Modelling Attitudes to Climate Change — An Order Effect and a Test Between Alternatives

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Abstract. Quantum-like models can be fruitfully used to model attitude change in a social context. Next steps require data, and higher dimensional models. Here, we discuss an exploratory study that demonstrates an order effect when three question sets about *Climate Beliefs*, *Political Affiliation* and *Attitudes Towards Science* are presented in different orders within a larger study of $n = 533$ subjects. A quantum-like model seems possible, and we propose a new experiment which could be used to test between three possible models for this scenario.

Keywords: attitude models, quantum decision theory, order effect

1 Modelling Attitude Change in a Social Context

How do the attitudes of a population vary according to its social makeup? Understanding the manner in which the social context of an individual will influence their attitudes is a difficult problem, but highly important. Privately held attitudes play a critical role in people's personal choices about their health, education, social groups, and housing, as well as the importance they attribute to national issues such as the environment, immigration and state security [1].

However, the way in which people express their attitudes is highly contextual. How will a given person think about 'global warming' vs 'climate change'? What if their daughter has just had her house flooded? Or if they are about to make a very large tax payment that includes a carbon component? People's attitudes are not static immutable objects, but change in response to persuasion [2], and attempts to maintain cognitive consistency [3]. We often express different attitudes in accordance with the social context we find ourselves in [4], and it is frequently the case that an explicitly expressed attitude is quite different from an internally held one [5]. As a further complication, many factors beyond the social setting itself are involved, from worldviews and cognitive styles [6–8], through to more traditionally studied factors such as education and demographics.

This complexity makes attitude change and opinion formation very difficult to model. While dual process models exist (such as the Elaboration Likelyhood Model (ELM) [9]; and the Heuristic-Systematic Model (HSM) [10]), this paper demonstrates a *framing effect* [11] which such models struggle to explain.

In the following section we will briefly introduce a model of attitude change that has been developed by two of us (Kitto & Boschetti) which uses a quantum-like approach. This model shows promise of unifying a number of cognitive variables into one consistent model of attitude change. Testing this model will require datasets which combine a number of variables which are not traditionally collected together, and for this reason, section 2 will introduce some preliminary results from an extensive survey recently collected in the Australian context. We will show that there is evidence to believe that a weak order effect is at work when subjects are asked about their attitudes to science, politics and climate change. This leads us to propose an experimental scenario which could test between a collection of classical, quantum and quantum-like models.

1.1 A Quantum-like Model of Attitude Change

A recent set of papers by the authors [12–14] have proposed a quantum-like model of attitude change, which allows for a natural explanation of framing effects. More details can be found in those papers, but in brief, this model makes use of the following key concepts.

The *cognitive state* $|A\rangle$ of an agent A is represented as a vector in a Hilbert space. This state is an objective feature of the model (i.e. it is a representation of how the agent currently thinks) but it cannot be objectively recovered (i.e. it can only be measured within a social context, or *framing* of an issue).

The *framing* of a social issue is represented by the choice of orthonormal basis states (e.g. $\{|0\rangle_p, |1\rangle_p\}$) which mathematically represent the cognitive state in that context. Within the particular frame (represented by p) used to denote an issue under consideration by the agent A, the state $|1\rangle_p$ denotes a case where the agent is in complete agreement with that interpretation of the issue, and $|0\rangle_p$ the case where they completely disagree. The current model utilises two types of frame; a *local* frame which represents the way an agent understands the issue under consideration, and *global* frames, which represent the combined attitudes of a particular social group (currently generated using a k-means style clustering algorithm [14]).

The *personality* of individual agents is modelled using two parameters which specify the psychological need that an agent A feels for *cognitive consistency*, $0 < w_i(A) < 1$, (i.e. making decisions that are highly correlated, or consistent, with their current cognitive state) and *social cohesion*, $0 < w_s(A) < 1$, (i.e. a bias towards making decisions that are similar to those of the social group to which A currently belongs, allowing A to 'fit in' with their current social context). These weights can range over a population of agents, providing a rough social parameterisation, and should match data about the society under consideration in the model. Thus, a society that values social conformity is likely to have more agents with a high $w_s(A)$ value, and one which values individualism would consist of more agents with a high $w_i(A)$, but other scenarios can be imagined. The model then considers the orientation of each agent's local frame to result from an attempt to navigate these two different drives, which may prove to compete with one another in the mind of the agent. Far more details about these parameters are provided in [13], but it is important to realise that they are not fixed. Introducing more frames will require more parameters (in order to model the time dynamics as they are introduced in (2)), and which ones to use must be a modelling decision. Is the model aiming to describe group cohesion vs individualism? In this case the above two parameters would be a logical choice. However, in a model that was aiming to describe attitudes to work then it might be more appropriate to use personality variables derivative from the "big-5" [15], or even something else.

