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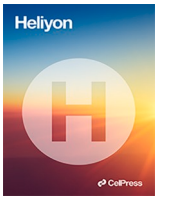

Contrasting two models of utilitarian reasoning

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ABSTRACT

One influential framework for examining human moral cognition has been a dual process model, in which utilitarian judgment (e.g., infliction of harm for the greater good) is associated with cognitive control processes, while non-utilitarian judgment (e.g., avoiding such harms) is associated with emotional, automatic processes. Another framework of moral cognition, the two-dimensional model of utilitarian psychology, posits that utilitarian choices may reflect either instrumental harm, i.e., inflicting harm on an individual for the greater good; or impartial beneficence, i.e., impartially and altruistically acting for the benefit of the overall welfare. We evaluated preregistered hypotheses (https://osf.io/m425d) derived from these models of moral cognition in a sample of 275 neurologically healthy older adults. Our results suggest that both the dual process and two-dimensional models provided insights regarding utilitarian reasoning, including three cardinal domains of conflict between utilitarianism and common-sense morality: agent-centered permissions, special obligations, and personal rights. One prediction of the dual process-based model was supported by our findings, with higher emotionality associated with decreased endorsement of utilitarian judgments (b = - 0.12, $p < .001$). We also found partial support for the two-dimensional model, as utilitarian judgments about dilemmas involving agent-centered permissions and personal rights were dissociated; however, both sets of judgments were associated with utilitarian judgments involving special obligations ($p < .001$ and $p = .008$, respectively). We propose that our findings, with support for some elements of the dual process and two-dimensional models, can be integrated into a revised two-dimensional model of utilitarian judgment as including impartial beneficence and acceptance of attributable harms.

1. Introduction

There has been broad scientific interest in the psychological underpinnings of human moral cognition. An organizing focus of this research has been the contrast between utilitarian and non-utilitarian modes of moral reasoning. Utilitarianism, as a philosophical theory, assesses actions by the extent to which they bring about a state of overall welfare that is deemed intrinsically valuable, often glossed as the *greater good* [1]. Of course, as an empirical matter, most people who are not philosophers do not explicitly apply such a theory to their moral decisions or judgments of action. However, research has demonstrated systematic variation among people's moral judgments about individual scenarios, which may be characterized as falling on a spectrum between "utilitarian" and

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"non-utilitarian" based on the extent to which these judgments favor the collective welfare [2] (even when we do not know whether these judgments are guided by utilitarian considerations i.e., Level-1 utilitarian judgments). Also, beyond individual case judgments, people also demonstrate varying sensitivity to features of situations that are treated as morally significant in some theories and as insignificant in others, such that some are guided more than others by "utilitarian" considerations even if not explicitly applying any theory or decision procedure [2,3] (see Kahane et al. on "proto-utilitarian psychological tendencies," and Conway et al. on Level-3 utilitarian judgments).

One influential model of the contrast between utilitarian and non-utilitarian tendencies is the dual process model of moral cognition as advocated by Greene et al. [4–7,[8]9], informed by broader dual process models of intuitive "fast" and deliberative "slow" judgments [9]. In this account, non-utilitarian judgments are characteristically subtended by automatic, emotional responses while utilitarian judgments are driven by controlled cognitive processes. Process dissociation approaches have been applied to provide evidence that these two processes (e.g., the balance of consequences and rules) and different brain areas independently contribute to moral judgments [4]. Characteristically, cognitive load has been suggested to selectively reduce utilitarian inclinations, whereas emotion manipulation designed to increase empathy selectively increases non-utilitarian tendencies. Of note, the process dissociation model has been criticized for its limitations in predicting moral decision-making. In response, new models, such as the consequences, norms, and inaction (CNI) model, have been proposed to account for the role of consequences, social norms, and inaction in moral decision-making [10].

Neuroanatomic correlates have been proposed by proponents of the dual process model of moral cognition, with dorsolateral prefrontal cortical (dlPFC) areas postulated as associated with utilitarian choices and ventromedial prefrontal areas (vmPFC) with non-utilitarian choices [5]. More specifically, the dlPFC has been linked with the ability to facilitate cost-benefit analyses, and override salient affective responses elicited by the aversive nature of moral dilemmas. Neurostimulation studies on the other hand provide mixed evidence regarding the role of dlPFC in utilitarian choices. Tassy et al. [11] demonstrated that disrupting the right dlPFC increased the probability of utilitarian choices. The role of vmPFC may be suggested by lesion studies, in which affective responses mediated by vmPFC appear to play a role in non-utilitarian choices in emotionally salient moral scenarios [12].

An alternative account of utilitarian reasoning has been proposed by Kahane et al. [3,12,13]. While this has been proposed as a "two-dimensional" model (i.e., 2D model), the two dimensions here do not refer (as in Greene's dual process model) to contrasting psychological processes underlying utilitarian and non-utilitarian decisions, but instead to purportedly dissociable components within utilitarian judgment itself. That is, while Greene's dual process model assumes that utilitarian decisions result from a unitary psychological pattern (marked by the presence of cognitive control and diminished emotional elicitation), this paradigm proposes that utilitarian decisions encompass two dimensions: absence of constraints against instrumental harm (the negative dimension) and promotion of impartial beneficence (the positive dimension).

Kahane et al. [3] have presented preliminary evidence that these two dimensions of utilitarian decisions are psychologically dissociated in the lay population. Developing a new instrument, the Oxford Utilitarianism Scale (OUS), they report that impartial beneficence is linked with greater levels of trait empathic concern. Importantly, while increased empathic concern was associated with scores in the impartial beneficence subscale, decreased empathic concern was associated with absent constraints against instrumental harm. Psychopathy on the other hand was associated with higher scores in the instrumental harm but not impartial beneficence subscale. These authors' interpretation is that willingness to endorse harm in hypothetical moral dilemmas need not indicate impartial concern for the greater good.

1.1. Positive dimensions of utilitarianism: special obligations and agent-centered permissions

In Kahane and colleagues' 2D model, the primary focus in the positive dimension of utilitarianism is on the utilitarian requirement for impartial maximization of the greater good. This requirement is applied when the agent's personal and close others' interests conflict with the greater good and subsequently necessitates the sacrifice of those interests so that overall welfare is obtained. On the contrary, common-sense morality encompasses agent-centered permissions, in which one is *permitted* (but not required) to favor one's own interests over others.

