Rethinking Clinical Decision Support Alerts from Behavioural Economics Perspectives

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Rethinking Clinical Decision Support Alerts from Behavioural Economics Perspectives

Short Paper

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Abstract

Clinical decision support (CDS) alerts can enhance clinicians’ decision-making, yet they are frequently ignored or overridden—highlighting challenges in designing alerts. Nevertheless, current design guidelines for CDS alerts often fail to consider the intricacies in human decision-making, limiting their ability to inform alert designs. This study aims to address this limitation by adopting behavioural economics (BE), a dominant behavioural decision theory, to explain how humans make decisions and why they fail or succeed in their decision-making. Specifically, it utilises the MINDSPACE framework, underpinned by BE, to help design CDS alerts with considerations of human decision-making behaviour. This research-in-progress paper reports the conceptual stage of the study and proposes preliminary design guidelines for CDS alerts informed by this framework. The paper contributes to the body of knowledge in designing CDS alerts and provides the basis for the study’s exploratory stage of such alerts from various stakeholders’ perspectives.

Keywords: Clinical decision support, alerts, behavioural economics, MINDSPACE.

Introduction

Clinical decision support (CDS) aims to enhance clinicians’ decision-making. Alerts are a widely used CDS intervention type that aims to notify clinicians of a departure from recommended clinical practice to prevent potential errors or omissions, to support patient safety and quality of care. Evidence, however, indicates that alerts are frequently ignored or overridden in various settings, including ambulatory (Isaac et al. 2009), outpatient (Nanji et al. 2014), and inpatient settings (Nanji et al. 2018). Although many alert overrides are clinically justified (Olakotan and Yusof 2021), mounting evidence points to pressing issues such as alert fatigue (Stultz and Nahata 2014), workflow disruption (van der Sijs et al. 2006), and inappropriate or even habitual overrides (Baysari et al. 2017; Nanji et al. 2018), that influence clinicians’ responses to alerts. Nevertheless, alerts are often used to influence clinicians’ behaviour (Powers et al. 2018), such as prescribing behaviour (Schedlbauer et al. 2009), despite growing concerns around their design (e.g., Horsky et al. 2012).

Over the years, attempts to address these concerns have resulted in several design recommendations for alerts. These recommendations are based on design principles that are primarily informed by usability (e.g., Marcilly et al. 2018) and human factors engineering (e.g., Russ et al. 2014). While both usability and human factors engineering touch upon human cognition and decision-making (e.g., Wickens et al. 1998), there is little evidence that the complexities of human decision-making behaviour have been fully translated into existing design principles (e.g., Nielsen 1994; Zachariah et al. 2011). A closer analysis of these principles
reveals that they only recognize the limitations of human cognition (e.g., the working memory’s limited capacity) but do not consider the intricacies in human decisions (e.g., how humans make decisions and why they fail or succeed in their decision-making). As a result, these principles are limited in delineating human decision-making behaviour. This limitation, in turn, undermines these principles’ ability to inform the design of CDS interventions – such as alerts – that aim to improve clinical decisions. Evidence indicates that humans are not rational decision-makers, and their decision-making behaviour is often based on heuristics and subject to cognitive biases (Kahneman et al. 1982). This behaviour can be explained and shaped by insights from behavioural decision theory.

Consequently, this study adopts a dominant behavioural decision theory, namely behavioural economics (BE), as the theoretical foundation to address this limitation. Specifically, the study utilises the MINDSPACE framework for behaviour change, which offers nine effects that “have been repeatedly found to have strong impacts” on human behaviour (Dolan et al. 2012, p. 265). In doing so, the study follows two stages. The first stage involves conducting conceptual exploration into the merits of the MINDSPACE framework for designing CDS alerts and proposes design guidelines informed by this framework for CDS alerts. The second stage involves adopting a qualitative approach to investigate the merits of this framework for designing CDS alerts from the perspectives of Medical Officers, Pharmacists, Nurses and Midwives, and Health Informaticians.

