# Battery Smarts: Assessing Public Knowledge and Habits of Charging Lithium-Ion Cells

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# Battery Smarts: Assessing Public Knowledge and Habits of Charging Lithium-Ion Cells

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*Abstract*—**This work assesses the knowledge and practices that consumers have about the optimum usage of lithium-ion batteries (LIBs). To do so, a survey was conducted with questions that targeted user perceptions and habits about the duration and frequency of charging. From 453 valid responses, the results indicated that the majority of consumers lack knowledge about proper battery charging practices. A key result from the survey was the misconception that waiting to charge LIBs until they are nearly empty promotes long-term battery health. This notion to "charge only when empty" goes against best-practices for LIBs, yet about half (51%) held this misconception. While survey participants were asked about battery charging in relation to mobile devices, consumer knowledge about LIBs carries over to other critical applications, such as electric vehicles (EVs). The results of the survey, combined with battery fundamentals and best practices, point to opportunities for manufacturers to provide better charging features and more visible guidance about how to charge LIBs properly. Ultimately, this increase in "battery smarts" will enhance the lifespan of batteries in EVs and other key application areas, delivering economic and environmental benefits by alleviating production demands for new cells.**

*Index Terms*—**batteries, environmental degradation, social intelligence, social sciences, technology social factors, consumer behavior, consumer electronics**

## I. Introduction

As lithium-ion batteries (LIBs) gain prevalence and importance in society, there is a growing need to maximize the long-term health of cells. The economic and environmental costs associated with battery production are high, especially while battery recycling technologies are still emerging [1]. Therefore, it is important to optimize the usable life of cells in electric vehicles (EVs) and other major LIB applications.

The useful life of LIBs is shortened by improper practices in charging, discharging, and storage. While consumers seek vehicles and devices that simply work with minimum maintenance, consumer action is generally necessary for connecting cells to a charger. Therefore, it is important that manufacturers either empower consumers with a basic understanding about how to optimally charge LIBs or alleviate this burden altogether.

Although battery charging algorithms and chemistries are progressing, current applications have not fully solved many of the issues associated with their health [2]. To optimize the long-term health of current LIBs, fast charging rates and the limits of capacity (empty and full) should be avoided [3]. When cells are charged slowly and within the intermediate capacities of a cell, degradation can be reduced. While consumers generally cannot control the charging rate, they can decide when and how long to charge cells. For LIBs in mobile devices, the decision of when and how to recharge is largely driven by the user's location and the time of day, rather than the battery charge level [4]. This suggests that convenience is a primary factor in the habits associated with charging. Nonetheless, there may be opportunities for manufacturers to deliver benefits to consumers through enhanced battery charging features and simple, visible guidance on best practices for LIB maintenance.

In addition to charging rates and depth of charge/discharge, another aspect of LIB maintenance is the storage of cells when not in use. When cells are stored for several months at or near 100% state of charge (SoC), the useful capacity of the cell fades [5]. Additionally, storing cells near 50% SoC can maintain cell capacity better than storing near empty or full [6]. This effect is reflected in how manufacturers use a smaller range for the *reported* SoC on devices versus the *actual* SoC of the cells. This smaller range in reported SoC prevents the device from completely charging to full capacity or discharging to zero capacity. For example, when "0%" is displayed to the user, the actual SoC is typically higher (*e.g.*, 10%, although specific numbers are not disclosed by manufacturers).

Along with degradation during storage, cells can decay at different rates based on the minimum and maximum SoC during discharge and charge half cycles, respectively. For example, LIBs comprised of $Li(NiMnCo)O_2$ and graphite, cycling between 0 and 20% SoC results in the smallest capacity fade compared to charging between 20–40%, 40–60%, 60–80%, and 80–100% [7]. However, when these narrow ranges of SoC are used in charge/discharge cycles, only a fraction of the capacity in the cell is used. Thus, consumers can implement these narrow SoC cycle ranges only under certain conditions, such as

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brief trips in an EV or short times away from a mobile device charger. Furthermore, while cycling near empty (0–20%) reduces capacity fade, it leads to the highest increase in internal impedance (power fade) [7].

