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Representing Sequence: The Influence of Timeline Axis and Direction on Causal Reasoning in Litigation Law

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Abstract

Can the representation of event sequence influence how jurors remember and reason in a legal case? We addressed this question by examining the interaction between an individual's preferred *spatial construal of time* (SCT) for an external (visual-spatial) representation and the SCT of a courtroom graphic. One hundred fifty three undergraduates played the role of jurors in a fictitious civil trial. The details of a case were recounted in a multimedia presentation featuring timelines animated in one of four orientations: left-right, right-left, top-bottom, and bottom-top. Participants were assessed on measures of comprehension and causal reasoning. Results indicated effects of timeline orientation and SCT choice behavior on comprehension and reasoning. We discuss these results in terms of the role of attention in temporal-causal reasoning, and implications for the design of multimedia materials for the courtroom.

Keywords: external representation; courtroom graphics; visualization; spatial construal of time; sequence; events; multimedia learning

Introduction

In litigation, lawyers often describe a situation while making an argument as to the cause of an alleged wrongdoing. Temporal order—a sequence of events—is the most basic requirement for causation. Increasingly, lawyers are turning to graphical representations such as animated PowerPoint presentations to support their courtroom arguments. In this study, we investigate the influence of the visual-spatial representation of event sequence on the comprehension and causal reasoning of jurors.

Visual Evidence

While computers and their multimedia artifacts are nearly ubiquitous in classrooms and boardrooms, their introduction to the American courtroom is a more recent phenomenon. A growing body of research is addressing the use of computer-generated exhibits as *demonstrative evidence*[1]. Park and Feigenson (2013) found that mock jurors remembered more information offered by attorneys using PowerPoint presentations than those offering the same information by oral argument alone. Participants also believed these attorneys were more credible, and decided in favor of their clients more often. The authors concluded that the use of visual aids influenced juror decision-making through both cognition (comprehension of the evidence) and persuasion (attitudes about the evidence). In a review of research addressing the effect of visualizations on courtroom decision-making, Feigenson (2010) noted a lack of convergent evidence on the effects of courtroom graphics, suggesting a nuanced role of visual evidence moderated by a number of factors, including: message format (i.e. still image, static-sequential animation, moving image animation, simulation), features of the case (e.g. complexity and familiarity of the scenario), and features of the case presentation (e.g. timing in case, differential use by opposing party). Feigenson also hypothesized a number of mediating variables, including: comprehension of the scenario, juror's ability to visualize the scenario, credibility, likeability, and emotional responses. While the results of experimental studies are mixed, this body of research suggests a range of effects that multimedia exhibits may have on comprehension, reasoning and subsequent decision-making. There is an urgent need for targeted research to explore the mechanisms by which these effects may occur, and the extent to which they are relevant to the high stakes arena of litigation law.

Sequence

We are interested in exploring how litigators might use multimedia displays to communicate about *causation*. Causation is a complex, multi-faceted construct in both law and philosophy, that has at least one basic requirement: the order of events. A cause can only be a cause if it occurs before an effect. In the auditory verbal medium, we can represent temporal order *in situ*, the first thing I say precedes the second thing I say, and so on. Similarly, in the visual-verbal medium, the first thing I write precedes the second. Research on text and listening comprehension has shown that comprehension for temporal order is significantly better when events

[1] Demonstrative evidence is offered to illustrate or clarify the testimony of a witness or the argument of a lawyer. Examples include a list of facts the lawyer refers to in supporting a claim of causation, or a timeline of events leading up to a crime.

are presented in chronological order in language (Mandler, 1985; Fenker, Waldmann, & Holyoak, 2005). Accordingly, if lawyers wish for their arguments to be understood and remembered, they would do well to instruct jurors about a sequence of events in the order they are alleged to unfold. To accompany such an oral argument, a lawyer might use a visual aid such as a *timeline* as demonstrative evidence.