Cognitive dissonance [3] suggests that agents who make decisions that are very different from their current cognitive states will experience a feeling of discomfort which may cause them to alter their cognitive state. We make use of *Binary entropy*, $H(P) \equiv -P\log_2 P - (1-P)\log_2(1-P)$, as a measure of this discomfort, where P is the probability of an agent making a decision given their current cognitive state and the context in which they are currently making that decision. Agents have a propensity (dependent upon their personality parameters) to align their cognitive states towards their current framing of a problem. Thus, agents are driven to update their cognitive state to align more closely with their decisions if they have a high consistency, and to update their individual framing of a problem to a closer alignment with the global frame to which they currently identify if they have a high need for social cohesion. Defining Θ as the angle between the agent's current state $|A\rangle$, and the $|1\rangle$ axis in their current global context, and θ as performing a similar function in their local frame, allows for the specification of an entropy measure for each agent [14]

$$H(|A\rangle, \theta, \Theta) = w_i(A)H_b(P(\theta)) + w_s(A)H_b(P(\Theta)). \tag{1}$$

Depending upon the social dynamics to be described the system is then updated in time, with agents making decisions, and then updating their cognitive states and individual framings of an issue to reflect the decisions made, their social context, and their personality variables [14].

If the decision was in the local frame, then only the cognitive state of the agent is updated (within the local frame). Thus, an agent who has made a decision within a certain framing of a problem will shift their state towards the decision ('yes' or 'no', represented by $|1\rangle_p$ and $|0\rangle_p$ respectively) that they made in the context (denoted by p). The size of this shift is defined as dependent upon two factors: (1) the personality profile of the agent (given in this case as w_i, as it represents the desire of an agent to align their cognitive state with their local frame); (2) the angle θ. Writing θ_0 for the angle between the agent's state and the $|0_p\rangle$ axis, and θ_1 for the angle between their state and the $|1_p\rangle$ axis, the new angle between the agent's state and the frame will become:

$$\text{if } A \text{ decides} \begin{cases} \text{to act: } \theta_1(|A\rangle_{t+1}, w(A)) = \theta_1(|A_t\rangle) \times w(A) \\ \text{not to act: } \theta_0(|A\rangle_{t+1}, w(A)) = \theta_0(|A_t\rangle) \times w(A) \end{cases} \tag{2}$$

where $w(A)$ depends upon the comfort of A with holding an attitude that is dissonant from their decision. Thus, for this update process $w(A) = w_i(A)$. Agents who make a decision that agrees with the attitude expressed in that frame will thus experience a rotation of their cognitive state by a certain distance dependent upon their personality towards the $|1_p\rangle$ axis (recall that θ is the distance between the $|1_p\rangle$ axis and the current state of the agent $|A\rangle$), and agents who disagree with that attitude will experience a rotation of their cognitive state in the opposite direction.

If the decision was made in the global frame, then both the cognitive state of the agent and their local frame are updated (with reference to their global frame). Thus, in addition to the update of the cognitive state that is represented in equation (2), the local frame of the agent will shift towards the global axis that represents the decision made by the agent. The amount by which the local frame shifts is given by an equivalent version of equation (2), thus the new angle between the local frame and the global frame is given by (2), but with $w(A) = w_s(A)$.

Over time, we expect the agents to self-organise towards a scenario where they are highly aligned within groups who all hold similar ideologies (or global frames). This process can be measured by the total entropy of the system, given by a summation of each agent's individual entropy

$$H = \sum_{i=1}^{N} H(|i\rangle, \theta_i, \Theta_i). \tag{3}$$

1.2 Alternative Quantum Inspired Models

We note that a few other models exist which could be used to model the same complex social scenarios. One example is a dynamic update semantics which uses non-commutative logics to describe changes in epistemic states in a society of agents [16–19]. These models take a formal approach to quantum logic, and so can be classified as pure classical and/or quantum models. Similarly, standard Quantum Decision Theory [20] can also be adapted to the modelling of attitude change. In section 3 we will consider the QQ-model due to Wang & Busemeyer [21] which like all of these models precisely matches standard quantum time evolution. This model provides a very strong test which must be satisfied by any quantum inspired model which matches the standard quantum axioms. This will lead us to the possibility of testing between classical, quantum, and the weaker quantum-like model presented above.