In the context of phones and mobile electronics, prior surveys have shown that only 26% of users are either dissatisfied or very dissatisfied with their phone's battery [8]. Furthermore, a large majority of smartphone users have a phone less than 2 years old, [8] limiting the amount of capacity fade in the cells. However, in the case of EVs, there are larger demands for high-power, high-capacity cells with useful lifespans of several years. Thus, as EVs gain popularity, there is a greater need for widespread awareness and optimization of battery health.

Prior works have surveyed consumers about their habits and knowledge of charging LIBs in smartphones and other electronic devices [4], [8]–[11]. Charging habits are mostly tied to convenience, and location is the driving factor when consumers decide how to charge their devices [4]. Furthermore, while consumers are generally dissatisfied with their battery performance, most users do not take advantage of power-saving settings [9], [10]. In a related way, devices with high battery satisfaction tend to have the highest overall customer satisfaction [11]. More recently, a large study presented by Saxena, et al. [8] surveyed users' overall perceptions and satisfaction of LIBs in mobile devices. While 35% of laptop users keep their laptop plugged in when near the charger and power socket, 36% of smartphone users follow a fixed charging routine, such as every night. Also, 78% of smartphone users expect enough battery capacity for 6 to 24 hours of normal use. This suggests the need for an overnight charging mode that delivers low charging rates and thereby reduces damage to battery materials [8]. While these works focus on user interactions with mobile devices, the results they revealed about consumer knowledge of LIBs may translate to other LIB applications, such as EVs.

To build upon these prior results, this work conducted a public survey to assess current knowledge and habits about battery charging. Prior surveys such as Saxena, et al. [8] were used as a framework to guide this study, while adding new topics and details. Specifically, while some overlap was included with prior surveys for comparison, our study added or expanded upon questions that target optimized charging software, average SoC, and SoC range. The results of this work point toward specific misconceptions among the public regarding proper battery charging practices. With the results of this work, there is a clear need for greater development of optimized battery charging features from manufacturers. As optimized charging features become more common, consumers will be more likely to acquire the basic knowledge required to make good use of optimized charging (*e.g.*, when possible, by plugging in their devices before the charge is exhausted). Furthermore, manufacturers may be inspired to develop instructional features or marketing campaigns that are crafted to address knowledge gaps among their customers. Ultimately, this increase in "battery smarts" among consumers—driven by the enhancement of LIB charging features and instructional recommendations by manufacturers—will enhance the lifespan of batteries in EVs and other key application areas, delivering economic and environmental benefits by alleviating production demands for new cells.

## II. Methods

A survey of the general public was conducted with an online crowd-sourcing platform, Mechanical Turk (MTurk). Although minor, MTurk has some inherent bias among its users. Participants may possess a degree of survey familiarity, introducing a potential non-naivete bias. However, this concern is unlikely to critically affect the results. To mitigate this risk, a 95% approval rating threshold was selected for our study, as recommended for minimizing participant bias [12]. Participant eligibility was limited to individuals who fit the following criteria: at least 18 years old; currently residing in the United States; able to read English; possessing MTurk Masters status; having a smartphone and using it at least on an approximately daily basis; and not having participated in the study before. The pool of participants represented 47 states in the United States (Figure S1). The majority of respondents (59%) were between the ages of 30 and 45 (Figure S2).

Respondents were directed from MTurk to an online survey instrument (Qualtrics). The survey consisted of seven questions that related to battery charging and usage (Table I). Additionally, the survey contained five validity checks to assess meaningful responses: agreement to the consent form; verification of being 18 years or older; a total response time of at least 60 seconds; a stated ZIP postal code that matched the reported state of residency; verification that the survey had not been completed before by the same MTurk ID holder; and a correct answer to the question "What is a dog most likely to do?" (Table I). To receive compensation, participants needed to answer all of the questions and pass all five validity checks. A single compensation of $1.50 was given to participants that completed the full survey mindfully. Only 1 attempt was allowed per participant. The survey received 628 total responses, from which 453 valid responses (72%) were recorded and imported into MATLAB for analysis and visualization.