Utilitarianism diverges from common sense morality not only regarding how much one should sacrifice on an individual level but also for whose sake. Characteristically, utilitarianism forbids giving any special priority to those close to us over others, requiring individuals to adopt a thoroughly impartial moral stance and to treat the well-being of every person as equally important. On the contrary, common-sense morality includes special obligations, in which one is positively *obliged* to favor the interests of close relations and those otherwise related to oneself, over strangers – even at the cost of the greater good [14–17]. Dilemmas under the positive dimension would thus encompass utilitarian choices where the greater good is promoted at the cost of self-interest and by forgoing opportunities to benefit close others.

While philosophers have distinguished between special obligations and agent-centered permissions as two distinct categories of conflict between utilitarianism and common-sense morality [14,15], the impartial beneficence subscale [3] of the OUS encompasses both together. For instance, one of its items asks whether, *from a moral perspective, people should care about the well-being of all human beings on the planet equally without favoring the well-being of people who are especially close to them*, reflecting thus a conflict between special obligations and utilitarianism. Similarly, another item asks whether *it is morally wrong to keep money that one doesn't need if one can donate it to causes that provide effective help to those who will benefit a great deal,* representing a conflict between agent-centered permissions and utilitarianism. In our study, utilitarian choices at the cost of self-interest (e.g., Would you agree to these repeated blood donations to keep this person from dying?) and forgoing opportunities to benefit close others (e.g., Would you save your nephew instead of six strangers?) were examined separately.

1.2. Negative dimension of utilitarianism: personal rights

According to Kahane's 2D model of utilitarian psychology (see Fig. 1), components embedded in the positive dimension of utilitarianism should be dissociated from those of the negative dimension. For instance, in the instrumental harm dimension of utilitarianism, the violation of personal rights (e.g., Would you keep this injured person on the boat instead of throwing him overboard to save the passengers?) is allowed or even required so that overall welfare is obtained. Such a premise departs from common-sense morality, in which respect for individual personal rights is preferred even at the cost of utility-maximizing (in utilitarianism, individual well-being counts, but as a component of collective well-being) [18,19]. Importantly, utilitarian tendencies falling under the *personal right* category (referred also as utilitarian tendencies in sacrificial/personal moral dilemmas) would be dissociated with categories falling under the positive one. Meanwhile, in Greene's dual-process model [4], tendencies to utilitarian judgment in all domains of moral conflict (those involving personal rights, agent-centered permissions, and special obligations) are presumed to reflect controlled cognitive processes resulting from cost-benefit reasoning (see Fig. 1) or/and lack of emotional elicitation. Because dual-process accounts of moral cognition have largely employed personal/sacrificial dilemmas, it is implicitly assumed that utilitarian decision-making involves a unitary psychological phenomenon that is reflected in pro-sacrificial choices (e.g., employing harm) for the greater good.

1.3. Aim of the study

We conducted a preregistered study (https://osf.io/m425d) utilizing an existing research platform enrolling healthy older adults, to test the predictions of these competing theoretical models (see Fig. 1). Our instrument [20] included dilemmas involving both dimensions of utilitarian psychology, per Kahane and colleagues [3] account, addressing three core domains of conflict between utilitarian judgment and common-sense morality: agent-centered permissions (AP), special obligations (SO), and personal rights (PR, related to the literature on cases involving "sacrificial harm"). This instrument also included post-decision questions for each dilemma assessing difficulty and emotion elicitation, as well as control questions to assess participants' understanding of the moral dilemma vignettes.

Of note, in the process of planning this study, a worldwide outbreak of a novel coronavirus (COVID-19) infection occurred. This environmental event could accordingly influence utilitarian reasoning. More specifically, reduced utilitarian willingness to violate personal rights has been observed during the COVID-19 pandemic compared to pre-pandemic [21]. We accounted for the potential influence of the COVID-19 pandemic by controlling the time of data collection (i.e., pre and during COVID-19) as described in the registered planned analyses (https://osf.io/m425d).

1.4. Hypotheses

Hypotheses tested were preregistered (https://osf.io/m425d) and derived from two competing models of utilitarian reasoning (see Table 1 and Fig. 1).

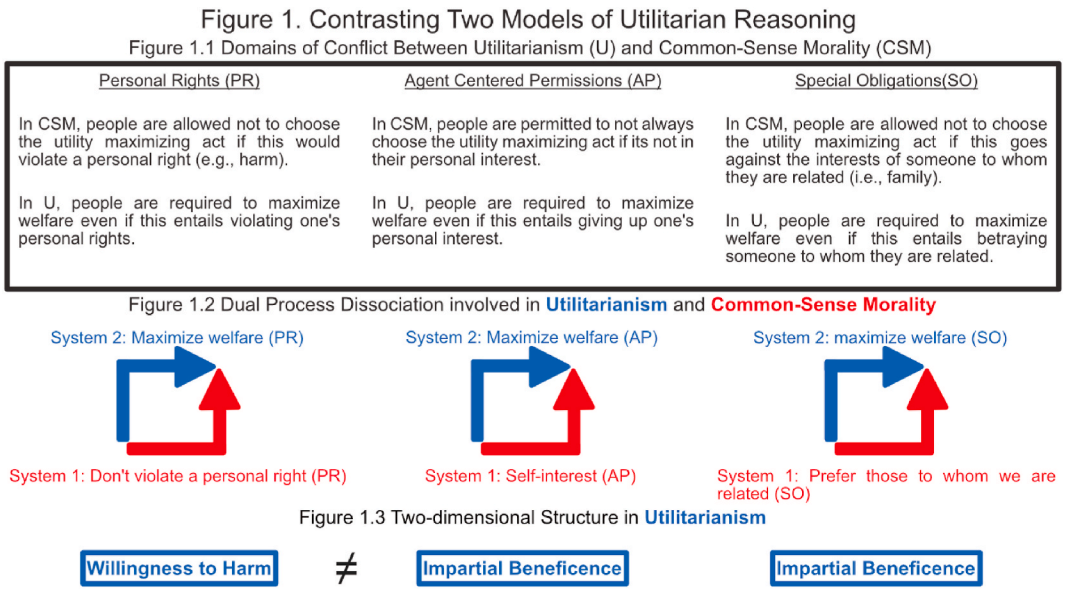

Fig. 1. Contrasting two models of utilitarian reasoning.