The first stage contributes to the body of knowledge in designing CDS alerts by delineating (i) how to design alerts with consideration of humans’ decision-making behaviour, and (ii) why such consideration can improve the efficacy of alerts. The second stage, once completed, will enable practitioners such as health informaticians to (i) rethink alert designs from a behavioural perspective, and (ii) consider adopting this perspective when designing various features of alerts.

This research-in-progress paper reports the first stage of the study and is organised as follow: Research Background examines the limitation of the existing principles to inform alert designs. Theoretical Foundation presents the adopted theoretical lens and justifies the chosen framework for the study. Research Design describes how the chosen framework helps derive design guidelines for CDS alerts and how the study sets to investigate its merits from various perspectives. Finally, Discussion and Conclusion presents some crucial points to consider when using these guidelines and offers some directions for future works.

**Research Background**

As stated earlier, the existing design recommendations for alerts are mostly underpinned by principles which are informed by the fields of usability and human factors engineering (e.g., Marcilly et al. 2018; Russ et al. 2014). However, a closer analysis of these principles reveals a crucial limitation. That is, neither set of principles recognise the intricacies of human decision-making behaviour. Instead, they only recognise and address the limitations of human cognition.

For example, two of the most cited sets of principles in usability (e.g., Nielsen 1994; Shneiderman et al. 1986) only acknowledge the working memory’s limitations in processing and retaining information. Evidence shows that the working memory can hold only 7±2 elements of new information (Miller 1956) and is capable of processing 4±1 elements at any given time (Cowan 2001). In line with this, Nielsen’s ten usability heuristics only address this limitation with two points. First, using information that the user recognises in order to reduce the cognitive effort required for recalling information (Heuristic #6: Recognition rather than recall). Second, maintaining consistency to improve learnability, thereby reducing the cognitive load associated with learning something new (Heuristic #9: Consistency and standards). Similarly, in Shneiderman et al. (1986), the eight golden rules suggest avoiding interfaces where the user must remember information from one display and then use it on another (Rule #8: Reduce short-term memory load).

The same is also true for principles informed by human factors engineering (e.g., Zachariah et al. 2011; Russ et al. 2014). For instance, Zachariah et al. (2011) eighth principle (Proximity of task components being displayed) points to spatial and temporal proximity of informational components for decision-making (e.g., using infobuttons within alerts). In essence, this principle highlights the working memory’s limitations in retaining and processing spatially or temporally distributed information. Evidence indicates that understanding informational components, which are less intelligible when distributed, requires the individual to mentally integrate these components (Sweller et al. 2019). In such cases, the individual must retain some components while processing or searching for others. As a result, their working memory resources are diverted from learning information (schema formation) to an unnecessary mental integration of information: an effect known as Split-attention (Tarmizi and Sweller 1988).
The above limitation is particularly interesting because the fields of usability and human factors engineering recognise both the limitations in human cognition and the intricacies in human decision-making behaviour. The latter, however, is yet to be effectively translated into a set of principles for designing CDS alerts. This is especially true for human factors engineering. Authoritative works in this area (e.g., Wickens et al. 1998) present an in-depth understanding of human decision-making behaviour to the extent they acknowledge that humans are predictably irrational, often making decisions on heuristics subject to biases and errors. Advocates for usability also have a similar understanding. For instance, the Nielsen Norman Group acknowledges that humans’ decisions are not always rational and can be subject to cognitive biases (Harley 2016). Interestingly, both fields cite seminal works in behavioural economics, such as Tversky and Kahneman (1974). Nevertheless, the core concepts from these works are not fully utilised in the resultant design principles. In this study, we utilise insights from BE to address this limitation.

