

Online Supplemental Material 3 to

“Lost in Search: (Mal-)Adaptation to probabilistic decision environments in children and adults”

1. Accuracy scores

Accuracy is measured in terms of the number of treasures found by the participant. If an individual followed the prediction of the high validity cue (HVC) in all 24 target decision trials, he or she would collect about 20 treasures according to the payoff structure that reflects cue validities. Results are depicted in Table 1. Obviously, there are pronounced age differences. Accuracy increases with age ($F(2, 296) = 107.4, p < .01, \eta^2_{\text{partial}} = .42$). Compared to the low dispersion conditions, accuracy is smaller under high dispersion ($F(1, 296) = 65.6, p < .01, \eta^2_{\text{partial}} = .19$). Notably, this main effect is qualified by an interaction effect. Adults maintain their level of accuracy under high dispersion, whereas children strongly decrease in accuracy ($F(2, 296) = 23.6, p < .01, \eta^2_{\text{partial}} = .14$). This finding further substantiates our interpretation that children suffer from their deficits in search. Because they do not increase their focus on the HVC under high dispersion, their choice accuracy decreases. There were no other significant effects in the full factorial GLM-analyses (all $F < 1.1$).

Table 1: Number of treasures found by participants

		Dispersion				
		Low		High		
		Search constraint		Search constraint		
	No	Yes	No	Yes	<i>Overall</i>	
Preschoolers	16.19 (1.70) <i>n</i> = 26	15.56 (1.99) <i>n</i> = 27	12.40 (2.08) <i>n</i> = 25	12.04 (3.57) <i>n</i> = 27	14.057 (3.05) <i>n</i> = 105	
Elem. schoolers	16.67 (2.85) <i>n</i> = 24	16.92 (2.17) <i>n</i> = 24	13.15 (2.78) <i>n</i> = 26	13.73 (3.01) <i>n</i> = 26	15.05 (3.18) <i>n</i> = 100	
Adults	18.54 (1.56) <i>n</i> = 24	18.38 (2.22) <i>n</i> = 24	19.15 (1.62) <i>n</i> = 26	18.62 (1.93) <i>n</i> = 29	18.68 (1.85) <i>n</i> = 103	
<i>Overall</i>	17.11 (2.31) <i>n</i> = 74	16.89 (2.40) <i>n</i> = 75	14.94 (3.75) <i>n</i> = 77	14.90 (4.04) <i>n</i> = 82	16.00 (3.30) <i>N</i> = 308	

Table 1: Table shows mean values, standard deviations are in parentheses.

2. Conditional utilization of HVC in choice

How often did participants follow the HVC given that it was looked at? Table 2 shows results on this measure. Conditional utilization of the HVC in choice increases with age ($F(2, 296) = 148.04, p < .01 \eta^2_{\text{partial}} = .50$). Compared to the low dispersion conditions, conditional HVC utilization is higher under high dispersion ($F(1, 296) = 7.4, p < .01 \eta^2_{\text{partial}} = .024$). Notably, this main effect is qualified by an interaction effect. Conditional utilization increases in adults under high dispersion whereas it decreases in children ($F(2, 296) = 27.3, p < .01 \eta^2_{\text{partial}} = .16$). This finding again substantiates the interpretation that children suffer from their deficits in search. Because they do not increase their focus on the HVC under high dispersion, their conditional use of the HVC in choice decreases as well. No other effect reached an acceptable level of significance in the full factorial GLM-analyses (all $F < 2.2$).

Table 2: Frequency of choices following the HVC's prediction given that it was looked at

	Dispersion				<i>Overall</i>
	Low		High		
	Search constraint		Search constraint		
	No	Yes	No	Yes	
Preschoolers	9.65 (3.94) <i>n</i> = 26	9.81 (3.60) <i>n</i> = 27	9.12 (3.87) <i>n</i> = 25	10.48 (5.02) <i>n</i> = 27	9.78 (4.12) <i>n</i> = 105
Elem. schoolers	14.00 (4.18) <i>n</i> = 24	13.50 (4.44) <i>n</i> = 24	10.04 (5.60) <i>n</i> = 26	12.88 (5.29) <i>n</i> = 26	12.56 (5.10) <i>n</i> = 100
Adults	16.17 (2.60) <i>n</i> = 24	16.75 (5.67) <i>n</i> = 24	22.69 (2.11) <i>n</i> = 26	22.48 (1.99) <i>n</i> = 29	19.73 (4.52) <i>n</i> = 103
<i>Overall</i>	13.18 (4.53) <i>n</i> = 74	13.21 (5.38) <i>n</i> = 75	14.01 (7.45) <i>n</i> = 77	15.49 (6.79) <i>n</i> = 82	14.01 (6.22) <i>N</i> = 308

Note: Table shows mean values. Standard deviations are in parentheses.