## III. Results

The survey consisted of seven questions that related to batteries (Table I). Four questions (Q8, Q10, Q12, Q13) examined participant *habits* of LIB charging, while two questions (Q9 and Q11) probed participant *knowledge* of proper LIB charging.

| | Question | Answer choices |
|---|---|---|
| Q8† | On most days, how do you charge your phone? **(select all that apply)** | I charge it **when I go to sleep**<br>I charge it when the battery is **empty** or close to empty<br>I charge it **occasionally** during operation<br>*(<2 hours total charge time during the day)*<br>I charge it **as often as possible** during operation<br>*(>2 hours total charge time per day)* |
| Q9† | What would you say is the best way to charge your phone in order to **promote battery health over several years**? | Charge it only when the battery is **empty** or close to empty<br>Keep the battery **full** or nearly full<br>Keep the battery about **half full** |
| Q10 | Do you **turn off your phone** when you sleep or overnight? | **Yes**, most or all nights<br>**No**, or only rarely<br>**Sometimes**, or about half of all nights |
| Q11 | Are you aware of the **optimized battery charging features** on newer phones? (Note: these optimized battery charging features are **not the same as low-power mode**.) | Yes, and I understand the gist of what these features do<br>Yes, but I don't really know what they do<br>No |
| Q12 | Do you have an **optimized battery charging feature enabled** on your phone? | Yes<br>No, I turned this feature off<br>No, my phone does not have this feature<br>I don't know |
| Q13 | For most of your phone's charging needs, do you use the **charger that came with your device** (or an identical, brand-name replacement)? | Yes<br>No<br>I'm not sure |
| Q15 | Among the following options, **which would you prefer** for your phone? | 15-minute charge time and 3-month battery lifespan<br>30-minute charge time and 6-month battery lifespan<br>1-hour charge time and 1-year battery lifespan<br>2-hour charge time and 2-year battery lifespan<br>3-hour charge time and 3-year battery lifespan<br>4-hour charge time and 4-year battery lifespan<br>6-hour charge time and 6-year battery lifespan<br>8-hour charge time and 8-year battery lifespan<br>10-hour charge time and 10-year battery lifespan<br>12-hour charge time and 12-year battery lifespan |

TABLE I: Questions and answer options from the survey. The survey instrument had the same question numbering and text formatting (boldface, underline, *etc.*) as this table. (Q1 through Q6 related to participant eligibility). † For Q8 and Q9, the ordering of the answer choices was randomized in the survey presented to each participant. The full list of questions are given in Table I.

The remaining question (Q15) asked about preferences for charge time and battery lifespan. For comparison, two questions in our survey have been similarly presented in a previous study. Specifically, Q8 in our study is similar to Q8 and Q11 from Saxena et al. [8]. Lastly, for all questions except Q8, participants could only select one response choice (Q8 permitted selecting any combination of the response choices).

When asked about their habits regarding how they charge their phones on most days (Q8), about half of respondents (51%) charge when empty or nearly empty (Figure 1). Slightly fewer respondents (46%) chose either that they charge occasionally or charge often. It should be noted that more than one answer selection was permitted for Q8.

The results from Q8 are consistent with similar questions from Saxena et al., [8] with differences in the way the answers were presented. Their question Q8 asked, "When do you usually charge the batteries of your device(s)?" and their question Q11 asked, "How frequently do you charge the batteries of your device(s)?" However, in the study from Saxena, et al., respondents could only select one option, while in Q8 for our study, respondents could select all that apply. Saxena, et al., found that 18% of users charge when the charge goes below a certain level (*e.g.*, 20 or 30%), and 27% of users charge when there is a low-battery warning.

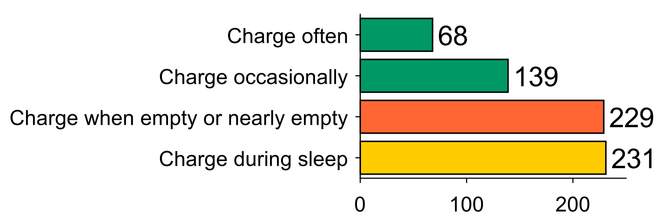


Fig. 1: Results to Q8 *(On most days, how do you charge your phone? — select all that apply)*. Respondents were allowed to select more than one answer on Q8.