**Theoretical Foundation**

**Behavioural Economics (BE)**

BE is a collection of decision-making theories and principles describing how and why humans make decisions. It is a dominant form of behavioural decision theory (Fox 2015), which unlike economic decision theory that considers humans with perfect rationality, views humans with bounded rationality (Simon 1955) and acknowledges the effects that hinder rational decision-making behaviour. BE covers different aspects of decision-making ranging from crucial theories in human decision-making: the dual-process theory of decision-making cognition (Kahneman 2011) and the prospect theory (Kahneman and Tversky 1979) to collections of judgment heuristics and cognitive biases influencing decision-making (e.g., Tversky and Kahneman 1974) and sets of interventions such as debiasing to mitigate repercussions of cognitive biases (e.g., Fischhoff 1982) and nudging to subtly shape behaviour in a predictable way (e.g., Thaler and Sunstein 2008). Arnott and Gao (2019) provided a chronological account of early and contemporary BE and discussed its potential uses in Information Systems (IS) research, particularly those involving decision support.

Despite the repeated calls for using BE in IS (see Goes 2013), IS research has been slow in adopting BE as a reference theory (Arnott and Gao 2022). This is partly attributable to the sheer volume of BE principles, making it difficult to identify effects that strongly influence human decision-making behaviour. Additionally, a considerable portion of interventions informed by BE seek to influence human decisions through changing human minds (e.g., altering intentions with persuasive information) (Sheeran 2002) or changing their contexts (e.g., altering choice environments through nudges) (Thaler and Sunstein 2008). However, evidence indicates that human behaviour is not only influenced by either changing human cognition or context. It is often shaped by both the reflective processing of cognitive cues and the automatic responses to contexts in which we operate (see Vlaev et al. 2016). Therefore, identifying a collection of behavioural effects that joins the cognitive with contextual cues can contribute to the interventions’ efficacy. Such a collection is presented in the MINDSPACE framework for behaviour change (see Dolan et al. 2012 for the inner workings of the framework).

**The MINDSPACE Framework**

The MINDSPACE framework (Dolan et al. 2012) is a well-established framework for changing human behaviour (e.g., decision-making behaviour). MINDSPACE is the mnemonic for: Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitment, and Ego. These effects strike a balance between the automatic and reflective processing of the contextual and cognitive cues, respectively. Of these effects, five explain the automatic processes of human behaviour (N, D, S, P, A). The remaining four (M, I, C, E) draw more on the reflective processes (Dolan et al. 2010). The framework was initially developed to provide policymakers with evidence in designing and implementing behaviour change interventions that utilise insights from BE (Institute for Government 2010). It is underpinned by BE’s core principles and has been adopted in various domains, including healthcare (Ogdie and Asch 2020), and informed different intervention designs such as a prescribing tool in this domain (King et al. 2014). Each effect in this framework is briefly described below, and more detailed descriptions are provided in Dolan et al. (2012, p. 266 - 272).

- **Messenger:** This effect focuses on the source of information and our feelings towards that source. The weight we give to information depends on the automatic reactions we have to the perceived authority of the source of that information. Additionally, we are more likely to consider information from sources that we perceive as trustworthy, particularly if that information is tailored to us.
• **Incentives**: This effect focuses on human response to incentives. Our responses to incentives are often influenced by impulsive yet predictable mental shortcuts. It is strongly linked to our tendency for loss aversion – as we prefer avoiding losses more than we prefer gains of the equivalent amount.

• **Norms**: This effect concentrates on conformity. What others do can be a powerful driver of our behaviour because of the innate desire to belong and seek affiliation with others. When a norm is desirable, it should be highlighted and reinforced (e.g., through social comparison).

• **Defaults**: This effect leverages human tendency for inaction. We tend to prefer the current state of affairs (Status quo bias) because losing that state may loom larger than gaining from the alternative state. Defaults, therefore, refer to an option that will come to force if no active choice is made. The critical feature of default options is influencing human behaviour without restricting their choice.

• **Salience**: Salience leverages our tendency for noticing things that stand out, particularly when relevant to us. We have limited cognitive resources, and our choices tend to be affected by anything that falls within our limited attention span. Consequently, we make decisions based on the most salient points.