A timeline is both a communication tool and a cognitive artifact. It consists of a chronological organization of events, most often depicted on a two-dimensional surface. Events may be represented by descriptions (i.e. text) and/or depictions (i.e. icons, pictograms or photographs). The *flow of time* unfolds along a linear path, often a horizontal or vertical axis. The positions of events serve as indicators anchoring their relative place in time. Depending on the granularity of detail, much information about the temporal relations of the events may be extracted from the representation, such as timing (a date/time) and duration (a quantity). Sequence information is always present, inherent in the spatial structure of the representation. In conjunction with an auditory narration, a pictorial timeline becomes a multimedia presentation. A timeline may also be animated to progressively elaborate a sequence of events *in situ*. Such a multimedia representation is potentially powerful, with both space and time, verbal and pictorial, auditory and visual mechanisms employed to communicate event sequence.

Learning About Sequence From Multimedia

When individuals experience a multimedia presentation, they process the stimuli through sensory mechanisms into working memory where stimuli are processed in accordance with their modalities (auditory, visual) and representational formats (descriptive, depictive) (Schnotz, 2014). The information is integrated with existing knowledge from long-term memory, the result of which is a mental model, representing the sequence of events in terms of spatial relations (Schaeken & Johnson-Laird, 1995). But what happens when the stimuli contain information about abstract concepts, such as time? A substantial body of research suggests that the embodied experience of space serves to structure our conceptualization of the abstract notion of time, such that certain properties of space (e.g. relative position, continuity) are imported into the domain of time (e.g. sequence, succession) (Lakoff & Johnson, 1980; Boroditsky, 2000). The mapping of time onto space is guided by conventions established through the habitual use of language and cultural artifacts (Núñez & Cooperrider, 2013). We call these mappings *spatial construals of time* (henceforth SCTs). Although multiple SCTs may be present in long-term memory (Núñez & Cooperrider, 2013), it is theorized that the import of mappings into working memory for task performance is constrained by a coherence-seeking mechanism[2]. According to the Coherent Working Models Theory, given a set of available mappings, only one is selected based on its adequacy to fulfill task demands (Torralbo, Santiago, & Lupiáñez, 2006; Santiago, Román, & Ouellet, 2011; Santiago, Ouellet, Román, & Valenzuela, 2012).

A task requiring the representation of temporal sequence on a two- dimensional surface brings attention to an allocentric frame of reference (Torralbo et al., 2006), thus activating a Reading/Writing Direction (RWD) consistent SCT of left-right for English speakers (Tversky, Kugelmass, & Winter, 1991). The result is the construction of a left-right oriented mental model in working memory, structuring knowledge of the sequence of events. If, however, a multimedia stimulus is presented in a different SCT, an individual must either import an alternative mapping into working memory, or perform a transformation of the incoming information into the SCT of the existing mapping. This raises two important questions: (1) Does the format of multimedia materials impact on the construction of the mental model? (2) If so, how does this impact reasoning operations on the mental model?

Present Investigation

We apply this conceptual framework to the domain of litigation law with three goals: (1) Preferences: replicate previous research on the relationship between SCTs and RWD, extended to computer-based stimuli. (2) Flexibility: test hypotheses derived from the Coherent Working Models Theory (Santiago et al., 2011) about the construction of mental models from inconsistent SCTs. (3) Stability: explore the stability of SCT preferences and potential impacts on mental model construction. We address these goals by focusing on the interaction between an individual's preferred SCT for a narrowly-defined task and the SCT of a stimulus.

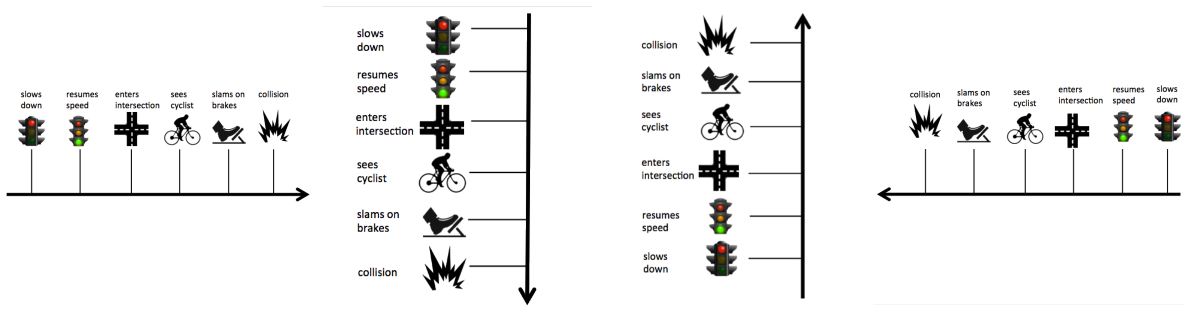
Hypotheses We hypothesize that individuals in the target population (English speakers of jury-eligible age) will prefer a RWD-consistent SCT (left-right) for a computer-based sequencing task. We predict the choice of this SCT will be *stable*: when asked to reconstruct a sequence of events after a stimulus, participants would likely persist. We hypothesize a limit to the flexibility of thinking with differing SCTs, such that the presentation of timelines oriented with different SCTs (same axis/opposite RWD or different axis) will impair the development of coherent mental models. Consequently, participants exposed to such stimuli will have poorer comprehension of the case and make more errors in causal reasoning.