Together, these results indicate that 45% of users from their survey charge when a cell is empty or nearly empty, which is close to our survey's finding of 51% for a similar criterion. These survey results point to improper charging behavior in many LIB users—as discussed by Woody, et al., charging when a cell is empty or nearly empty is detrimental to the long-term cell health [3].

Respondents were also asked about their knowledge of when it is best to charge LIBs (Q9) — "What would you say is the best way to charge your phone in order to promote battery health over several years?" The answer options were: keep the cell full or nearly full, keep the cell about half full, or charge when the cell is empty. A majority of respondents (51%) believed that the correct practice is to charge after draining completely (Figure 2). 24% selected that keeping a full or nearly full charge extends battery health. Only 25% selected the recommended practice of keeping the battery about half full (50% SoC) [3].

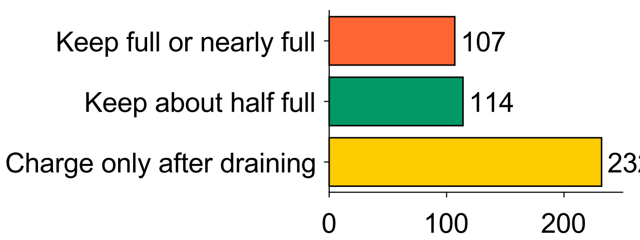


Fig. 2: Results to Q9 *(What would you say is the best way to charge your phone in order to promote battery health over several years?)*.

When asked about habits regarding overnight charging (Q10), the large majority of respondents (89%) said they rarely or never power off their phone overnight or when they sleep (Figure 3). Only 8% claimed they routinely power off their phones at night, and 3% responded they sometimes power off their phones at night.

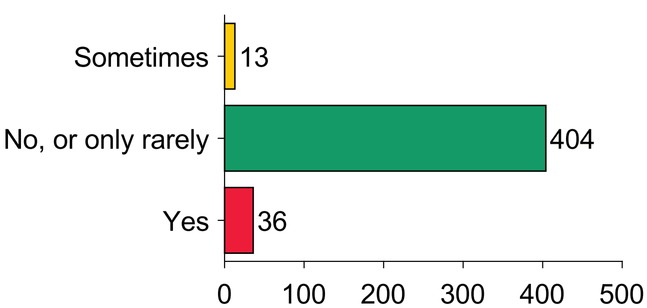


Fig. 3: Results to Q10 *(Do you turn off your phone when you sleep or overnight?)*

Since nearly all users keep their phone on at night, software-based optimized charging features are likely to work well for most of the population, as software-based features require the phone to remain powered on. This parallels the most common optimized charging features on the market, which have been introduced in recent years via on-device software for phones, laptops, and other electronic devices. Optimized charging may consist of charging cells to a limited SoC (*e.g.*, 80% reported capacity), and then completing the charge at the predicted time when device use will recommence. As pointed out by Saxena, et al., [8] optimized charging software could be improved by providing an overnight charging mode with a low charging rate. This would decrease damage to batteries not only by limiting the duration of time at full charge, but also by limiting C-rate.

Another question in the survey measured awareness and usage of optimized charging features (Q11). About half of respondents (49%) said they were not aware of these new optimized charging features (Figure 4). This points to an opportunity for manufacturers to better inform users about the availability and benefits of optimized charging features.

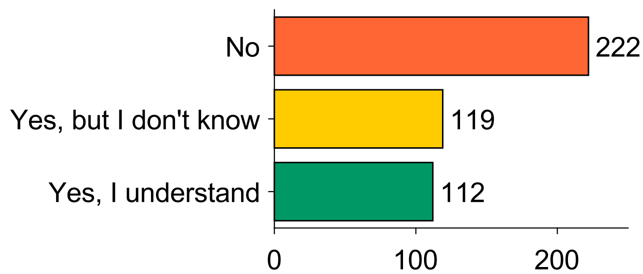


Fig. 4: Results to Q11 *(Are you aware of the optimized battery charging features on newer phones?)*. If users responded yes, they were also directed to a follow-up question (Q12) that asked about their habits regarding these features.