• **Priming**: Priming focuses on subliminal effects on behaviour. We are often influenced by subconscious cues, and our subsequent behaviour can be altered if we are first exposed to perceptual stimuli such as sights and smells.

• **Affect**: Affect leverages underlying feelings and emotions. Emotions are powerful automatic forces in decision-making and can forcefully influence our actions. Nevertheless, we often underestimate how visceral factors can affect our judgement or behaviour (see Hot–cold empathy gap).

• **Commitments**: Commitments leverage our desire for consistency, particularly with our public promises. We tend to procrastinate taking decisions that are likely in our long-term interest (e.g., due to will-power weakness) and use commitment devices to control procrastination and achieve long-term goals. Increasing the cost of commitment (e.g., by making it public) can make it more effective.

• **Ego**: Ego also leverages our desire for consistency, particularly for self-image and social status. We tend to act in ways that make us feel better about ourselves and maintain a positive self-image in public.

While these effects are viewed as “the most robust effects on human behaviour” (Dolan et al. 2012, p. 273), only a few effects are individually used in alert designs (e.g., Hillstrom et al. 2021). To the best of our knowledge, this study is the first of its kind that investigates the merits of these effects collectively for designing CDS alerts under the MINDSPACE framework.

**Research Design**

As stated, alerts are frequently ignored or overridden for reasons such as alert fatigue and workflow disruption, highlighting the need for improvements in designing alerts. This is partly attributable to the limitations of the existing design principles in delineating human decision-making behaviour, which undermine their ability to inform alerts as a CDS intervention to support clinical decisions. We propose to utilise the MINDSPACE framework to address this limitation. In so doing, we adopt an exploratory qualitative approach to investigate the merits of each effect in this framework for designing CDS alerts.

In the first stage, we conducted a comprehensive scoping review of behavioural effects that informed CDS alert designs. The review covered the extant literature on effects within and outside the MINDSPACE framework, such as Priming (Hillstrom et al. 2021) and Injunctive Norms (Meeker et al. 2016). We then systematically examined each effect in terms of its applications and efficacy to derive design guidelines for alerts (Table 1). An example of effects with high efficacy in CDS alert designs that achieved statistically significant outcomes is presented by Meeker et al. (2016). The targeted alert focuses on prescribing behaviour for high-risk medicines based on the APINCHS classification by the Australian Commission of Safety and Quality in Health Care (ACSQHC) (ACSQHC 2022). The targeted medicine is antibiotics in line with the ACSQHC’s Antimicrobial stewardship Clinical Care Standard released in 2020.

In the next stage, we set to investigate the merits of each effect for designing prescribing alerts from various perspectives. To do so, we plan to conduct semi-structured interviews with different participant cohorts, comprising: (i) Medical Officers who prescribe the targeted medicine, (ii) Pharmacists who dispense the same medicine, (iii) Nurses and Midwives who administer that medicine, and (iv) Health Informaticians.
who design alerts for the targeted medicine. The participants represent both the user (Medical Officers, Pharmacists, Nurses and Midwives) and designer groups (Health Informaticians) of alerts to compare and contrast their views on each effect. A minimum of 24 participants (six in each cohort) with a balance in expertise and gender will be recruited using two non-probabilistic sampling strategies (i.e., Purposive; Snowball samplings). All participants will be recruited from a large public hospital in Melbourne, Australia (the Participating Organisation).

The data collection instrument has been derived from the literature containing open-ended questions on each effect based on the MINDSPACE framework. It comprises 17 questions distributed across two sections. The first section explores each participant’s experience (four questions) and expectations of alerts (four questions). These questions are similar for all participants. The second section explores the merits of each effect in the MINDSPACE framework (nine questions). The questions in this section are worded specifically for each participant cohort to capture their perceptions of each effect. Data collection will occur between April and July 2022 after finalising approval from the Participating Organisation’s Ethics Committee. The interviews will be recorded upon participants’ consent. The interview recordings will be anonymised and transcribed verbatim. For data analysis, we take a reflexive approach to thematic analysis and adopt the framework suggested by Braun and Clarke (2006) to guide the analytical process within NVivo 12 environment. The analysis outcome will help refine the proposed guidelines by taking into consideration both the user and designer groups’ perspectives.