Methodology

Design

Two factors, Timeline Axis and Consistency of Timeline Direction with Reading/Writing Direction (henceforth, direction) were fully crossed, yielding a 2-Axis (Horizontal/Vertical) x 2-Direction (Consistent/Inconsistent) design with four between-subjects conditions: (1)left-right, (2)top-bottom, (3)right-left, and (4) bottom-top.

[2]For example, it would be incoherent to simultaneously construe the flow of time as both Back-to-Front and Front-to-Back.



(a) $SCT_s = L - R$ (b) $SCT_s = T - B$ (c) $SCT_s = B - T$ (d) $SCT_s = R - L$

Figure 1: Stimuli - Timelines for Four Experimental Groups

Participants

One hundred fifty three undergraduates (63% female) sampled from a mid-sized American university were randomly assigned to the experimental conditions in exchange for course credit. The participants ranged from 18 to 64 years of age (Median=22). All reported fluency in English, with 89% reporting English as a first language, and 11% reporting Spanish. Native speakers of Mandarin, Arabic and Farsi were excluded from the sample. No significant differences were found between experimental groups with respect to other demographic variables, including involvement in traffic accidents and laterality.

Materials

Measure of Spatial Construal of Time A novel measure was developed as an indicator of participants' preferred spatial construal of time (SCT) for event sequence in the context of a well-defined task. Participants were asked to construct a timeline to indicate the order of a sequence of events. They were first instructed to choose an orientation (axis and direction) for the timeline (Figure 2). The orientation selected by the participant was recorded as the SCT and utilized for the subsequent sequencing task. The SCT measure was utilized twice during the experimental protocol, once before stimulus presentation (SCT_1), and once after (SCT_2).

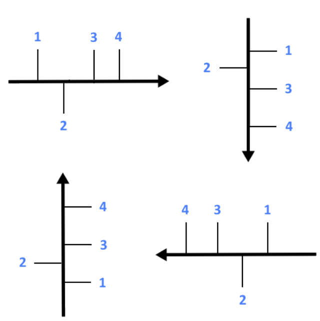


Figure 2: Measuring SCT preference for representational task. *The second item in each figure was positioned on the other side of the timeline to demonstrate that both sides could be utilized in the following task.*

Experimental Stimuli The experimental stimuli consisted of a fictitious civil litigation involving a motorist/cyclist traffic accident[3]. The scenario was developed such that verdicts in favor of the plaintiff or defendant were equally justified, depending on which of the conflicting witness statements a juror chose to believe. Measures of comprehension and reasoning were balanced for either verdict, mitigating the impact of bias toward either party.

The experimental manipulation was embedded in a multimedia presentation of testimony consisting of a PowerPoint presentation, ostensibly displayed in a courtroom accompanying a lawyer's examination of a witness. Participants heard an unidentified lawyer questioning a police officer who responded to a traffic accident. The police officer reported the events leading up to the accident as described by the defendent motorist and plaintiff cyclist. During each description, a timeline appeared on-screen, serving as the experimental manipulation. The axis and direction of the timeline depicted were different for each experimental group (Figure 1). Each timeline was animated in a sequential fashion and synchronized with the audio description.

Measure of Comprehension Comprehension was measured via twenty-five multiple-choice questions developed in accordance with the Meaning Identification Technique (MIT) for evaluating reading and listening comprehension (Marchant, Royer, & Greene, 1988).