The next question (Q12) asked users about their habits regarding optimized charging features. This question was presented if respondents answered "Yes, and I understand the gist of what these features do" or "Yes, but I don't really know what they do" to the previous question (Q11). 9% of all respondents (17% of respondents that were aware of optimized charging features) knowingly have them disabled (Figure 5).

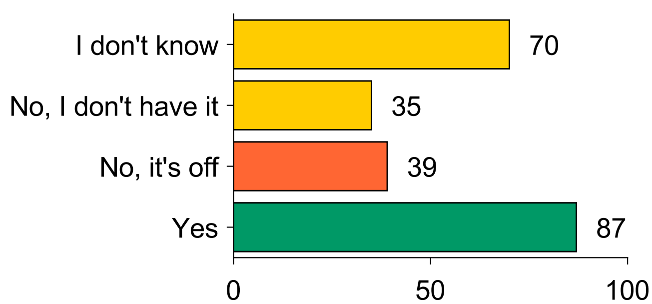


Fig. 5: Results to Q12: *(Do you have an optimized battery charging feature enabled on your phone?)*. Note that only respondents who selected "Yes" to Q11 were directed to Q12.

The survey also asked participants about which brand of charger they predominantly use (Q13). The intent of this question was to approximate if the charging rate of users' devices was likely to be an optimal rate (assuming stock/on-brand chargers deliver the appropriate current to a device — non-stock chargers may be more likely to charge faster than intended, thereby accelerating damage to the cell). The majority of respondents (74%) said they use the "stock" chargers that came with their device

(Figure 6). On the other hand, 24% do not use the stock charger. This points to the need for optimized charging features to be software-based (and not dependent on a particular charger).

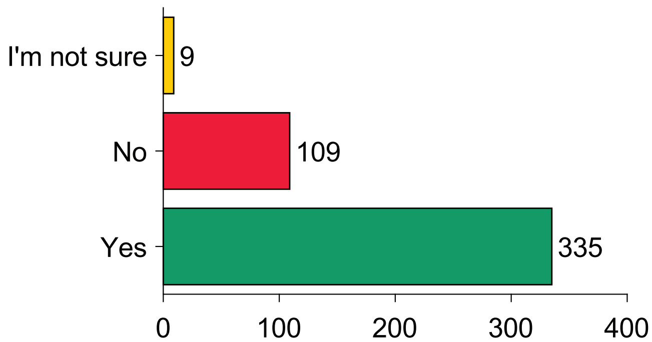


Fig. 6: Results to Q13 *(For most of your phone's charging needs, do you use the charger that came with your device (or an identical, brand-name replacement)?)*

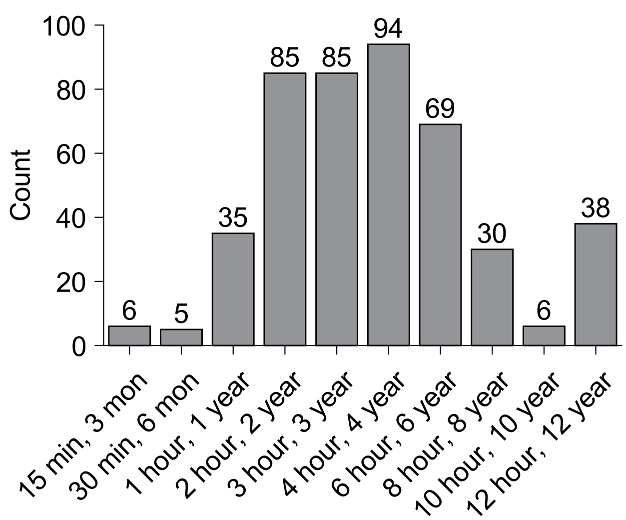


Fig. 7: Results to Q15 *(Among the following options, which would you prefer for your phone?)*. The first time value (in minutes/hours) indicates the charging time to reach full, and the second time value (in months/years) indicates the usable lifespan of the battery.