2 Attitudes to Climate Change, Science and Politics

Understanding how such a model will work in a realistic setting requires an extensive data set. We must be able to connect personality data with a Hilbert space representation of attitudes, and to then find a way in which to connect this space to measurement outcomes. In particular, the way in which order of presentation might change expressed attitudes must be studied, as this would start to provide an indication as to what the topology of attitude space might be. For example, should we expect the cognitive state of an individual to lie in one large n-dimensional Hilbert space? Or should attitudes lie in a set of incompatible subspaces and so exhibit order effects? Perhaps the spaces are more than incompatible, and cannot be framed in the same space at all? (As for example the momentum of an electron and its spin are modelled in two different Hilbert spaces.)

Many possible scenarios could be examined, but some have been attracting more interest than others of late, and so already have extensive datasets available. For example, the complex nexus of climate belief and worldviews has attracted considerable interest in recent years [7, 22, 6], and provides an interesting link between many variables that could prove useful to testing and extending this model. Of particular interest to the current model, a set of results have been obtained demonstrating a strong link between attitudes to climate change and the expressed worldview of a subject [7]. According to this *cultural cognition thesis*, personality types that can be classified as egalitarian and communitarian tend to worry about environmental risks such as climate change, while individualists tend to reject such claims of environmental risk (worrying instead about too much governmental control). Due to the current imperative to understand the attitudes of populations to climate change a large amount of data is being generated, and so many opportunities exist to create new models of attitude change in this setting. Here, we will discuss one recent survey which explored the attitudes held by the Australian public towards Climate Change, Science, and Politics. This section will introduce one particular result from that study, as it seems to hold promise for exhibiting quantum-like effects. Later sections will make explicit predictions about what a secondary follow up study would find.

2.1 An Australian 2013 Election Survey

The survey used was adapted from one that was originally developed to study attitudes towards environmental issues in the general public with the intention of helping scientists to better design communication and engagement processes [6]. That paper reports upon the full set of scales probing cognitive styles, political ideologies, worldviews and environmental attitudes etc. that were explored in the survey. The surveys were run at three different times: a) in 2011, b) in 2013, a few weeks before the Australian General Election and c) in 2013, a few weeks after the Australian General Election. The description and analysis of the 2011 survey can be found in [6], where each cognitive construct is described. A full analysis of the 2013 surveys is currently under way. In order to explore the ways in which framing a question might affect the resultant attitudes, the 2013 surveys were administered in 4 different orders of presentation.

Climate Beliefs: This question asked respondents “What best describes your thoughts about climate change?” with possible choices: “I don’t think that climate change is happening”, “I have no idea whether climate change is happening or not”, “I think that climate change is happening, but it’s a natural fluctuation in Earth’s temperatures”, “I think it is happening and I think that humans are largely causing it”. This question is taken from [22], where a record of responses over the last 4 years is discussed. Two other questions were also added to this section the survey in an attempt to gain further insight into the responses obtained: (1) "How important is the issue of climate change to you?" and (2) "How certain are you of your own position on climate change?" with responses ranging through {Very Unimportant, Moderately Important, Important, Important, Very Important} and {Extremely Uncertain, Uncertain, Moderately Certain, Certain, Extremely Certain} respectively.

Political Affiliation: "On the following scale, please indicate how you identify your political views" with choices: {Very liberal, Moderately liberal, Neither liberal nor conservative, Moderately conservative, Very conservative}.

Attitudes Towards Science: This is a construct of 5 questions with {Strongly disagree, Disagree, Neutral, Agree, Strongly agree} as available choices. The 5 questions in the construct were: (1) I strongly believe in science. (2) I believe science can provide solutions to environmental problems. (3) I do not believe science can provide solutions to social problems. (4) Science has caused more problems than it has resolved. (5) I am reluctant to use technology (including computers and models) to address complex natural and social problems.