Measure of Reasoning To assess temporal-causal reasoning, participants were asked to arrange twenty-eight events described in the testimony along a timeline (Figure 3). This task aims to capture both the *spatial structure* and *content* of a mental model. The structure of the model was determined by the chosen orientation of the timeline SCT_2. Causal reasoning was evaluated by scoring the submitted sequence in relation to its logical consistency with the verdict the participant rendered. For example, if a participant rendered a verdict in favor of the cyclist but indicated on the timeline that the cyclist ran the red light, the response would be logically

[3]Based on a scenario from the 2014 Colorado State High School Mock-Trial Program (Colorado Bar Association, 2014).

inconsistent. Two graduate students developed the scoring rubric which was applied via a computer algorithm.

Procedure

Participants were seated at computer workstations equipped with headphones and guided through the study under the guise of a mock-trial. First, participants completed the first measure of spatial construal of time (SCT_1). Then, they viewed the stimulus multimedia presentation. Following the testimony, they answered 25 questions testing their comprehension of the case. Then, they constructed a timeline of events mentioned in the testimony (SCT_2 and reasoning measures). Finally, they were asked to render a verdict. Participants were then debriefed. The total runtime averaged 43 minutes.

Results

Preferences for SCTs

A majority (76%) of participants selected a left-right SCT in the first sequencing task (henceforth SCT_1-constrained sample), followed by 12% selecting bottom-top, 10% top-bottom, and 2% right-left. In paper-based studies, participants face a stimulus oriented parallel to their sagittal axis, while in the present computer-based study, participants faced a stimulus oriented perpendicular to their sagittal axis (Figure 4). Our results are consistent with findings of studies conducted on children with paper-based stimuli (Tversky et al., 1991), suggesting that the influence of RWD is consistent across at least two spatial axes as well as a change in representational media.

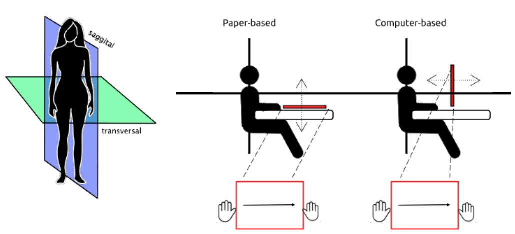


Figure 4: Orientation of Stimuli in Paper vs. Computer-based Studies.

Flexibility in SCTs

As hypothesized, a significant positive correlation was found between measures of comprehension and reasoning (r=.273, p<.01). A factorial MANOVA examining the effect of stimulus SCT on comprehension and reasoning yielded a significant main effect for direction, $\Lambda = .95$, F (2,111)= 3.08, p=.05, $\eta_p^2 = .05$. Univariate analyses revealed a significant effect of direction only on comprehension, F (1,112)=3.92, p=.05, $\eta_p^2 = .03$. Inspection of the estimated group-means revealed that the direction of the effect was *opposite* to our hypothesis. Timelines oriented inconsistent with RWD (bottom-top and right-left) were related to higher comprehension scores (see Figure 5). The data did not reflect a significant interaction between axis and direction, and no effects were significant for reasoning.

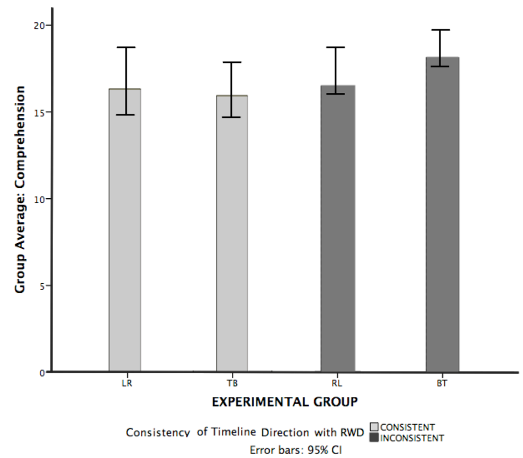


Figure 5: Group Means of Comprehension by Experimental Group.

