POINTS OF VIEW

Intuitive design

Appeal to intuition when making value judgments

Figure clarity and concision are improved when the selection of shapes and colors is grounded in the Gestalt principles[1], which describe how we visually perceive and organize information. These principles are value free—they tell us, for example, how we group objects but do not speak to any meaning that we might intuitively infer from visual characteristics. This month, we discuss how appealing to such intuitions can help us add information to a figure as well as anticipate and encourage useful interpretations.

A figure should depict objects and processes using shapes and colors that reflect the properties and roles of the entities they represent. If a graphic can be related to a physical system, the design should mirror its spatial and temporal dimensions. For example, the timeline of an experiment in which a reagent is periodically added and measurements are made can be drawn as an axis (**Fig. 1**). If we consider a physical representation of this timeline to be a series of laboratory tubes, then the positioning of the "Reagent" label in **Figure 1a** is unintuitive, as we would not expect a reagent to be added to a tube from below. Arrows naturally communicate movement and direction and are well suited to show the addition of a reagent, but less so to represent data collection. Points placed on the timeline would more intuitively represent sampling (**Fig. 1b**).

Although value judgments regarding color vary by context and culture—for example, red is energetic and passionate in the West and lucky and prosperous in the East—we can still avoid design decisions that muddle our message. For example, the mapping of color onto the certainty of risk factors in **Figure 2a** is poorly done because (1) red is likely to be interpreted as corresponding to a worse scenario than green and (2) differences between risk and protective factors are only

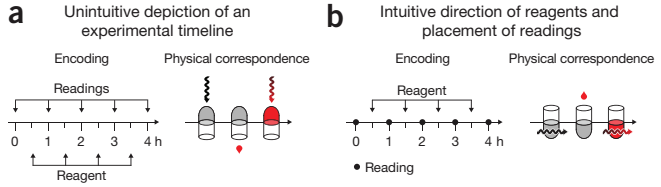

Figure 1 | An abstract representation of a system should embody its physical and temporal characteristics. (**a**) On the left, the use of arrows for both sampling data and the addition of reagents confounds the processes. The direction of the arrows is unintuitive, as exemplified by a schematic (right) of the underlying physical system. (**b**) Flipping the timeline improves the display. Timeline encoding adapted from ref. 2.

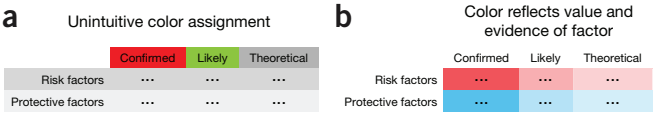

Figure 2 | Choose colors with likely value judgments that are compatible with the underlying meaning. (**a**) Using a red/green combination falsely implies negative/positive values of the categories. Gray is used for multiple purposes. (**b**) Encoding factor type with hue provides the option to use decreasing color opacity across column to encode the three levels of confidence. Red/blue combinations are color-blind safe[3].

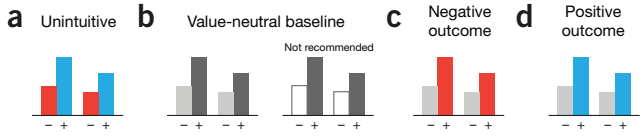

Figure 3 | Encode the control condition (–) and experimental intervention (+) with colors that reflect the nature of the intervention. (**a**) The control is unduly emphasized when it is depicted in red. (**b**) The use of gray avoids value judgments based on color, and using a lighter shade for the control makes it visually subordinate to the intervention category. Avoid hollow bars because they interfere with figure–background perception[1]. (**c**) Use red for the intervention if it is harmful or corresponds to a negative outcome. (**d**) For the positive outcome, blue is preferable to green to aid color-blind readers[3].

weakly distinguished by gray, which is further applied to the theoretical category of risk factors. Instead, risk and certainty can be effectively shown using hue and opacity (**Fig. 2b**). Here the dark red used for confirmed risk factors connotes negative outcomes and stands out more than the blue, which recedes.

When color is used arbitrarily it can interfere with interpretation (**Fig. 3a**). To avoid evoking a value judgment altogether, do not use color (**Fig. 3b**). Reserve red for categories that correspond to experimental intervention or conditions associated with worse outcomes, and use blue for positive outcomes (**Fig. 3c**,**d**).

When using shapes, try to match the visual characteristics of the shape to the expected physical or behavioral attributes of the item being represented (**Fig. 4**). In a progression, avoid making arbitrary decisions (**Fig. 4**, row 1), and have adjacent shapes vary according to a consistent recipe (**Fig. 4**, row 2). One should be able to reasonably guess a shape based on its neighbors—at the very least, one should not be surprised! For example, knowing that a normal cell is represented by a green circle does not help one deduce that an immune cell is represented by a hexagon (**Fig. 4**, row 1).

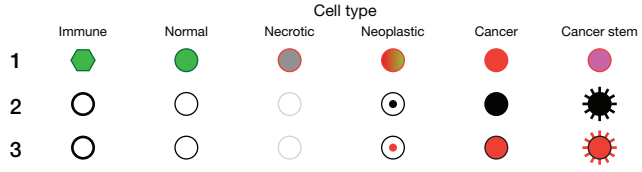

Figure 4 | Shapes can intuitively encode cellular properties. In row 1, the variation in color and shape lacks a unifying theme demonstrating the progression from normal to cancer stem cell. Row 2 presents a more intuitive progression; the immune cell is intuitively visualized as one with a thicker (more resistant) boundary. The spikes of the cancer stem cell suggest the potential to do physical harm. In row 3, the continuity across shapes is improved by encoding cancer with a fill color that differs from that of the outline. Now the shape of the normal cell remains distinguishable throughout. Adapted from ref. 4.

Anticipate unwanted interpretations of shapes and colors and avoid situations in which design elements that are purely stylistic may be confused with ones that encode data.

COMPETING FINANCIAL INTERESTS
The author declares no competing financial interests.

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