While six different orders of presentation are possible for three sets of questions, it was decided that concentrating on just four orders provided the best compromise between increasing the size of the subject pools for each order, and exploring a variety of different possibilities:
Order A: {Climate Beliefs, Attitudes Towards Science, Political Affiliation},
Order B: {Attitudes Towards Science, Climate Beliefs, Political Affiliation},
Order C: {Political Affiliation, Attitudes Towards Science, Climate Beliefs},
Order D: {Attitudes Towards Science, Political Affiliation, Climate Beliefs}

Participants were recruited nationally within Australia using an on-line research only internet panel, administered by ORU, an online fieldwork company with QSOAP 'Gold Standard' and the new Global ISO 26362 standard accreditation. The online panel consisted of a group of community members who have explicitly agreed to take part in web-based surveys from time to time. In return they were offered a small non-cash incentives for completing the task, such as points towards shopping credits. The selection process utilised by ORU guarantees a sample that is strongly representative of the Australian population.

2.2 An Order Dependency for Climate Change Belief

All data analysis was performed using the R statistical environment [23]. The total number of respondents was 533, with $A_n = 148$ (27.7%), $B_n = 131$ (24.6%), $C_n = 132$ (24.8%), $D_n = 122$ (22.9%), as the breakdown into the various order categories. ORU split the demographics of the pools evenly across the four different orderings as far as was possible. Table 1 also compares the responses to the *Climate Beliefs* question with the fourth CSIRO national survey [22], and shows that the sampled respondents are generally representative of the larger Australian population, although with a slight bias away from the "I don't think that climate change is happening" response and towards "I have no idea whether climate change is happening or not".

Climate change is:	A	B	C	D	Total	Study	CSIRO
not happening	8	10	2	0	20	3.8%	7.6%
	(1.04)	(2.29)	(-1.33)	(-2.14)			
I don't know	15	12	10	13	50	9.4%	6.3%
	(0.30)	(-0.08)	(-0.68)	(0.46)			
happening but natural	60	53	47	43	203	38.1%	38.8%
	(0.48)	(0.44)	(-0.46)	(-0.51)			
happening & human caused	65	56	73	66	260	48.8%	47.3%
	(-0.85)	(-0.99)	(1.07)	(0.84)			
Total	148	131	132	122	533	(n=533)	(n=5219)

Table 1. The contingency table for the question: *What best describes your thoughts about climate change?* showing order of presentation in columns, response obtained across rows, and Pearson residuals listed underneath in parentheses. The last two columns compare responses to the Climate Beliefs question in the current study with the fourth CSIRO national survey of Australian attitudes to Climate Change [22].

Questions exhibiting order dependencies were found using chi-square tests of independence (*Climate Beliefs*, *Political Affiliation*, and *Attitudes to Science*). Each separate test of independence involved the four orders and the relevant response category variables. Three significant chi-square results were obtained: two in the *Climate Beliefs* scale: "What best decribes your thoughts about climate change?" ($\chi^2(9, N = 533) = 17.89$, p=0.036, Cramers's V = .105) and "How important is the issue of climate change to you?" ($\chi^2(12, N = 533) = 22.23$, p=0.035, Cramer's V = .118); as well as one question in the *Attitudes towards science* scale: "I do not believe science can provide solutions to social problems" ($\chi^2(12, N = 533) = 21.07$, p=0.049, Cramer's V = .115).

Fully understanding these significant rejections of independence is difficult, as many factors are involved. However, considering the dominant residuals reveals a very interesting pattern. Firstly, we note that a strong contribution to the significant χ^2 values comes from the people who express the view that climate change is not happening. Indeed, the top row of Table 1 is responsible for 70.8% of the obtained value, with a further 19.9% arising from those who believe that climate change is happening and human caused. A disproportionate amount of the variance depends upon a comparatively small subset of the population (n=20, or 3.8%), and three of the order categories for this response had expected values just under 5 ($A_e = 5.55, B_e = 4.92, C_e = 4.95, D_e = 4.58$, note that this table still satisfies the standard assumption that 80% or more of the expected counts should be larger than 5). This means that larger pool of denialists is required before we can feel confident in declaring that we have indeed found an order dependence for this question, however, paying careful attention to these two response categories reveals an interesting pattern of behaviour that is somewhat masked by the dominant effect of the top row. While orders A-B show a decrease from the expected value of climate 'believers', C-D show a slight increase in the same subset. A similar but reversed pattern occurs for those who do not believe that climate change is occurring. Reconsidering the question ordering reveals a significant difference between these two categories; in C-D the *Climate Beliefs* questions were asked last. Furthermore, turning our attention to the third row of Table 1 (which lists the responses of those who think that climate change is happening, but just a natural fluctuation of the Earth's temperatures), we see a set of residuals that exhibit the same $\{+,+,-,-\}$ signature, although of a much smaller magnitude. This suggests that a merger of both denialist positions (i.e. rows 1 and 3) could lead to a test for independence that was less dependent upon the extreme denialist position. This aggregation leads to a $\chi^2(6, N = 533) = 8.11$ which is not significant at the 5% level (p=0.230), however, the same $\{+,+,-,-\}$ signature persists across the residuals. The other two significant results did not yield this intriguing signature.