Stability in SCTs

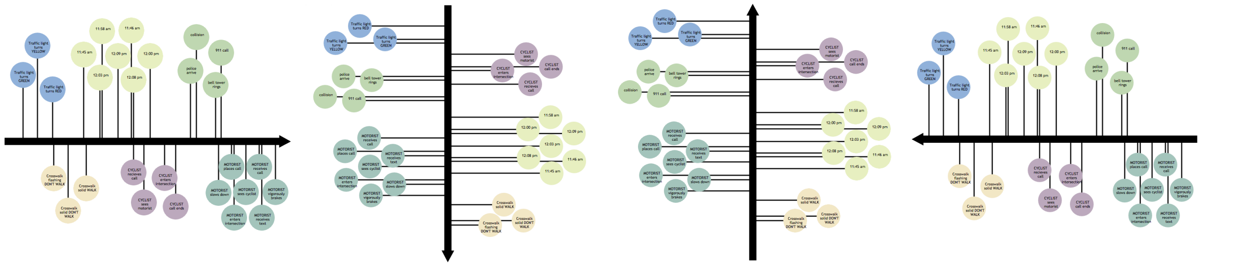
To explore the stability of SCT preferences while performing cognitive activities, we derived a new measure, *SCT Choice Behavior*[4], based on the post-stimulus SCT_2 in relationship to the SCT_s (experimental group) and pre-stimulus SCT_1.

Of the 116 participants in the SCT_1-constrained sample, seventy-one persisted with SCT_1 when presented with a differing SCT_s. Twenty-eight received the same stimulus as SCT_1 and persisted. Ten adapted to the SCT_s and seven chose a third, different SCT_2. We performed a multivariate Kruskal-Wallis test to examine the influence of SCT choice behavior on comprehension and reasoning, which revealed a significant effect on reasoning, $\chi_2(3, n{=}116){=}10.7$, p=.013. Participants who chose SCT_2 different than both SCT_1 and stimulus SCT_s had significantly lower scores on the reasoning task.

Discussion

To explore preferences, flexibility and stability of spatial construals of time (SCTs) and effects on courtroom reasoning, we asked participants to assume the role of jurors in a mock-trial. We successfully replicated previous findings on the concordance of SCTs with RWD (Tversky et al., 1991) this time with computer-based interactive data visualizations. Concerning flexibility, our results shed light on the flexibility of SCTs and the role of attention as a coherence-seeking mechanism. Regarding stability, we offer new evidence as to the stability of SCT choices over sequential representational tasks, and discuss how these behaviors might affect operations on mental models.

[4]SCT Choice Behavior values: *persist* ($SCT_1 \neq$ stimulus, $SCT_2 \equiv SCT_1$), *adapt* ($SCT_1 \neq$ stimulus, $SCT_2 \equiv$ stimulus), *neither* ($SCT_1 \neq$ stimulus, $SCT_2 \neq$ stimulus, $SCT_1 \neq SCT_1$), *indeterminate* ($SCT_1 \equiv$ stimulus $\equiv SCT_2$).



(a) $SCT_2 = L - R$ (b) $SCT_2 = T - B$ (c) $SCT_2 = B - T$ (d) $SCT_2 = R - L$

Figure 3: Start Positions of Interactive Timelines for Reasoning Measure. *Text inside circles provide short description of events (e.g. CYCLIST enters intersection). Circles are organized into color coded categories (e.g. car events, bicycle events, traffic signals, etc.)*

Preferences for SCTs

As predicted, participants demonstrated a strong preference for the left-right SCT in the sequencing task. The observation that the preference was consistent across transversal and sagittal axes presents an interesting question for future research on SCTs. Might a change in axis be equally flexible when considering deictic time as sequential time? Or is this effect only observable for sequential relations, and on axes for which culturally derived SCTs exist? Answers to these questions may have practical applications in the realm of immersive virtual reality and 3D data visualization, as well as shed light on the complex relationship between external representations and temporal/spatial cognition.