The final question in the survey (Q15) provided several options for numeric pairs of "time required to charge" (in minutes/hours) combined with "battery lifespan before replacement" (in months/years). Respondents were asked to select which combination of charging time and battery health they would prefer for a mobile phone. For example, respondents could specify that they would prefer a battery for a phone that charges within 1 hour and has a useful lifespan of 1 year. A majority of respondents (74%) selected options within the span of 2–6 hour charge times and 2–6 year lifespans (Figure 7). As the majority of respondents (also 74%) prefer to charge their phones while sleeping (Figure 3), it is reasonable that desired charge times are shorter than a typical sleep span. It is noted that while most respondents are content with at least 2 hour charge times for mobile phones, this charge time for EVs is too long for certain use cases (*e.g.*, long trips). Also, a cluster of respondents (8%) selected the maximum cell lifespan of 12 years, despite the 12 hour charge time.

## IV. Discussion

This work surveyed adults in the United States about their knowledge and habits regarding LIB usage. The key findings of this work are discussed below.

1) About half of respondents (51%) were mistaken in thinking that the optimum practice for long-term health is to charge LIBs after draining them completely.
2) The same number of respondents (51%) also had charging habits for their phones that result in wide cycle limits (between low and high SoC), which can accelerate capacity fade.
3) A majority of respondents (74%) used the stock chargers that came with their mobile phone, a favorable practice that implies appropriate charging rates are occurring.
4) About half of respondents (49%) were not aware of optimized charging features in mobile phones that can extend long-term battery health. Furthermore, only 38% of respondents that knew about optimized charging features stated that they had these features enabled.
5) Among all combinations of questions, the strongest correlation was between the knowledge and practice of when and how long to charge a battery. In other words, when users know about proper charging practices, there is evidence that they are more likely to follow them.

## V. Social Implications

The largest opportunity found in this study to increase "battery smarts" in the general population is to counteract the mindset and habits associated with depleting cells before charging (*e.g.*, "charge only when empty"). As measured in Q8 (Figure 1), about half of respondents charge their devices when empty. This practice parallels the knowledge of respondents: from Q9 (Figure 2), about half of respondents reported that the optimum time to charge a device in order to extend battery health is when the cell reaches empty. Notably, these two questions (Q8 on practice, and Q9 on knowledge) had the highest correlation (Cramér's V value of 0.203) among any pair of questions in the survey (Figure S3). However, the optimum practice to extend battery health is avoiding full or empty SoC (instead of charging only when empty) [3]. Specifically, cycling LIBs into the near-full and/or near-empty SoC exacerbates capacity fade [13]. It is hypothesized that this misconception of "charge only when empty" is a result of carry-over knowledge from NiCd and NiMH batteries, for which the best practice is to drain completely before recharging to avoid "memory" effects. However, these effects are not present in LIBs.

Manufacturers must provide more features and instructional tips for optimized LIB charging, especially as EVs gain market share. This study surveyed consumers about LIBs in phones, and it is recognized that the LIBs in phones and and EVs are distinct, such as the specific electrode compositions, cell geometries, etc. However, the overall characteristics of charging, performance, and degradation are the same for Li-ions in phones and EVs (e.g., what is bad for phone batteries is also bad for EV batteries).

Already, there are emerging features that increase "battery smarts" and charging control for consumers of EVs and other battery-powered systems. For example, in some EVs, a "daily use" charging limit can be specified by the user to extend the long-term health and range of the cells based on anticipated driving needs. For daily driving, a reduced charge-limit (*e.g.*, 75%) will extend long-term LIB health. In the event of a long trip in the vehicle, the driver may opt for a charge to the full reported capacity for that day. All EVs and many other battery-powered systems should implement similar user-specified charging limits, thereby providing users with greater latitude to optimize long-term battery health. In addition to user-specified charging limits, there are opportunities to enable "slow-charge mode" or "overnight charge mode," as described by Saxena, *et al*. [8]. Finally, these user-specified charging features will be most beneficial when manufacturers combine them with "tool tips" and other educational and marketing strategies to increase knowledge and awareness of optimum LIB charging practices. Such measures would increase the lifespan of LIBs in EVs and other devices, thereby saving money for consumers and reducing environmental damages associated with the production and disposal of batteries. As the importance of LIBs increases [1], it is essential that manufacturers empower device owners to make informed decisions about LIB charging to promote better use of resources.

Based on the results of our survey and the best practices for LIB charging, our work suggests that manufacturers should consider the following improvements.