It appears that framing a question about whether a subject believes in climate change within a political *and* scientific context is having a weak impact upon the response obtained. This framing results in a shift of subject responses towards belief, with climate change 'denialists' less likely to deny, and 'believers' more likely to believe that anthropogenic climate change is happening. Interestingly, framing climate belief questions in just a scientific context appears to have the opposite impact (as exhibited by order group B).

We propose an interaction between the *Political Affiliation* and *Attitudes Towards Science* is required, which would, when the two sets of questions are combined, result in a slight bias towards belief in anthropogenic climate change. A higher dimensional version of the model discussed in section 1.1 can describe this effect, but alternative approaches are possible.

One such alternative model is based upon Quantum Decision Theory (QDT) [20] and a recent refinement called the QQ model [21]. Both models predict that incompatibility between questions results when answering one question reframes the perspective from which a subject will view the next one. Thus, both models would predict that the space in which people make decisions about climate change expands in orders C-D, which moves them towards framing the question in a different way (and so sometimes giving a different response). The model proposed by Wang & Busemeyer [21] creates a very strong condition that must be satisfied by quantum models. However, as a pure quantum model, it is highly restrictive, and would rule out the time update proposed in equation (2) above. Unfortunately, this model also requires that questions be asked consecutively, with no intervening questions or information provided, which makes the application of this test to surveys such as that discussed in section 2 difficult. In what follows we will briefly introduce the QQ model, before attempting to adapt the current survey to a form where it might be applied in a three way scenario that could eventually test between classical, pure quantum, and quantum-like models of attitude change.

3 An Quantum Approach: the QQ Model

Denoting the projector representing the probability of responding yes to question Q_A as $\mathbf{P}_{Ay}$ (similarly that of responding no as $\mathbf{P}_{An}$) allows for an examination of how different sets of questions affect a cognitive state in some larger attitude space (let us assume this is a Hilbert space). According to the QQ Model proposed by Wang & Busemeyer [21], a necessary condition for producing order effects in a full quantum model is that a set of questions (for now call them Q_A and Q_B) be non-commuting: $\mathbf{P}_{Ay}\mathbf{P}_{Bn} \neq \mathbf{P}_{Bn}\mathbf{P}_{Ay}$. This reflects the manner in which asking question Q_A creates a *comparative context* for further questions (in this case question Q_B). The first question (in this case Q_A) is denoted as a *non-comparative context*. This allows for the definition of the comparative context in which a question (say Q_B) was asked:

$$TP_{Q_B} - P(By) = 2 \cdot P(AyBy) - 2\theta_{AB}\sqrt{P(By)} \cdot \sqrt{P(Ay)}, \tag{4}$$

where $P(\dots)$ is the probability of the given response (yes or no) to the question denoted (Q_A or Q_B), $TP_B = P(AyBy) + P(AnBy)$ is the probability of answering yes to question Q_B in the comparative context of question Q_A, and θ_{AB} is the *similarity* between the two questions as represented by their projections:

$$\theta_{AB} = \frac{P(AyBy) - TP_{Q_B} + P(By)}{2\sqrt{P(By)} \cdot \sqrt{P(Ay)}}. \tag{5}$$

4 A Three-way Scenario

The data from Table 1 suggests that a dual comparative context of *Attitudes to science* and *Political affiliation* shifts subjects towards a higher rate of belief in climate change, across both denialist and belief positions.

Wang & Busemeyer rightly claim that the QQ model makes strong predictions for a three question scenario [21]. For example, the similarity parameters for three consecutive questions A, B and C should satisfy a triangle equality:

$$\theta_{AB} + \theta_{BC} = \theta_{AC}. \tag{6}$$

This is a very interesting requirement, and it allows for a strong test to see if a system is exhibiting the fully quantum behaviour predicted by the QQ model.