Table 1
Dual process and 2D model predictions and statistical analyses.

Predictions by Model	Dual Process	2D	Statistical Test
Association among moral categories			
SO-AP	positive	positive	Pairwise Pearson correlational analyses
PR-SO	positive	negative/null	
PR-AP	positive	negative/null	
Utilitarian Judgements & Emotionality	negative	no prediction	Linear mixed effects model
Utilitarian Judgements & Cognitive Control	positive	no prediction	Linear regression model
Exploratory: Neuroanatomical Associations			
Utilitarian Judgments	dlPFC	no prediction	Linear regression model
Non-utilitarian Judgments	vmPFC	no prediction	

Note. SO refers to dilemmas involving special obligations, PR to dilemmas involving personal rights, and AP to dilemmas involving agent-centered permissions.

1.4.1. Dual process model: main analyses

On the dual process model of moral cognition [4] psychological processes of cognitive control and emotion elicitation are positively and negatively associated with utilitarian judgments respectively. More specifically:

- Neuropsychological measures of cognitive control are positively associated with utilitarian judgments. Because the dual process model views utilitarian judgments as being associated with a unified construct of cognitive control, its effect was evaluated across all three moral categories, namely personal rights (PR), special obligations (SO), and agent-centered permissions (AP).
- Post-decision self-reports of emotion elicitation are negatively associated with utilitarian judgments. Consistent with the dual process model that does not distinguish within utilitarian judgments, the hypothesis was tested across all three moral categories namely personal rights (PR), special obligations (SO), and agent-centered permissions.

Since Greene's dual process model posits that utilitarian decisions stem from a single psychological pattern characterized by the presence of cognitive control and reduced emotional elicitation, we further hypothesized that:

- Utilitarian judgments are positively associated across all three categories (personal rights, agent-centered permissions, and special obligations).

1.4.2. Dual process model: exploratory analyses

Lastly, we explored whether dorsolateral prefrontal grey matter volumes are positively associated with utilitarian judgments across all three moral categories tested and whether ventromedial prefrontal grey matter volumes are negatively associated with utilitarian judgments across all three moral categories tested.

1.4.3. 2D model: main analyses

The 2D model of utilitarian psychology [3] entails that utilitarian judgments in dilemmas that reflect impartial concern for the greater good (categorized under the positive dimension) are positively associated. Conversely, on the 2D model judgments in dilemmas that reflect violations of personal rights (categorized under the negative dimension) are not correlated with judgments in dilemmas falling under the positive dimension. To elaborate further:

- At the subject level, utilitarian judgments in dilemmas involving agent-centered permissions are positively associated with utilitarian judgments in dilemmas involving special obligations.
- At the subject level, there is no positive association between utilitarian judgments in dilemmas involving personal rights and utilitarian judgments in dilemmas involving either special obligations or agent-centered permissions (i.e., negative or no association).

2. Material and methods

2.1. Overall procedure

We recruited neurologically healthy, community-dwelling older adults from a cohort at the UCSF Memory and Aging Center in which participants regularly undergo in-person measurements and complete online web-based behavioral tasks. Participants included in this cohort were assessed as neurologically normal based on a multidisciplinary evaluation including informant interview, neurological examination, and cognitive testing. All members of this cohort received an e-mail inviting them to participate in an online instrument that included the moral reasoning task described below (see Material section).

The data (https://osf.io/ym5wu) and Material (see Supplementary Material) that support the findings of this study are openly available. The Brain Aging Network for Cognitive Health protocol was reviewed and approved by the UCSF Committee on Human Research (IRB number: 10–02076). This study was conducted in full compliance with the ethical principles set forth by the Declaration

Table 2
Moral reasoning task.

Category	Dilemma
Personal Rights	**Q1.** "You are on good terms with your two neighbors, Jeffrey and Benjamin. Unfortunately, they are both hot-headed and hate each other. The other day, you saw Benjamin carelessly drop some trash near Jeffrey's yard. Jeffrey knocks on your door, visibly angry, and asks if it was Benjamin who left the trash. If you tell him the truth, you know he will go to Benjamin's house and they will have a violent fight. If you lie and tell him that it was you who accidently dropped the trash, Jeffrey will soon forget about the whole thing. Would you tell the truth that it was Benjamin who left the trash near Jeffrey's yard? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - If you lie and say that it was you who dropped the trash, will Jeffrey get angry at you? **Q2**. You are leading a rescue team for seven miners that are stuck in an underground mine, which is flooding. Six miners are trapped at the bottom and will drown if not rescued soon. One miner is trapped higher in the elevator shaft and will not drown. The only way to rescue the six at the bottom is to quickly send down the mine elevator. If you do this, the one miner in the shaft will be crushed to death. If you do not send down the elevator, you will have enough time to rescue the one miner in the shaft. Would you send down the mine elevator to rescue the six miners at the bottom? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - If you do not send down the elevator, will the six miners live? **Q3.** You are negotiating with a powerful and determined terrorist. He is about to set off a bomb that will kill thousands of people. Your one advantage is that you have his teen-age son under your control. There is only one thing you can do to stop him from setting off his bomb. You can contact him over the video connection that he has created and break one of his son's arms. You can then threaten to break the other one if he does not give himself up. Would you refrain from breaking the boy's arm even though the terrorist will kill thousands of people with his bomb? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Will more people die if you break the boy's arm? **Q4.** You are a waiter. One of the regular customers of your restaurant will go to jail in 48 h. You overhear him saying that he plans to infect as many people as possible with HIV before he goes to jail. You know that he is telling the truth and has access to many potential victims. You also know that he has a strong allergy to poppy seeds. If he eats even one he will go into convulsions and have to be hospitalized for at least 48 h. Would you cause this man to have a serious allergy attack to prevent him from spreading HIV? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - If you do not cause this man to have an allergy attack, will more people get sick? **Q5.** An epidemic has spread worldwide killing millions of people. You have developed two substances in your underground shelter. One of them is a cure but the other one is deadly. You don't know which is which. Two people have run downstairs to your shelter trying to avoid the epidemic. The only way to identify the cure is to inject each of these people with one of the two substances. One person will live but the other will die. Then you will be able to start saving lives with the cure. Would you kill one of these people with a deadly injection to identify a cure that will save millions of lives? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Will more people live if you inject these two people with the unknown substances? **Q6.** A runaway trolley is heading down the tracks toward five workers and will kill them if it keeps going. You are on a footbridge over the tracks, in between the approaching trolley and the five workers. Next to you on this footbridge is a stranger who is very large. The only way to save the lives of the five workers is to push this stranger off the bridge and onto the tracks below where his large body will stop the trolley. The stranger will die if you do this, but the five workers will be saved. Would you push the stranger onto the tracks to save the five workers? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Will more people die if you push the stranger than if you don't? **Q7.** You are on a cruise ship when a fire breaks out, forcing everyone to abandon the ship. The lifeboats are carrying many more people than they should. The seas start to get rough, and your lifeboat begins to fill with water. If you do nothing, the boat will sink before help arrives and everyone on board will die. However, there is an injured person on board who will not survive even if help comes. If you throw that person overboard the boat will stay afloat and the rest of the passengers will be saved. Would you keep this injured person on the boat instead of throwing him overboard? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - If the injured person is kept on the boat, will he live? **Q8.** You are leading a group that is lost in the wilderness. Your group includes a family of six with a genetic vitamin deficiency. A few people's kidneys contain large amounts of this vitamin. There is one such person in your group. The only way to save the lives of the six family members is to remove one of this man's kidneys and take the necessary vitamins from it. He will not die if you do this, but his health will get worse. He does not want to give up his kidney, but you have the power to do what you choose. Would you allow this man to keep his kidney rather than save the vitamin-deficient family? (*continued on next page*)

