

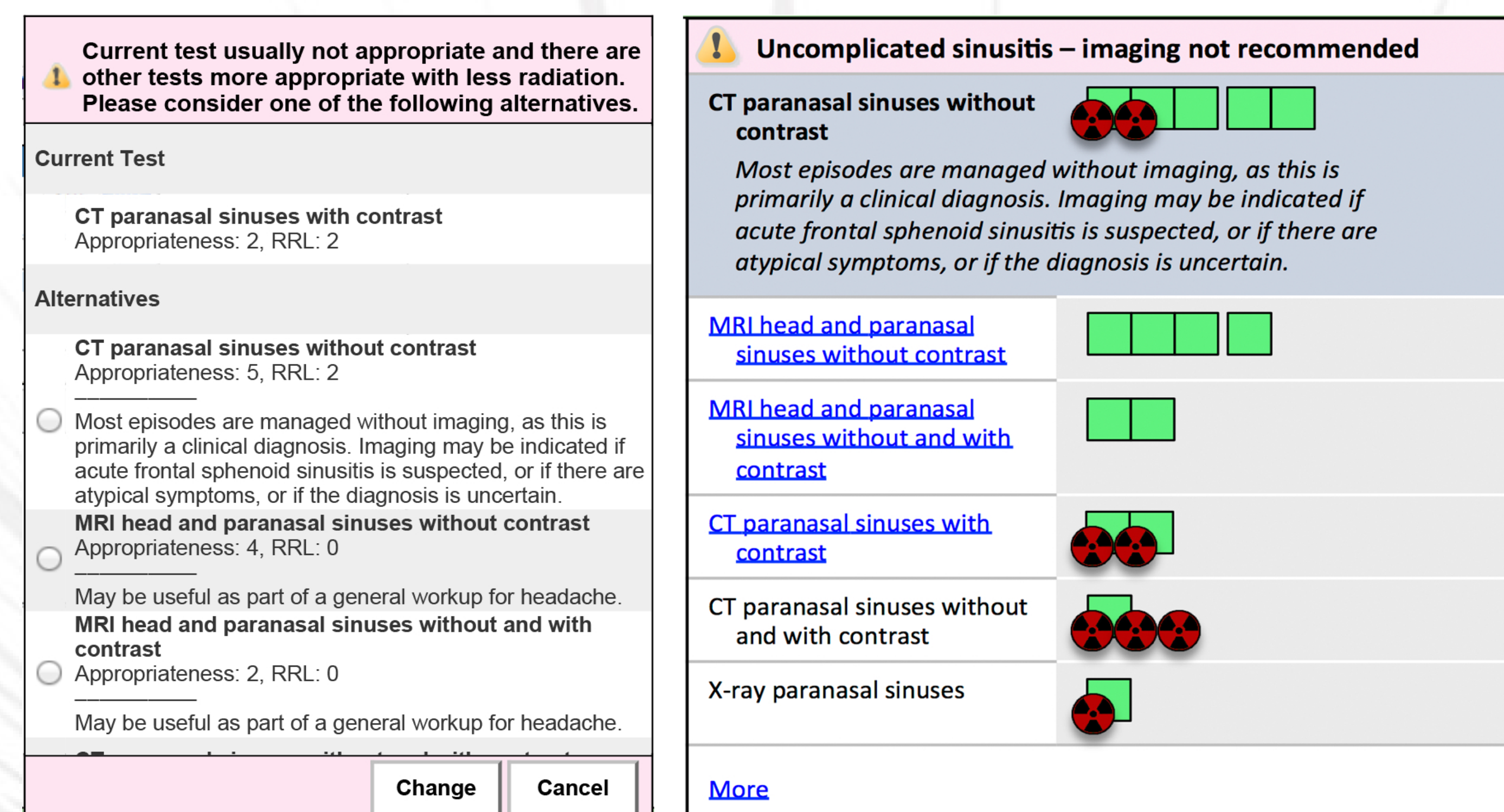
Introduction

Computational analytics solutions have been shown repeatedly to provide critical data to decision-makers. However, it has also been shown that design choices regarding how to present that data has a major impact on how that data is interpreted and responded to (Burns & Hajdukiewicz, 2004; Smith, McCoy, & Layton, 1997; Woods, 2003). This effect is most notably seen in situations of increased complexity and uncertainty, in which the decision-maker must not only diagnose the state of the system but also the relevance of the decision-support technology. Solutions that support visual analytics, in which visual cortex processing is recruited to assist in problem-solving, may help in these situations because they are able to simultaneously encode multiple data relationships that may prove to be necessary to understand a particular situation (Woods & Patterson, 2002). We explored the ability of a visual analytics solution to improve decision-making in increasingly uncertain and complex situations in a healthcare setting.

Aims

- Aim 1: to determine if the visual analytics display would facilitate similar performance to the text-based display in nominal situations.
- Aim 2: to determine if the visual analytics display would facilitate superior performance in increasingly complex and uncertain situations.
- Aim 3: to determine if perceived understandability, algorithm transparency and relevance improved with the visual analytics display.

Figure 1: Text-based (left) and Visual Analytics (VA) display (right) recommending alternative imaging order



Methods

A between-subject design was used to determine the efficacy of the visual analytics display relative to a typical text-based display in a healthcare setting. Both displays presented the results of the same clinical appropriateness algorithm. Efficacy was defined as the reduction of inappropriate diagnostic imaging orders across 11 patient scenarios in a simulated environment. Nine attending and 11 resident physicians with experience using computer-based decision support were randomly assigned to either the visual analytics or text-based display. Uncertainty was increased in four scenarios by inputting incomplete data into the algorithm. Complexity was increased in two of these four by inputting incorrect data into the algorithm. Chi-square tests of independence were used to assess the difference of inappropriate tests across display types.

After completing all patient scenarios, participants were shown both display types side-by-side and asked to rate each for perceived understandability, algorithm transparency, and clinical relevance for each scenario. The self-report ratings of the two types of displays were analyzed using a two-way repeated measures MANOVA.