3. Pattern-wise classification of systematic HVC users

In accordance with prior work (Betsch & Lang, 2013; Betsch et al., 2014), we assessed the portions of systematic HVC-users separately for the three types of cue patterns and different age groups. Figure 1 depicts the percentages of individuals following the high validity cue's prediction in the majority of trials for each pattern, age group, and experimental condition. Given a specific pattern, we considered an individual to be a systematic user of cue validity if his/her choices followed the prediction of the HVC in at least 6 of 8 trials (75 %). There are two main observations. In contrast to preschoolers, a considerable portion of elementary schoolers systematically rely on the HVC's predictions. This finding indicates that 9-10 year old children are able to use probabilistic information as weights for decision making. Strongest pattern effects are found in elementary schoolers, indicating that these children are prone to consider multiple information (rather than the HVC only) when making decisions.

In all analyses, we used a dummy coded variable (1,0) in which “1” indicates that a person is a cue user. Following the suggestions of Rosenthal and Rosnow (1985) for analyzing proportions, we subjected data displayed in Figure 1 to an analysis of variance (GLM). We conducted separate analyses for age groups, with *pattern-type* as a repeated measurement factor and *dispersion* and *constraint* as between-subjects factors. We report Greenhouse-Geiser corrected inferential statistics (Greenhouse-Geisser) due to violations of sphericity.

Preschoolers

As immediately evident from inspection of Figure 1, systematic utilization of the HVC is generally low in preschoolers' choices. Binomial tests reveal that, in the majority of conditions, the proportions of systematic choices in line with the HVC's predictions do not exceed chance level ($p < .05$ only once in 12 conditions, resulting from the 3[pattern] x 2 [constraint] x 2 [dispersion] design). This finding converges with previous results of studies

using a similar decision environment (cf. Betsch et al., 2014). Only two effects reached an acceptable level of significance in the analysis (all other $F_{\text{within}} < 1.3$, $\eta^2_{\text{partial}} < .02$; $F_{\text{between}} < 1$, $\eta^2_{\text{partial}} < .01$). First, we obtained a main effect for the repeated-measurement factor *pattern* ($F(1.5, 146.8) = 3.3$, $p < .05$, $\eta^2_{\text{partial}} = .03$). This effect reflects the observation that the highest rate of systematic cue utilization occurred in the Type 3 pattern. This was somewhat unexpected, as deviations from the HVC-predictions might be invited by a pattern in which the two other cues jointly speak against the HVC's prediction. Second, the two-way interaction effect between *pattern* and *dispersion* was significant ($F(1.5, 146.8) = 2.5$, $p < .05$, $\eta^2_{\text{partial}} = .03$). To a considerable extent, this effect was driven by an increase in HVC-congruent choices vis-à-vis a Type 3 pattern in a high-dispersion decision environment.

Elementary schoolers

Figure 1 shows that systematic utilization of the HVC in elementary schoolers' choices is substantially higher than in preschoolers and above chance ($p < .01$ in 10 of 12 conditions). In some conditions, the proportions of systematic choices in line with the HVC's predictions approach the level found in adults (up to 70%). As in preschoolers, we obtained a main effect for the repeated-measurement factor *pattern* ($F(1.4, 137.1) = 4.7$, $p < .05$, $\eta^2_{\text{partial}} = .05$) and a two-way interaction effect between *pattern* and *dispersion* ($F(1.5, 146.8) = 2.5$, $p < .05$, $\eta^2_{\text{partial}} = .03$). The main effect reflects the unexpected observation that the highest rate of systematic cue utilization occurred in the Type 3 pattern. This tendency becomes even more pronounced under high dispersion, as indicated by the interaction effect. No other within-subjects effects were significant (all $F_{\text{within}} < 1.1$, $\eta^2_{\text{partial}} < .01$).

Two between-effects occurred. In elementary schoolers, high dispersion tended to provoke a decrease in HVC-congruent choices ($F(1, 96) = 3.2$, $p < .10$, $\eta^2_{\text{partial}} = .03$). Moreover, HVC-congruent choices were most rare under high dispersion and constrained

search, bearing a significant dispersion-by-constraint interaction ($F(1, 96) = 5.01, p < .05, \eta^2_{\text{partial}} = .05$). Again, these findings run counter to expectations derived from models of adaptive decision making. The main effect for constraint was not significant ($F < 1, \eta^2_{\text{partial}} < .01$).