Table 2 (*continued*)

Category	Dilemma
	- How difficult did you find that decision? - How emotional were you when thinking about the situation? - Will more people live if you take the man's kidney?
Agent-centered Permissions	**Q1.** You have a very rare type of blood. There are some people who can only receive blood transfusions from you, though you cannot receive blood from them. One of these people is a stranger who is very sick and will require many blood transfusions in order to survive. To donate all the blood that this person will need to get well, you will have to live in the hospital for six months. During this time, you will undergo multiple large blood donations. These donations will make you feel weak and tired most of the time. Would you agree to these repeated blood donations to keep this person from dying?
	- How difficult did you find that decision? - How emotional were you when thinking about the situation? - Will this person get better without your blood donations?
	Q2. You are a poor farmer during an unusually severe drought. Fortunately, there is a spring on your farm with enough water for all your crops this year. The nearest farm is miles away, and that farmer will have to abandon his farm and move away because he has no water. You could give him some water for enough crops to keep his farm, but then you could only plant some of your own crops. Your farm would survive, but would not make enough money to afford some improvements that you have planned. He will not be able to repay you. Would you keep your water so you can afford the improvements that you have planned?
	- How difficult did you find that decision? - How emotional were you when thinking about the situation? - Will the other farmer keep his farm if you do not help him?
	Q3. You are a college student who is very good at science. During your studies, you find that you do not enjoy doing research. You also discover that you are very interested in dance. You meet with a career advisor who has known many other students with the same skills and interests. She tells you that if you become a scientist, you will make discoveries that save many lives but you will always feel unfulfilled. If you become a dancer, you will have a satisfying career but will not help many other people. Would you decide to become a scientist so that you can help more people?
	- How difficult did you find that decision? - How emotional were you when thinking about the situation? - Would you find a career as a scientist fulfilling?
	Q4. Your favorite band will perform one final concert before retirement. You have never had the chance to see them perform, and you really want to go. You have reserved tickets for this concert for $150. One week before the concert, an earthquake in a faraway country leaves thousands of people homeless and without enough food. You could give up your concert tickets and donate the $150 to earthquake relief. This money would provide two families with food and shelter through the winter. Otherwise, they will be cold and hungry but will survive. Would you keep your tickets so that you can see this final concert? - How difficult did you find that decision? - How emotional were you when thinking about the situation?
	- Would anyone's life be improved if you miss the concert?
	Q5. On vacation, your cruise ship stops at an island, and you bring a few dollars with you onshore. You find some local fruit for sale, which you have heard about and are curious to try. Another passenger forgot to bring her money from the ship, and she finds a type of shell for sale that is only found on this island. She asks to borrow your money to buy a shell for her friend, who is a biologist and would treasure it. If you agree, she will pay you back on the ship, but you will miss your chance to try the fruit. Would you keep your money so that you can try the fruit?
	- How difficult did you find that decision? - How emotional were you when thinking about the situation? - Can you buy the fruit and also lend this woman money to buy the shell?
	Q6. While waiting for a bus you begin to talk with a stranger. You remember that you have seen him on TV news shows and that he is a very rich but strange man. He says that he has $10,000 in his wallet, and then gives you a choice. He says you can take the money for personal use. However, if you do not take the money, he will donate $1,000,000 to a charity to cure cancer. He will not make that donation if you take his money now. Given what you know about him, you are sure that he will keep his word. Would you take the $10,000 for your own personal use? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Will the rich man make a larger donation if you do not take his money now?
	Q7. You are at home one day when the mail arrives. You receive a letter from a charity. You have heard of this charity, which has won many awards for its work. The letter asks you to make a donation of $200. The letter explains that this money will allow them to provide needed medical care to some poor people in another part of the world. If you do not make this donation, they will not be able to help as many people as they could if you do donate this money. Would you make this donation rather than keep the money for your own personal use?
	- How difficult did you find that decision? - How emotional were you when thinking about the situation? - Would anyone's life be improved by your donation?
	Q8. You are on a flight arriving at a small airport at night and are very tired. You stand in line and get the last taxi, as all the other drivers have gone home. Just then, another passenger runs up and asks to share a ride. If he rides with you, the driver will have to take a longer route and it will take you 20 more minutes to get to your destination. If he cannot ride with you, it will take him an hour longer to

(*continued on next page*)

Table 2 (*continued*)