1) Products with LIBs should include features to control the *extent* of charging. For example, when a user knows that a full charge will not be needed or when the product will be connected to the charger for an extended duration, then the user may select a reduced capacity for charging (*e.g.*, 75% of reported charge).
2) Products with LIBs should include features to control the *rate* of charging. For example, when a user knows that the charge may proceed slowly because the product will not be used for a relatively long duration (*e.g.*, overnight), then the user may select a reduced charging rate (*e.g.*, C/8 for a charge over 8 hours).
3) These features should be accompanied with instructional "tool tips" and marketing materials to increase the "battery smarts" of the product owners.

Ultimately, empowering consumers for proper LIB charging will deliver economic and environmental benefits by alleviating the demand to continually produce new cells.

## VI. Conclusion

This study highlights several misconceptions and knowledge gaps that adversely affect consumer behavior and decision-making surrounding LIBs. Evidence suggests that the general public not only lacks proper knowledge on maintaining Li-ion cells but is also often misinformed. Fostering greater "battery smarts" has become additionally critical as the adoption of EVs and other LIB-intensive technologies has continued to increase. Resolving knowledge gaps in "battery smarts" could generate significant economic and environmental benefits for both consumers and manufacturers. Manufacturers must invest in educating consumers and promoting better battery management practices for battery literacy to occur. Implementing strategies such as integrated control features and instructional tool-tips offers a practical path forward. Doing this will help society prepare for a future that is becoming increasingly reliant on LIBs and similar energy-storage technologies.

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The University of Tulsa Institutional Review Board reviewed this study (21-05) as exempt from the requirements of the 2018 Common Rule and approved under the regulations of the University of Tulsa Campus Policies and Procedures for the Protection of Human Subjects. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

The authors declare no competing financial interest.

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## Supplementary Information

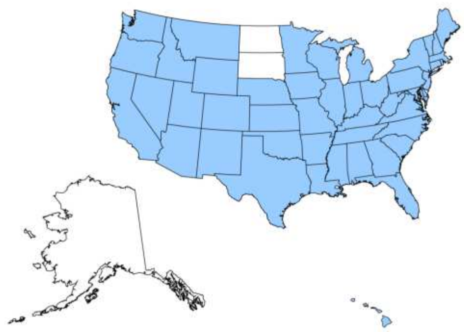

Fig. S1: National distribution of states in the U.S.A. for survey respondents.

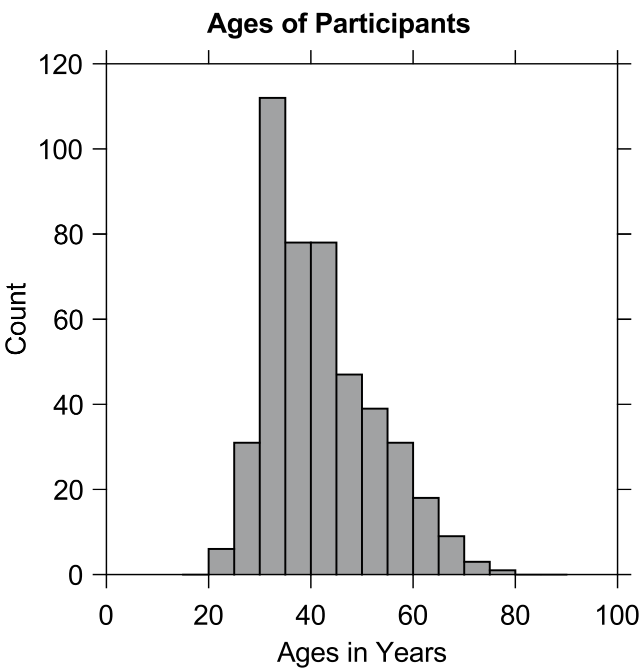


Fig. S2: Histogram of the ages of the survey participants.