Flexibility in SCTs

The most interesting results came when examining the influence of stimulus SCT_s on comprehension. We found that stimulus SCTs different from RWD resulted in superior comprehension. One explaination for this result is found by considering the role of attention in thinking with SCTs. By asking participants to construct a simple timeline prior to stimulus exposure, we brought attention to their preferred spatial construal for the task (SCT_1), ostensibly resulting in import into working memory. When presented with a different SCT_s (stimulus) individuals needed to import an alternative mapping, or transform the incoming information to the SCT_1. Rather than impair model construction, our data suggest this allocation of cognitive resources had an advantageous effect. If we assume that the discrepancy between SCT_1 and timeline orientation required additional attention be paid to the stimulus, then this increased attention may have resulted in a net increase in the cognitive resources dedicated to model construction. The harder the task was, the more the attention the participants devoted. As attention is a limited resource, however, we think it unlikely this effect would persist for increasingly complex tasks. We predict a threshold level of complexity, after which inconsistent SCTs would result in decreased performance.

The data failed to support our hypothesis that inconsistent timeline SCTs have a deleterious effect on causal-reasoning. We presumed that reasoning, an operation that manipulates a mental model, depends first on the fidelity of the contents of the model (Schaeken & Johnson-Laird, 1995). In this way, we expected that comprehension and reasoning measures would be strongly correlated. The actual correlation between measures was weak (r=.273, $p<.001$), and in fact only significantly correlated for the left-right stimuli condition (r=.403, p=.05). This suggests that participants in other groups may have found the reasoning task so challenging that they either substantially reduced their effort, or, through manipulation of the interactive data visualization, altered the contents of their mental model. To investigate these alternatives in the future, we need to compare the internal consistency of answers on the comprehension measure with arrangement of events on the reasoning measure. This will allow us to determine if participants indicated a different understanding of the sequence of events on the reasoning task than they indicated on the prior comprehension task.

We suspect that the task difficulty likely influenced the effort expended on the reasoning task (indicated by reasoning time). While there were no significant differences in reasoning time between groups, there was a strong correlation between reasoning time and reasoning scores only for the right-left group (r=.647, $p<.001$). It is likely that the lengthy manipulation of the interactive data visualization required by the reasoning task had the unintended consequence of altering participants' mental models, rather than reflecting their structure and content. A substantial body of literature supports the view that data visualizations are tools on which individuals may offload cognitive processing (see (Hollan, Hutchins, & Kirsh, 2000). We seek to refine the reasoning measure to more accurately reflect the content of participants' mental models without manipulating them.

Stability of SCTs

As predicted, most individuals persisted with their intial choice of SCT. Our analysis revealed that participants who chose a SCT_2 different from both their SCT_1 and SCT_s had significantly lower scores on the reasoning task. This result may indicate a limit on the flexibility of SCTs during higher order cognitive activities; perhaps individuals can perform transformation between two SCTs without performance impairment, but not three. We plan a follow-up experiment to investigate the use of differing SCTs within the same stimulus presentation (i.e. one orientation for the defense, a different orientation for the prosecution). Alternatively, it is possible that the choice of a third SCT for the reasoning task was in itself indicative of a lack of effort on the part of the participant.

Limitations and Future Work

While we placed a high value on external validity in the design of our experimental materials, the participants' exposure to stimuli was not reflective of genuine litigation, where juries hear arguments over the course of several hours or days before group deliberation. Additionally, participants were not permitted to use external cognitive aids such as note taking, or review of testimony and transcripts. Any effect of graphics on real-life courtrooms must be considered in combination with the effects of persuasive argumentation and jury deliberation, and how these might operate in a more representative population.

In this investigation, we approached the courtroom as a classroom; before jurors can be persuaded, they must be instructed about the details of a case. Our approach was to apply research from the learning sciences to understand how jurors might integrate information from multiple sources and modalities. Our results add to the growing body of research on the influence of multimedia in the courtroom (see (Feigenson, 2010, 2011; Park & Feigenson, 2013) by providing evidence that differential presentations of temporal sequence *can* influence comprehension. To clarify these results, we plan subsequent studies that carefully control allocation of attention to the learning materials and measurement tasks. Our data suggest that the orientation of timelines can impact the comprehension of jurors, and that in situations where a lawyer wishes to capture jurors' attention, a left-to-right timeline may be preferable. We recommend testing the hypothesis that SCTs inconsistent with RWD improve comprehension by inducing increased allocation of attention, up to a threshold, at which point performance will begin to degrade. Answers to these questions will guide the designers of courtroom multimedia presentations on how to orient timelines to be maximally coherent for jurors; or alternatively, how to induce confusion for persuasive purposes.

Acknowledgments

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