**The Proposed Design Guidelines**

Table 1 presents the proposed design guidelines for prescribing alerts. These guidelines are informed by the MINDSPACE framework, our scoping literature review of behavioural effects used in CDS alert designs, and the process of abductive reasoning (Fann 1970; Takeda et al. 1990). The proposed guidelines are applicable to three features of alerts: (i) alert content (what information is communicated), (ii) alert display (how information is displayed), and (iii) alert function (which functions the alert is expected to perform).

<table>
<thead>
<tr>
<th>Effects</th>
<th>Design guidelines</th>
<th>Design rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Messenger</strong></td>
<td><strong>Alert content:</strong> Include vital information (e.g., the risks associated with a high-risk medicine) from an authoritative and trustworthy source.</td>
<td>Using a source of information that is perceived as highly authoritative and trustworthy generates compliant behaviour.</td>
</tr>
<tr>
<td><strong>Incentives</strong></td>
<td><strong>Alert function:</strong> Allow comparison between high and low performers and incentivise for appropriate prescribing performance.</td>
<td>The tendency for loss aversion (e.g., the fear of getting no incentives) can lead to better prescribing performance.</td>
</tr>
<tr>
<td><strong>Norms</strong></td>
<td><strong>Alert function:</strong> Allow the clinician to quickly compare his/her prescribing performance with peers.</td>
<td>A visible comparative figure such as the percentage of conforming peers can influence the clinician’s behaviour.</td>
</tr>
<tr>
<td><strong>Defaults</strong></td>
<td><strong>Alert function:</strong> Set the desired prescribing decision (e.g., stop prescription) as the pre-selected choice without restricting other choices (e.g., start or maintain prescription).</td>
<td>The tendency for inaction can lead to choosing the pre-selected choice (e.g., stop prescription) that is in line with the desired prescribing behaviour.</td>
</tr>
<tr>
<td><strong>Salience</strong></td>
<td><strong>Alert display:</strong> Present vital information elements (e.g., associated risks) as noticeable and relevant to the prescribing clinician.</td>
<td>The tendency for observing things that stand out can draw more attention towards the desired prescribing decisions.</td>
</tr>
<tr>
<td><strong>Priming</strong></td>
<td><strong>Alert display:</strong> Use perceptual stimuli (e.g., meaningful colour scheme) to shape decisions according to the desired prescribing behaviour.</td>
<td>Perceptual stimuli, such as text or buttons in green colour, can subconsciously guide decisions toward the desired outcome.</td>
</tr>
<tr>
<td><strong>Affect</strong></td>
<td><strong>Alert content:</strong> Frame information to evoke strong emotions (e.g., against repercussions for inappropriate prescription).</td>
<td>Emotional associations can influence the clinician’s decision toward a desired prescribing outcome.</td>
</tr>
<tr>
<td><strong>Commitments</strong></td>
<td><strong>Alert function:</strong> Incorporate a commitment device enabling the prescribing clinician to achieve the desired goal (e.g., deprescription).</td>
<td>The very act of commitment can increase the likelihood of achieving the desired goal, especially when the commitment is public.</td>
</tr>
<tr>
<td><strong>Ego</strong></td>
<td><strong>Alert function:</strong> Present the prescriber’s performance against his/her peers for self-evaluation of public image.</td>
<td>The desire for maintaining a positive self-image and social status can shape prescribing behaviour.</td>
</tr>
</tbody>
</table>