Results

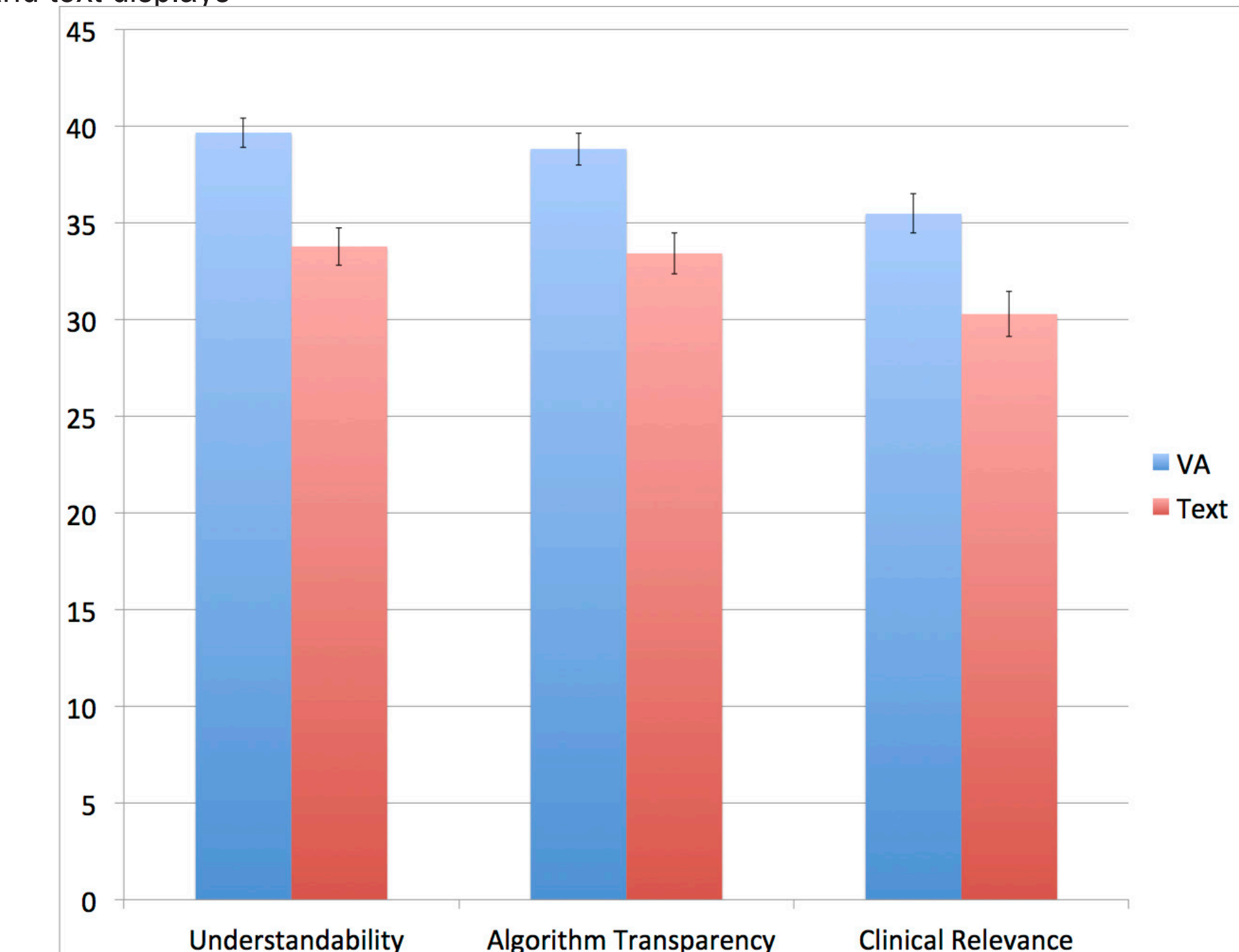
Nearly 50% fewer inappropriate tests were ordered with the visual analytics display than with text-based alerts (18% vs. 34%, $X^2(1, n=220, p=0.027)$). For the subset of scenarios with increased complexity and uncertainty, the difference between visual analytics and text was even more pronounced (28% vs. 60% $X^2(1, n=80, p=.009)$). Physicians rated the visual analytics display higher on understandability (40.1 vs. 34.0, $p<.05$), algorithm transparency (39.2 vs. 33.8, $p<.05$) and clinical relevance (35.9 vs. 30.6, $p<.05$).

Complexity and Uncertainty	Scenario #	% Inappropriate*		% With No Imaging		Relevant Guidance
		Text	VA	Text	VA	
Low (no ordering change suggested)	1,2,3,8	10	8	30	25	
	1	10	20	30	20	Yes
	2	10	0	40	20	Yes
	3	0	10	0	10	Yes
	8	20	0	50	50	Yes
High (incorrect and incomplete data)	4,6,10,11	60**	28**	33	50	
	4	50	10	30	30	No
	6	70	30	30	70	Yes
	10	70	50	20	30	Yes
	11	50	20	50	70	No
Low (ordering change suggested)	5,7,9	30	20	70	80	
	5	40	20	60	80	Yes
	7	10	0	90	10	Yes
	9	40	40	60	60	Yes
All	All	34**	18**	42	49	

VA=Visual Analytics solution
*Inappropriate tests defined by American College of Radiology appropriateness scale
** For all scenarios, $p=.027$, for high complexity/uncertainty scenarios, $p=.009$

Table 1: Proportion of inappropriate imaging while using text-based and visual analytics displays resulting in inappropriate imaging or no imaging

Figure 2: Understandability, algorithm transparency, and clinical relevance for visual analytics and text displays



Conclusion

Visual analytics displays were more effective than text-based alerts in reducing inappropriate imaging orders and were preferred for all patient scenarios, especially in scenarios where uncertainty and complexity were high. Also notable is that the visual analytics display was rated higher on understandability, algorithm transparency and clinical relevance, even though it was presenting data from the same algorithm as the text-based display.

Bibliography

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