Category	Dilemma
	get to his hotel by bus. Would you let him share a taxi ride with you so that he will not spend another hour on the bus? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - If you share the taxi ride, will you arrive at your destination faster?
Special Obligations	**Q1.** You are camping with your own small child and another child. Both children eat leaves from a poisonous plant. If untreated, your child will have painful boils all over his body for a year. The other child ate more leaves, and he will have painful boils for three years if he does not get treatment. Neither will have permanent scars or damage. You have a medicine that will keep these boils from appearing if a child drinks it immediately. Unfortunately, you only have one dose of this medicine. The medicine will not work if the dose is shared between the children. Would you give the medicine to your own child rather than the other child? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - If both children were not treated, would the other child suffer more than your own child would? **Q2.** You are driving a motorboat when a cruise ship nearby begins to sink. Looking left, you see that your nephew, who was on the ship, is holding onto a piece of floating wood. If you drive towards him at full speed, you can save him right before he sinks. In the opposite direction is another piece of wood with four strangers clinging to it. By driving at full speed in the opposite direction, you have just enough time to save them. You only have enough time to rescue either your nephew or the four strangers. There are no other boats in the area. Would you save the four strangers instead of your nephew? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Is there enough time to save all four strangers and your nephew? **Q3.** You are a doctor whose patient is on dialysis and is waiting for a kidney transplant. There is a new kidney that can be given either to your patient or another person. You have not met this other person, who is a little healthier than your patient. Based on your research, you know that the kidney would allow your patient to avoid dialysis for six more years. The kidney would allow the other person to avoid dialysis for nine more years. You can decide who will receive the kidney. Would you give the kidney to your own patient rather than the other person? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Other things being equal, will this kidney do more good for your patient than for the other person? **Q4.** You are a lawyer whose client has pleaded guilty to a serious crime and will go to jail for 20 years. You discover that the police have overlooked evidence that your client is also guilty of another crime. An innocent man will be jailed for this other crime for 20 years. You could suggest to the police that they look at this evidence again. You can do this in a subtle way, so they think this is their idea and not yours. If they do, the innocent man will go free, but 15 years will be added to your client's sentence. Would you keep quiet about the evidence out of loyalty to your client? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - If you keep quiet, will the innocent man spend as much time in jail as your client? **Q5.** You are a parent whose young daughter plays soccer on a local team. You have been invited to have her join a team in a special regional league with better players and coaches. You think that she will learn more and have more fun on the regional team. However, she cannot stay on the local team and play for the regional team. If she leaves the local team, they will not have enough players and will not be able to play together. If she stays, both the local and regional teams will still have enough players. Would you keep your daughter on the local team so that all the children can keep playing? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Will it be better overall for the other children if your daughter stays on the local team? **Q6.** You are a doctor researching a bad infection for which there is no cure. You discover a mold that makes a medicine that cures this infection. Before you can tell others about your results, your own patient contracts the infection and will die without treatment. In order to save her you must use up all of your mold. It would take two years to grow another batch. During this time, fifty other people will die of this infection. These people could be saved if you do not give the medicine to your patient and continue your research. Would you allow this patient to die in order to save many more lives in the future? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Will more people live if you save your own patient? **Q7.** You have been put in charge of a new charity to find housing for homeless children. You can either focus on helping children in your own neighborhood or in other countries. Your budget has enough money to give seven children in your neighborhood a home, food, and clothes for one year. You pass these children on the streets every day. Because things are cheaper in other countries, the same amount could give fifty children there home, food, and clothes. You will never meet these children. Would you help the fifty children in other countries, rather than the seven children in your own town? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Would you help more children overall by focusing on children in other countries?

(*continued on next page*)

Table 2 (*continued*)

Category	Dilemma
	Q8. Your best friend enjoys his work, though you know that he would still prefer to work for Company X. You have also heard that one of his coworkers recently lost her job and has been struggling to provide for her family. They both have similar skills and experience. You happen to meet the owner of Company X, and she mentions that she is planning to hire someone. Both your friend and his former coworker would be a good fit for this new job. You have an opportunity to suggest hiring either your friend or his former coworker. Would you suggest hiring your friend instead of his former coworker for this job? - How difficult did you find that decision? - How emotional were you when thinking about the situation? - Would it be more important for your friend to get this job than for his former coworker?

Note. This table contains the moral reasoning task with the follow-up questions on.
difficulty/emotionality and the control question, categorized by moral category: Personal Rights.
(PR), Agent-centered Permissions (AP), and Special Obligations (SO).

of Helsinki. All participants provided written informed consent.

2.2. Study participants

We collected data from 275 older adults. Some task data for this study (125 participants) were collected during an initial piloting phase (2014 wave) for our online platform; while descriptive statistical analyses were performed on responses for purposes of platform testing, cognitive/behavioral tests of these preregistered (https://osf.io/m425d) hypotheses were not previously performed on the data. We utilized a new opportunity to collect further task data (2020 wave) in an expanded cohort of older adults (150 participants) prior to performing the analyses described above (see Table 1). Of note, participants for this study were assessed only once (either 2014 or 2020 wave) and were recruited from the longitudinal cohort of healthy older adults described above.

3. Material

3.1. Moral reasoning task

In this task (see Table 2), participants read and answered a set of twenty-four moral dilemmas, which encompassed three moral categories:

1. Personal Rights dilemmas were eight items concerning choices that substantially affected the interests of other people, and in which the best overall outcome could only be produced by violating an individual's personal rights. For instance, whether to push one person into the path of a runaway trolley that would otherwise kill five people. Here, the utilitarian choice is to sacrifice the individual, so that the greatest welfare is produced.
2. Agent-centered Permissions dilemmas were eight items concerning choices in which others' welfare could be improved at the cost of one's own interests. For example, whether to donate or keep found money for one's own personal use. In this case, the utilitarian choice concerns disregard of self-interest for the greater good.
3. Special Obligations dilemmas were eight items concerning choices in which the interests of parties related to the agent (e.g., family members, friends) conflict with promoting the overall welfare. For example, parental choices that prioritize one's own child's well-being over the well-being of other children. Here, utilitarian judgments reflect disregard for tight social bonds for the greater good.

Participants also answered *difficulty* questions following up each moral dilemma. We weighted responses to each dilemma by difficulty to capture decisional conflict and ambivalence; intuitively, a participant who endorses the utilitarian violation of a personal right and scores the scenario as low-difficulty exhibits stronger utilitarian tendencies than a participant who endorses the same rights-violation but scores the scenario as high-difficulty, though the binary response is the same.