### Correlations among individual survey responses

Cramér's V provides a way to correlate the pairs of questions in this survey, as it can handle categorical and qualitative data [14]–[16]. Cramér's V values can vary from 0 to 1. A value of 1 means full certainty in predicting a respondent's answer choices from one question, given the respondent's answer to the correlated question. A value of 0 means there is no association between two questions [14]–[16]. A cross examination with Cramér's V was conducted among the questions in the survey (Figure S3). The only questions with at least a low degree of correlation (V-value > 0.2) were Q8 and Q9. There was little to no correlation between any other questions, meaning if a respondent made a certain choice on one question, this did not provide a confident prediction for what the respondent would answer on a separate question.

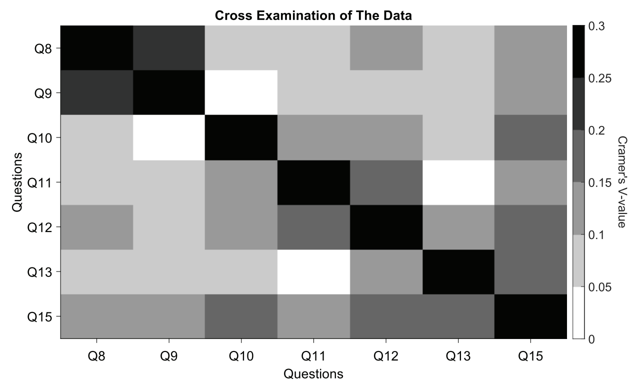


Fig. S3: Cross examination of all questions. The scale displays values in the range of 0 to 0.3 since no correlations were larger than 0.3. Each question has a correlation of 1 with itself, and this is indicated as 0.3 for simplicity.

## Survey questions

| | Question | Answer choices |
|---|---|---|
| Q1 | By selecting "I agree" below and continuing on to and completing the survey, I am giving my consent to participate in this study. | I agree<br>I do not agree |
| Q3 | What is your age? | |
| Q5 | What is your US Postal (ZIP) code? (5 digit number entry only) | |
| Q6 | In which state do you currently reside? | |
| Q8† | On most days, how do you charge your phone? **(select all that apply)** | I charge it **when I go to sleep**<br>I charge it when the battery is **empty** or close to empty<br>I charge it **occasionally** during operation<br>*(<2 hours total charge time during the day)*<br>I charge it **as often as possible** during operation<br>*(>2 hours total charge time per day)* |
| Q9† | What would you say is the best way to charge your phone in order to **promote battery health over several years**? | Charge it only when the battery is **empty** or close to empty<br>Keep the battery **full** or nearly full<br>Keep the battery about **half full** |
| Q10 | Do you **turn off your phone** when you sleep or overnight? | **Yes**, most or all nights<br>**No**, or only rarely<br>**Sometimes**, or about half of all nights |
| Q11 | Are you aware of the **optimized battery charging features** on newer phones? (Note: these optimized battery charging features are **not the same as low-power mode**.) | Yes, and I understand the gist of what these features do<br>Yes, but I don't really know what they do<br>No |
| Q12 | Do you have an **optimized battery charging feature enabled** on your phone? | Yes<br>No, I turned this feature off<br>No, my phone does not have this feature<br>I don't know |
| Q13 | For most of your phone's charging needs, do you use the **charger that came with your device** (or an identical, brand-name replacement)? | Yes<br>No<br>I'm not sure |
| Q14† | What is a dog most likely to do | Speak complete sentences in coherent English<br>Grow wings and fly<br>Solve complex calculus problems<br>Bark |
| Q15 | Among the following options, **which would you prefer** for your phone? | 15-minute charge time and 3-month battery lifespan<br>30-minute charge time and 6-month battery lifespan<br>1-hour charge time and 1-year battery lifespan<br>2-hour charge time and 2-year battery lifespan<br>3-hour charge time and 3-year battery lifespan<br>4-hour charge time and 4-year battery lifespan<br>6-hour charge time and 6-year battery lifespan<br>8-hour charge time and 8-year battery lifespan<br>10-hour charge time and 10-year battery lifespan<br>12-hour charge time and 12-year battery lifespan |

TABLE I: Full list of questions and answer options from the survey. Note that the survey question numbers are ordered to match the question numbers from the actual survey instrument. Q1 through Q6 related to participant eligibility. † For Q8, Q9, and Q14, the ordering of the answer choices was randomized in the survey presented to each participant.