

Feedback indicated that survey respondents are comfortable with the two-phase organize-then-vote design, demonstrating it as a central strategy for our interface development. However, several areas for enhancement were identified: First, the dragging and dropping mechanism in the organization phase is cumbersome and may inadvertently suggest a ranking process, contrary to our intentions. Second, placing unorganized options at the top of the voting list is counterintuitive. Third, the voting controls are disconnected from the option summaries, dividing attention between the left and right sides of the screen. These insights guided refinements in the final two-phase interface, adhering to the two-phase organize-then-vote design framework.

E List of Options

We provide the full list of options presented on the survey.

- **Animal Rights, Welfare, and Services:** Protect animals from cruelty, exploitation and other abuses, provide veterinary services and train guide dogs.
- **Wildlife Conservation:** Protect wildlife habitats, including fish, wildlife, and bird refuges and sanctuaries.
- **Zoos and Aquariums:** Support and invest in zoos, aquariums and zoological societies in communities throughout the country.

- **Libraries, Historical Societies and Landmark Preservation:** Support and invest public and specialized libraries, historical societies, historical preservation programs, and historical estates.
- **Museums:** Support and invest in maintaining collections and provide training to practitioners in traditional arts, science, technology, and natural history.
- **Performing Arts:** Support symphonies, orchestras, and other musical groups; ballets and operas; theater groups; arts festivals; and performance halls and cultural centers.
- **Public Broadcasting and Media:** Support public television and radio stations and networks, as well as providing other independent media and communications services to the public.
- **Community Foundations:** Promote giving by managing long-term donor-advised charitable funds for individual givers and distributing those funds to community-based charities over time.
- **Housing and Neighborhood Development:** Lead and finance development projects that invest in and improve communities by providing utility assistance, small business support programs, and other revitalization projects.
- **Jewish Federations:** Focus on a specific geographic region and primarily support Jewish-oriented programs, organizations and activities through grantmaking efforts
- **United Ways:** Identify and resolve community issues through partnerships with schools, government agencies, businesses, and others, with a focus on education, income and health.
- **Adult Education Programs and Services:** Provide opportunities for adults to expand their knowledge in a particular field or discipline, learn English as a second language, or complete their high school education.
- **Early Childhood Programs and Services:** Provide foundation-level learning and literacy for children prior to entering the formal school setting.
- **Education Policy and Reform:** Promote and provide research, policy, and reform of the management of educational institutions, educational systems, and education policy.
- **Scholarship and Financial Support:** Support and enable students to obtain the financial assistance they require to meet their educational and living expenses while in school.
- **Special Education:** Provide services, including placement, programming, instruction, and support for gifted children and youth or those with disabilities requiring modified curricula, teaching methods, or materials.
- **Youth Education Programs and Services:** Provide programming, classroom instruction, and support for school-aged students in various disciplines such as art education, STEM, outward bound learning experiences, and other programs that enhance formal education.
- **Botanical Gardens, Parks, and Nature Centers:** Promote preservation and appreciation of the environment, as well as leading anti-litter, tree planting and other environmental beautification campaigns.
- **Environmental Protection and Conservation:** Develop strategies to combat pollution, promote conservation and sustainable management of land, water, and energy resources, protect land, and improve the efficiency of energy and waste material usage.
- **Diseases, Disorders, and Disciplines:** Seek cures for diseases and disorders or promote specific medical disciplines by providing direct services, advocating for public support and understanding, and supporting targeted medical research.
- **Medical Research:** Devote and invest in efforts on researching causes and cures of disease and developing new treatments.

- **Patient and Family Support:** Support programs and services for family members and patients that are diagnosed with a serious illness, including wish granting programs, camping programs, housing or travel assistance.
- **Treatment and Prevention Services:** Provide direct medical services and educate the public on ways to prevent diseases and reduce health risks.
- **Advocacy and Education:** Support social justice through legal advocacy, social action, and supporting laws and measures that promote reform and protect civil rights, including election reform and tolerance among diverse groups.
- **Development and Relief Services:** Provide medical care and other human services as well as economic, educational, and agricultural development services to people around the world.
- **Humanitarian Relief Supplies:** Specialize in collecting donated medical, food, agriculture, and other supplies and distributing them overseas to those in need.
- **International Peace, Security, and Affairs:** Promote peace and security, cultural and student exchange programs, improve relations between particular countries, provide foreign policy research and advocacy, and United Nations-related organizations.
- **Religious Activities:** Support and promote various faiths.
- **Religious Media and Broadcasting:** Support organizations of all faiths that produce and distribute religious programming, literature, and other communications.
- **Non-Medical Science & Technology Research:** Support research and services in a variety of scientific disciplines, advancing knowledge and understanding of areas such as energy efficiency, environmental and trade policies, and agricultural sustainability.
- **Social and Public Policy Research:** Support economic and social issues impacting our country today, educate the public, and influence policy regarding healthcare, employment rights, taxation, and other civic ventures.

F Cognitive Demand Tables

Here we provide the full qualitative analysis table.

F.1 Mental Demand Table

F.2 Physical Demand Table

Table 3. Physical Demand Causes: Most participants expressed little or no physical demand. Results reflected that participants in the long two-phase interface required more actions, hence the higher mention of mouse usage as a source.