To confirm task engagement and comprehension, after making each moral judgment participants were presented with a control question testing comprehension of the details of the dilemma situation (binary format yes/no). They were then asked to rate, on a scale of 1–5 (Not at all – Very), how difficult they perceived the moral reasoning process to have been. Each moral response was first scored as binary (1 for utilitarian or −1 for non-utilitarian) and then scaled by a 1–5 factor of difficulty (6-difficulty)/5. Thus, a utilitarian response of minimal reported difficulty was ultimately scored as 1 (initial, raw score) * (6-1)/5 (difficulty scaling) = 1, and maximal reported difficulty was scored as 1*(6-5)/5 = 0.2. Accordingly, a non-utilitarian response of maximal reported difficulty was scored as −1*(6-5)/5 = −0.2, and minimal reported difficulty was scored as −1*(6-1)/5 = −1. Individual item scores in each category (PR, AP, SO) were summed to generate the overall utilitarian score per category (max = 8, min = −8).

3.2. Emotionality

After making each moral judgment, participants rated how emotional they were when thinking about the moral dilemma on a scale of 1–5 (Not at all – Very).

3.3. Cognitive control

Utilizing standard neuropsychological measures collected as part of participants' involvement in a longitudinal cohort study of aging, we generated a cognitive control score as the mean of standardized scores for a Stroop interference task, a modified trails task, and dysexecutive errors [20]. Dysexecutive errors included false alarm responses on a continuous performance test, rule violations and repetitions on verbal fluency tasks, and the tendency to make errors on the set-shifting trials relative to the non-shift trials. For the dysexecutive error variable, standardized scores were inverted so that higher values represented a higher index of cognitive control.

3.4. Analyses

To test the association between moral categories, we conducted pairwise correlations among participants' category scores for PR, AP and SO dilemmas. To examine whether utilitarian judgments are associated with cognitive control, we constructed a linear regression model with cognitive control summary score, age, gender, education, and wave of data collection as predictors and total utilitarian judgment score summed across all categories as the outcome variable. To test whether post-decision self-reports of emotion elicitation were negatively associated with utilitarian judgments, we fitted a linear mixed effects model with utilitarian responses in all three categories as the outcome variable. Fixed effects were emotion elicitation, gender, age, years of education, and wave of data collection. We fitted a random-intercept model to allow for utilitarian scores to vary for each individual (see Table 1). A priori power calculations were performed prior to analysis as described in the study preregistration (https://osf.io/m425d).

3.5. Exploratory neuroimaging analyses

Structural T1-weighted images were collected as part of this cohort's research involvement at the Memory and Aging Center (UCSF) and were pre-processed using SPM12. Regions of interest were extracted from the Neuromorphometrics atlas [22]. Dorsolateral prefrontal grey matter volumes were generated as the sum of volumes of the left and right middle frontal gyri, while ventromedial prefrontal volumes were the sum of volumes of left and right medial frontal cortices, gyri recti, medial orbital gyri, and subcallosal areas. Neuroanatomical associations were tested via two linear regression models, with primary predictors as dorsolateral and ventromedial prefrontal grey matter volumes respectively. The common outcome variable was the total utilitarian judgment score summed across all categories. Both linear regression models controlled for age, gender, education, and the wave of data collection.

3.6. Data exclusion

According to our exclusion criteria (https://osf.io/m425d), we excluded data from participants who answered 7 or more control questions incorrectly. In addition, during item-level analyses, we excluded responses where participants did not answer subsequent emotion elicitation and difficulty questions, resulting in a total exclusion of 14 participants. It is worth noting that the 14 excluded participants were those who both incorrectly answered control questions and did not answer emotion elicitation and difficulty questions, meaning that they were not excluded twice.

3.7. Sensitivity analyses

As sensitivity analyses (https://osf.io/m425d), we repeated our hypothesis testing using binary (−1 and 1) utilitarian judgment scores for each dilemma without scaling. We also repeated the analyses for predictions falling under the dual process model (i.e., the association between utilitarian judgments and 1: emotion elicitation, 2: cognitive control 3: neuroanatomical associations) for each moral category independently (PR, AP, SO). We lastly analyzed all hypotheses in the two waves of data collection separately and

Table 3
Descriptive statistics: Age, education, gender, and race.

Demographics	2014 wave (N = 125)	2020 wave (N = 150)	Total	*p*
Age (years)				<.001
Mean (SD)	76.8 (6.0)	73.6 (8.3)	75.1 (7.5)	
Education (years)				.250
Mean (SD)	17.8 (2.1)	17.6 (1.9)	17.7 (2.0)	
Gender				.115
Female	59 (47.2%)	86 (57.3%)	145 (52.7%)	
Male	66 (52.8%)	64 (42.7%)	130 (47.3%)	
Race				.003
White	121 (96.8%)	127 (84.7%)	248 (90.2%)	
Asian	4 (3.2%)	14 (9.3%)	18 (6.5%)	
Black	0 (0.0%)	5 (3.3%)	5 (1.8%)	
Other Race	0 (0.0%)	4 (2.7%)	4 (1.5%)	

Note. Descriptive statistics for participants who met inclusion criteria ($N = 275$). Continuous variables of age and education are represented as mean (standard deviation), with p values from t-tests between waves; categorical variables of gender and race as count (percentages) with p derived from Fisher's exact test between waves.

repeated our analyses with all excluded data re-included. Also, the analyses for cognitive control and emotionality were re-run without controlling for age, gender, educational attainment, and wave.

4. Results

We collected data from 275 older adults, with 125 participants being part of the 2014 wave and the remaining 150 being part of the 2020 wave. We excluded participants for not answering one or more *difficulty* questions, as scaled scores could not be generated ($N = 14$). For the hypothesis regarding the effect of emotionality in utilitarian reasoning (i.e., drawing from the dual process model), we additionally excluded participants that did not answer one or more follow-up questions regarding emotional elicitation.

4.1. Demographics

Descriptive statistics are provided in Table 3. Reflecting the research cohort from which the sample was derived, the study sample was highly educated ($M = 17.7$, $SD = 2.0$) and predominantly white (90.2%), with a mean age of 75 ($SD = 7.5$).

4.2. Analyses

The individual hypotheses tested were non-independent: some were predictions from the dual-process account, others from the 2D model. As our aim was to assess the relative support for either model in our experiment, all hypotheses were initially evaluated individually and reported as statistically significant at a p-value of .05. In sensitivity analyses (see Supplemental Material) with raw scores (1 or −1) rather than scaled scores, estimated coefficients, and p values differed only trivially (statistical significance of effects was unchanged).