We propose that a strong test of whether the QQ model applies to attitude change (in particular attitudes to climate change) could be constructed by taking three questions from the above survey and asking them consecutively. We propose that three questions from the above survey have a high likelyhood of revealing a significant order effect in the protocol required by the QQ model:

A: What best describes your thoughts about climate change?
B: Please indicate how you identify your political views.
C: I do not believe science can provide solutions to social problems.

If asking A, B, and C in the six possible orders reveals a significant order effect then applying the QQ model would enable a determination of whether this was due to quantum behaviour. Indeed, if the similarity measure between each of these questions satisfies (6) then this would be a very strong proof that the system was exhibiting the quantum behaviour expected by the QQ model, severely restricting the form of time evolution exhibited by this system.

However, it is important to realise that the quantum-like behaviour exhibited by the QQ model is of a purely quantum form, and that there is no *a priori* reason why this system might not violate classical probability (hence reveal quantum-like behaviour), but fail to satisfy the QQ model. Indeed, the time evolution model proposed in [14] (and briefly introduced in section 1.1) is not of a standard quantum form, although it is unitary in nature [12]. We would not expect a system that exhibits this behaviour to satisfy the QQ model.

This allows for a compelling test to be performed that would allow for a determination of what type of mathematical model this system of attitudes actually satisfy. Thus, the experiment proposed above would provide a straightforward way of determining whether the system of interrelating attitudes exemplified by climate change belief, attitudes towards science, and political affiliation is quantum, quantum-like or classical in nature.

4.1 Limitations of the QQ Model

While the QQ model provides a very powerful battery of tests that can be used to determine whether a system is exhibiting quantum behaviour, it does face some limitations. Firstly, and perhaps most pertinent to the present study, it is not particularly relevant to general survey scenarios. These usually consist of scales with multiple questions, and multiple responses, and so a direct application of the QQ model is generally not possible for such real world scenarios. Secondly, satisfaction of the QQ model requires that the system under consideration exhibit what we might term exact quantum behaviour. This is a very strong requirement, and many quantum-like models have been proposed in the QI community that do not have such a pure quantum form. The attitude model discussed above is just one such example, but Khrennikov also proposes models unlikely to satisfy this requirement (see e.g. [24]). A further battery of tests needs to be created, and perhaps most usefully, we envisage a hierarchy of tests that could be applied to a system exhibiting contextual behaviour, with an associated classification of the system as quantum, quantum-like and classical. Finally, we note that even a fully quantum system might not satisfy the QQ model if the associated subspaces cannot be represented in one space (as is the case with momentum and spin in a standard quantum system). We anticipate that this is highly likely to occur in many complex contextual systems, and so it is important that the model only be applied in the correct circumstances.

5 Conclusions

Even small effects such as the one discussed in this paper could prove highly significant in the modern world (e.g. in a very close election that has a focus upon the issue of climate change). Politicians already know that governments rise or fall on their ability to sell highly emotive issues such as climate change within the 'right' context. Indeed, Australian elections since the mid-1970's have always been won by a margin[4] of less than 10%, which means that an effect of the size reported here (slightly over 10%) would prove significant for any election fought on the issue of climate change. We note that the last two Australian federal elections have indeed featured climate change policy as a key dividing issue between the two major parties, and this issue is likely to become more controversial as the effects of climate change become more severe. However, few techniques exist for analysing the way in which public issues are framed in public debates. This means that the signature discovered in the residuals analysis performed in section 2.2 offers a intriguing statistical approach that merits further investigation in its own right.

It is essential that quantum inspired models become more applicable to real modelling problems. Many of the tests and models so far proposed have considered simple datasets with a small number of incompatible measurements, or toy models in low dimensional spaces. However, the rise of big data opens up many opportunities, and with a new battery of complex models and tests that can be applied to real world datasets and problems we would find many more opportunities to progress.

This paper has provided an initial discussion of a real world dataset that exhibits an interesting order effect. This exploratory data was collected in the hope that it could be used to prime a quantum-like model of attitude change in a social context, and indeed it provides a baseline step towards this goal. Attempting to understand the order effect obtained by performing a standard χ^2 analysis has left us with a proposal for a strong experimental test, which could determine if the time evolution that was exhibited by this system should be considered quantum (as is exemplified by the QQ model), quantum like, or classical in nature. Future work will be devoted to performing this experiment and analysing its results.

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