**Table 1. Design Guidelines Informed by the MINDSPACE Framework for Alert Designs**
Discussion and Conclusion

We utilised the MINDSPACE framework to inform the design guidelines for CDS alerts with consideration to both the contextual and cognitive influences on human decision-making behaviour. We do not suggest that the proposed guidelines are prescriptive. On the contrary, these guidelines only exemplify how a specific effect can inform alert designs. For instance, Messenger focuses on the source of information and its perceived authority. We propose to leverage this effect in alert content (i.e., what information is communicated) by communicating vital information such as the risks associated with the high-risk medicine to influence prescribing behaviour. Others may leverage this effect in a different feature such as alert function (i.e., which functions the alert is expected to perform) to communicate other information (e.g., feedback on prescribing behaviour) from an authoritative source (e.g., hospital administration). In any case, the crucial point to consider is that “we are heavily influenced by who communicates information to us” (Dolan et al. 2012, p. 266) and how to leverage this effect for designing a particular feature of alerts. The same holds for other effects.

Another point to consider is how an effect engages the decision-maker’s reflective or automatic processes. In the above example, Messenger leverages the clinician’s reflective process for considering vital information (e.g., associated risks) before deciding to prescribe the high-risk medicine. Other effects such as Salience can leverage the clinician’s automatic process in noticing prominent things. In such cases, we propose using Salience in alert display (i.e., how information is displayed) to make vital information such as associated risks prominent and noticeable. This way, the clinician can automatically notice that information before s/he decides to prescribe the high-risk medicine. Others may utilise effects such as Priming to engage automatic responses to perceptual stimuli. In such cases, a meaningful colour scheme for display elements such as buttons or texts (e.g., red texts highlighting the associated risks) can send a subliminal cue to the clinician to consider that information before prescribing the medicine. Either way, it is crucial to consider how to target reflective or automatic processes with suitable effects when designing alerts.

This paper presented a conceptual exploration into the merits of the MINDSPACE framework and proposed preliminary guidelines for designing CDS alerts. The next stage involves collecting and analysing empirical data to investigate the utility of the proposed guidelines. Future works will determine how the user and designer groups view these guidelines and the effects that informed them, especially their impacts on pressing issues such as alert fatigue and workflow disruption. The perspective of the user group with different levels of expertise (e.g., novice and senior medical officers) is of particular interest and will help refine these guidelines accordingly. Future works will also determine how joining effects are viewed by the user and designer groups. Of particular interest is their perspectives on the combination of effects that trigger an automatic response with effects requiring a reflective process. An example is joining Salience as an attentional device, with Messenger as a means to communicate vital information (e.g., associated risks). Joining these two effects can direct the user’s attention to the associated risks for more thoughtful consideration before prescribing the high-risk medicine. Comparing and contrasting the user and designer groups’ perspectives on such combinations can help further refine these guidelines.

In its first stage, the study contributes to theory and the body of knowledge in CDS alert design by delineating how to design alerts with considerations of humans’ decision-making behaviour and why such consideration can improve the efficacy of alerts to influence clinicians’ decision-making behaviour. Once completed in its second stage, the study will also contribute to practice and enable practitioners such as system developers and health informaticians to rethink CDS alert designs from a behavioural perspective and consider adopting this perspective when designing various features of such alerts using a validated set of design guidelines.

We are cognisant that designing CDS alerts may require behavioural effects other than those offered by the MINDSPACE framework. While alerts generally aim to increase situational awareness, CDS alerts aim to enhance clinical decisions with implications for patients’ safety. This distinction necessitates an in-depth understanding of human decision-making intricacies and how to leverage them to enhance CDS alerts’ clinical utility. This is particularly important in contexts where clinical information systems fragment interdisciplinary decision-making and communication due to the invisibility or inaccessibility of patient information. We hope this short paper furthers the discussions on utilising behavioural insights from the growing body of literature in BE to rethink CDS alert designs for enhancing decisions in clinical contexts.

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Rethinking CDS alerts from BE perspective