4.2.1. Association among moral categories

Consistent with both the dual process model, which assumes that utilitarian judgments are not dissociated within themselves, and the 2D model of moral cognition, which postulates that judgments falling under the positive dimension reflect impartial concern for the greater good, we found a significant association between utilitarian judgments involving agent-centered permissions and those involving special obligations ($r = 0.16$, $p = .008$).

In line with the dual process model, which assumes that utilitarian judgments are not dissociated within themselves, and in contrast to the 2D model, which proposes that judgments under the positive dimension are dissociated from those under the negative dimension, our findings indicate that utilitarian judgments involving special obligations were significantly associated with those involving personal rights ($r = 0.26$, $p < .001$).

In contrast to the dual process model, which posits that utilitarian judgments are a unitary construct, and as hypothesized by the 2D model of moral cognition, which differentiates between judgments falling under the positive and negative dimension, we found that utilitarian judgments in dilemmas involving agent-centered permissions were not significantly associated with utilitarian judgments in personal rights dilemmas ($r = 0.07$, $p = .3$).

4.2.2. Utilitarian judgments and emotion elicitation

Fixed effects estimates of the random-intercept model are shown in Table 4. As predicted by the dual process model, greater emotional responses were associated with decreased endorsement of utilitarian decisions ($b = - 0.12$, $t(6254) = - 17.2$, $p < .001$). In addition, utilitarian judgments were positively associated with age ($b = 0.006$, $t(6254) = 3.6$, $p < .001$).

4.2.3. Utilitarian judgments and cognitive control

Contrary to the dual process model, utilitarian responses to dilemmas from all three categories (PR, AP, and SO) were not significantly associated with neuropsychological measures of cognitive control ($b = 0.17$, $t(154) = 3.74$, $p = .7$). However, utilitarian responses to dilemmas were positively associated with age ($b = 0.2$, $t(154) = 3.74$, $p = < .001$).

Table 4
Emotionality and utilitarian judgments.

Variable	Estimate	95% *CI*		*t*	*p*
		LL	UL		
(Intercept)	.50	.44	.56	18.1	<.001
Emotionality	−.12	−.13	−.10	−17.2	<.001
Age (years)	.006	.003	.009	3.6	<.001
Education (years)	−.003	−.02	.009	−.05	.6
Female gender	.03	−.02	.08	1.2	.28
Wave	−.02	−.07	.03	−.8	.4

Note. The table shows the estimates of fixed effects, considering random intercepts. The coefficient *Estimate* contains the intercept in the first row and the slopes (beta) in the following ones. *SE* represents the standard error, *LL* and *UL* the lower and upper limits of the confidence interval, *t* the *t*-test statistic, and *p* the probability value ($N = 261$).

4.2.4. Exploratory: neuroanatomical associations and utilitarian judgments

In responses to dilemmas from all three categories (PR, AP, and SO), utilitarian judgments were not associated with dorsolateral and ventromedial grey matter volumes, respectively ($p = .73$ and $p = .4$). Utilitarian responses to dilemmas were again positively associated with age ($p = < .001$).

5. Discussion

This study was designed to evaluate two conceptual models of utilitarian judgment in moral dilemmas encompassing three major domains of conflict between utilitarianism and common-sense morality: personal rights, agent-centered permissions, and special obligations. A particular contribution of this study is its inclusion of dilemmas involving special obligations, which have been under-addressed in empirical work on moral reasoning. In pre-registered hypotheses, we surmised that according to the dual process model proposed by Greene, utilitarian judgments across all three domains would be associated; whereas on the 2D model proposed by Kahane et al[3] utilitarian judgments concerning agent-centered permissions and special obligations would be associated with one another (reflecting the dimension of impartial beneficence) and dissociated with judgments concerning personal rights (reflecting the dimension of instrumental harm). Our findings do not comport fully with predictions based on the dual process or the 2D model. Instead, while we did confirm dissociation between utilitarian judgments involving agent-centered permissions and personal rights (as predicted by the 2D model), utilitarian judgments involving special obligations were *separately* associated both with judgments involving agent-centered permissions and with judgments involving personal rights.

We also assessed mechanistic claims of the dual process model regarding psychological and neural processes underlying utilitarian and counter-utilitarian moral judgment. As predicted by the dual process model, emotion elicitation was associated with counter-utilitarian judgment across dilemmas of all three domains; but contrary to this model, measures of cognitive control did not predict utilitarian judgment. In exploratory analyses, we also assessed brain-behavior associations with utilitarian judgment, although modeling studies published after our pre-registration indicate that our sample sizes were too small to detect such associations in healthy individuals [23].

Overall, our findings may be interpreted in terms of a modified synthesis of the dual process and 2D models as proposed by Greene and Kahane. Utilitarian judgments in dilemmas involving agent-centered permissions and involving personal rights each share variance with utilitarian judgments in dilemmas involving special obligations, but do not share variance with one another. Meanwhile, across all three domains, emotion elicitation is associated with counter-utilitarian judgment (Supplemental Tables 3–5). Given these findings, we suggest a revised two-dimensional model (Fig. 2) as a potential (though not exclusive) explanation of these findings.

In this revised model we suggest, as in our original hypotheses based on Kahane's 2D model, that utilitarian responses to dilemmas involving agent-centered permissions and special obligations are associated along a dimension of impartial beneficence. However, utilitarian responses to dilemmas involving special obligations and personal rights are also associated along an orthogonal dimension of harm. Here we do not characterize this as a dimension of "instrumental harm" because special obligations dilemmas do not generally involve harming relatives as a means of maximizing welfare. Instead, we propose understanding these two domains of utilitarian judgment as involving *acceptance of attributable harms*; in personal rights dilemmas the utilitarian agent is causally responsible for a utility-maximizing harm, while in special obligations dilemmas, the utilitarian agent allows a utility-maximizing harm to befall someone whom they are conventionally expected to protect.