[Physical]	Total	Version				Experiment Conditions			
		ST	SI	LT	LI	Short	Long	Text	Inter
Reading	4	0	2	1	1	2	2	1	3
Mouse	16	3	5	2	6	8	8	5	11
Vertical Screen	4	1	0	1	2	1	3	2	2
None/Little	32	8	9	8	7	17	15	16	16

Table 2. This table lists all the causes participants mentioned as contributing to their Mental Demand. The shaded cells represent the percentage of participants citing each source of mental demand, allowing for comparison within columns. The abbreviations are: ST (Short Text Interface), SI (Short Two-phase Interface), LT (Long Text Interface), and LI (Long Two-phase Interface). Short and Long refer to the sum across both interfaces; Text and Inter refer to the sum across both survey lengths. We include Sparklines for comparisons across these experiment groups.

[Mental Demand]	Total	Version				Experiment Conditions			
		ST	SI	LT	LI	Short	Long	Text	Inter
Budget Management	14	3	3	5	3	6	8	8	6
Budget within limited credit	5	2	2	1	0	4	1	3	2
Track remaining credits	10	2	2	3	3	4	6	5	5
Maximize credit usage	8	2	3	2	1	5	3	4	4
Operational	12	3	2	4	3	5	7	7	5
Strategic	7	2	4	1	0	6	1	3	4
Preference Construction	39	10	9	10	10	19	20	20	19
Determining relative preference	16	4	4	5	3	8	8	9	7
Option prioritization	17	6	4	3	4	10	7	9	8
Precise resource allocation	30	9	6	9	6	15	15	18	12
Narrow - Consider a few options/personal causes	23	6	6	8	3	12	11	14	9
Broad - Considering all options or higher order values	23	5	5	4	9	10	13	9	14
Demand from Experiment Setup	24	6	6	6	6	12	12	12	12
Many options on the survey	6	0	0	3	3	0	6	3	3
QS Mechanism	4	2	0	2	0	2	2	4	0
Recalling experience or understanding options	20	5	6	4	5	11	9	9	11
Justification or Reflection on response	8	2	2	1	3	4	4	3	5
External Factors	12	3	1	4	4	4	8	7	5
Demand due to Interface	8	2	2	0	4	4	4	2	6
Increase	4	1	1	0	2	2	2	1	3
Decrease	4	1	1	0	2	2	2	1	3

F.3 Performance Table

Table 4. Performance Causes: Most causes are shared across experiment conditions. We provided qualitative interpretations of their own perfornace assessments.

[Performance]	Total	Version				Experiment Conditions			
		ST	SI	LT	LI	Short	Long	Text	Inter
Operational Action	13	2	3	3	5	5	8	5	8
Budget Control	6	1	1	2	2	2	4	3	3
Preference Reflection	6	1	1	2	2	2	4	3	3
Limited Resources	5	1	2	1	1	3	2	2	3
Social Responsibility	8	2	2	2	2	4	4	4	4
Decision maker	7	1	2	2	2	3	4	3	4
Outcome Uncertainty	7	1	2	2	2	3	4	3	4
Performance Assessment									
Did their best	8	2	1	3	2	3	5	5	3
Feel Good	17	3	5	3	6	8	9	6	11
Good Enough	10	2	2	3	3	4	6	5	5

F.4 Temporal Demand Table

Table 5. Temporal Demand Sources: Decision-making and Operational Tasks are the main causes. Participants framed their decision-making sources differently.

[Temporal]	Total	Version				Experiment Conditions			
		ST	SI	LT	LI	Short	Long	Text	Inter
Budget Management	4	0	1	1	2	1	3	1	3
Decision Making	15	5	2	3	5	7	8	8	7
Affirmative	9	0	2	2	5	2	7	2	7
Negative	8	5	1	2	0	6	2	7	1
Operational	16	5	6	3	2	11	5	8	8
Task completion	8	2	2	3	1	4	4	5	3
Being efficient	8	3	4	0	1	7	1	3	5

F.5 Frustration Table

Table 6. Frustration Sources: needs to be updated with some new terms definitions for some of the columns.

[Fustration]	Total	Version				Experiment Conditions			
		ST	SI	LT	LI	Short	Long	Text	Inter
Strategic	17	4	4	5	4	8	9	9	8
Higher-level	11	3	2	3	3	5	6	6	5
x Conflict between personal preference and broader society and common values	6	1	1	2	2	2	4	3	3
x Trade-offs among all options	8	3	1	2	2	4	4	5	3
Lower-Level	10	3	3	2	2	6	4	5	5
x Conflict between personal preference and	4	1	2	0	1	3	1	1	3
x Trade-offs among a few options	8	2	2	2	2	4	4	4	4
Operational	15	4	5	2	4	9	6	6	9
Credit management	6	2	3	1	0	5	1	3	3
Adhering to the Quadratic Mechanism	5	2	1	1	1	3	2	3	2
Deciding number of votes for an option	4	2	0	0	2	2	2	2	2
Making multiple decisions	3	2	0	0	1	2	1	2	1
Understanding Option	4	0	3	0	1	3	1	0	4
None/Little	16	4	5	5	2	9	7	9	7