What might be the underlying mechanism driving these utilitarian tendencies between special obligations and personal rights dilemmas would be a subject for further investigation. A promising explanation could be derived from intuition accounts which were studied across both positive and negative dimensions of utilitarianism [24]. More specifically, recent evidence suggests that intuition facilitates a refusal to inflict harm for the greater good specifically (instrumental harm versus impartial beneficence). One could

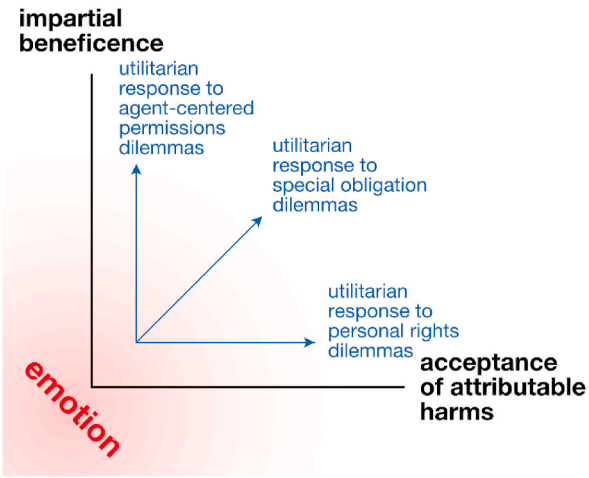

Fig. 2. Revised two-dimensional model of utilitarian judgment.

assume that the underlying mechanism explaining the shared variance between special obligations and personal rights categories, stems from the role of intuition. In the case of special obligation dilemmas, intuition would promote close ties that are not utility-maximizing. While Capraro's et al. [25] were centralized around the instrumental harm dimension only, our method and specifically the more in-depth investigation of the special obligation category could potentially explain our finding. Future studies exploring those assumptions could provide a clearer picture of whether intuition is indeed the connecting link between utilitarian tendencies in personal rights and special obligations dilemmas.

In our study across all three domains, utilitarian judgment was negatively associated with emotional elicitation. In conceptual literature, it has been surmised that utilitarian impartial beneficence is psychologically supported by emotional processes of universal sympathy [24]. While our findings do not exclude that specific claim about sympathy, overall the experience of emotion in these dilemmas has a counter-utilitarian influence, consistent with Greene's dual process model. We did not find support in our study for the other limb of this proposed dual process, in a hypothesized association between utilitarian judgment and cognitive control.

Age-related alterations in utilitarian judgments remain a topic to be further examined. In two prior studies comparing younger adult cohorts to older adult cohorts, reported by McNair et al. [26] and Huang et al. [27] older adults made fewer utilitarian judgments. In contrast, in the present study in an older adult cohort, age (considered as a continuous rather than categorical variable) is positively associated with utilitarian judgment. This positive association should be treated with caution as age was included only as a potential confounding covariate; associations between age and utilitarian judgment were not among our prespecified hypotheses. Recognizing this caveat, other potential explanations exist for the discrepancy between our incidental finding and these two prior studies. For instance, McNair and colleagues [26] recruited two non-overlapping cohorts of adults aged 18–25 and 55–81, and Huang and colleagues [27] recruited non-overlapping cohorts of adults aged 18–34 and 60–83. Group designs utilizing the ends of the adult age spectrum can increase statistical power but presume that the effect of age is consistent across different parts of the lifespan; in some domains of decision-making, U-shaped and inverted-U-shaped relationships with age are observed [28]. Also, all studies using cross-sectional designs to assess the influence of age are susceptible to cohort (generational) effects, but studies sampling distant ends of the age spectrum may be more susceptible to such uncontrolled differences between cohorts. These may account for differences in findings between study designs that treat age as a continuous variable and those that treat age as a categorical variable.

Also, in our study, non-utilitarian judgments in older adults were not explained by poorer performance in cognitive control, which has been hypothesized to explain age-related differences in moral judgment. Of note, this study utilized an existing cohort of healthy older adults to facilitate data collection. Participants within this cohort were verified as neurologically normal based on a multidisciplinary assessment including a neurological examination, in-person neuropsychological testing, and an informant interview; thus, our findings are not attributable to neurodegenerative or other pathologies associated with age. The competing models of utilitarianism evaluated in our study are presented as general rather than specific to any given life stage, so predictions made by these models should hold in this population as in other adult populations. At the same time, the generalizability of our proposed revised two-dimensional model still awaits confirmation in other demographic cohorts (including more racially, ethnically, and socioeconomically diverse cohorts, see below).

Our study is subject to limitations. First, there were some dissimilarities in data collection and broader context between the two waves. Responses collected during the 2020 COVID-19 pandemic differed systematically from responses collected in the 2014 distribution wave, likely reflecting the different context [21]. Our participant compensation also differed between data collection waves: participants in the 2014 wave received a gift card for their participation while 2020 participants did not. However, we note that there was not a significant wave effect on overall emotional elicitation.

In our study, via the use of moral dilemmas, we gained a clearer understanding of the psychological processes underlying utilitarian decisions across different moral categories. However, it is important to note that moral dilemmas may not always accurately reflect an individual's actual moral behavior in real-world contexts and are thus can be considered only a proxy for measuring morality. Additionally, different moral dilemmas may elicit different responses from different individuals, which can make it difficult to compare results across studies and populations [29].

Regarding our negative finding of no association between utilitarian judgment and cognitive control, our measurements of cognitive control (e.g., set shifting) may not have reflected the kinds of controlled executive processes that are involved in emotional context decision-making. Tasks that evaluate emotion regulation and reappraisal could be more sensitive in precisely eliciting differences in psychological processes and their respective influence on moral cognition. Finally, our study sample was largely white and highly educated, limiting the demographic generalizability of our findings. Moral judgments and intuitions have been shown to vary across cultural settings [30], so further work is needed to assess the revised two-dimensional model we have proposed among groups under-sampled in our cohort.

Author contribution statement

Rea Antoniou: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Heather Romero-Kornblum: Performed the experiments; Contributed reagents, materials, analysis tools or data.

J. Clayton Young; Michelle You; Joel H. Kramer: Contributed reagents, materials, analysis tools or data.

Katherine P. Rankin: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Winston Chiong: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Data availability statement

Data associated with this study has been deposited at https://osf.io/ym5wu.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: No potential competing interest was reported by the authors. This study was pre-registered using the Open Science Framework (https://osf.io/m425d). All the sufficient information to replicate the study is available. The data (https://osf.io/ym5wu) that support the findings of this study are openly available.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e17498.

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