Adults

The vast majority of adults made their decisions according to the prediction of the high validity cue. Inspection of Figure 1 reveals that, in some conditions, the entire group of participants can be classified as systematic HVC users. These groups can be found in each of the three within-subjects conditions (type of pattern). This lack of variance violates some requirements for applying a GLM-analysis. However, we still report these results, because the effect pattern does not change when one applies non-parametric tests. None of the within-subjects effects approached an acceptable level of significance (all $F_{\text{within}} < 1.3, \eta^2_{\text{partial}} < .02$), with the exception of a tendency towards a three-way interaction between *pattern*, *dispersion*, and *constraint* ($F(1.2, 121.7) = 2.3, p = .11, \eta^2_{\text{partial}} = .02$). We will not consider this tendency further.

More important are the between-subjects effects. Foremost, there was a strong main effect for dispersion ($F(1, 99) = 16.8, p < .01, \eta^2_{\text{partial}} = .15$; Mann-Whitney-U test: Type 1 pattern $p < .03$, Type 2 $p < .01$, Type 3 $p < .01$), reflecting the observation that adults increasingly rely on the HVC predictions when cue validity dispersion is high. This finding is in line with our hypotheses. The main effect for *constraint* was also significant and moderately strong in effect size ($F(1, 99) = 5.9, p < .05, \eta^2_{\text{partial}} = .06$). Non-parametric tests conducted separately for the three types of patterns indicate that the effect stems mainly from decisions in Type 1 trials (Mann-Whitney-U test: Type 1 $p < .05$, Type 2 $p = .26$, Type 3 $p = .22$). Nevertheless, the result points in the unexpected direction. Similar to elementary schoolers, HVC-choices increase if search is unconstrained. Finally, we obtained a two-way interaction effect between dispersion and constraint ($F(1, 99) = 4.9, p < .05, \eta^2_{\text{partial}} = .05$;

Mann-Whitney-U test: for all types of patterns $p < .01$). On the descriptive level, the interaction effect is caused by the finding that the lowest rate of systematic HVC-users occurs under low dispersion and constrained search, which again is unexpected.

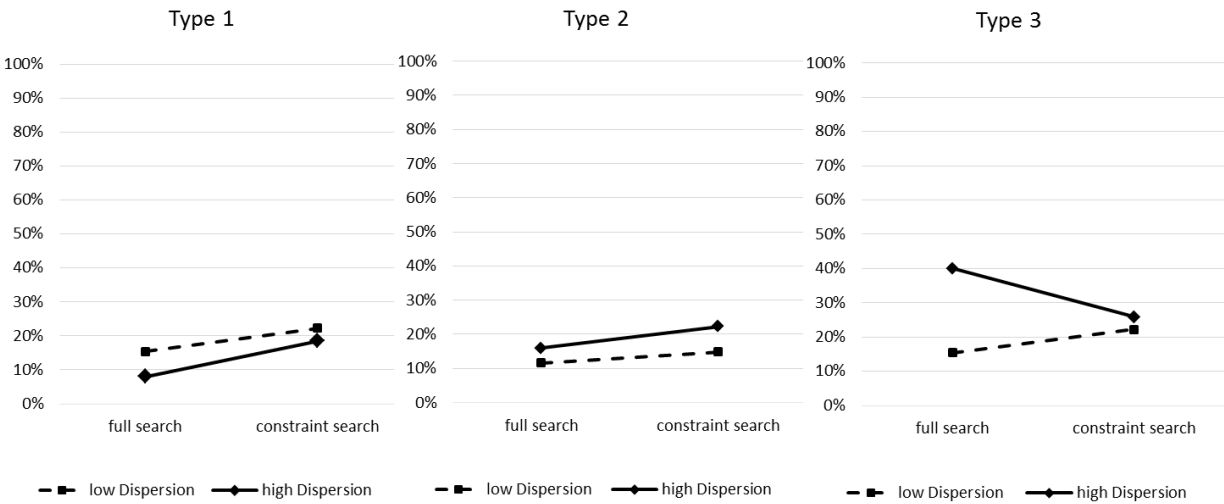
References

- Betsch, T., & Lang, A. (2013). Utilization of probabilistic cues in the presence of irrelevant information - A comparison of risky choice in children and adults. *Journal of Experimental Child Psychology*, 115, 108–125.
- Betsch, T., Lang, A., Lehmann, A., & Axmann, J.M. (2014). Utilizing probabilities as decision weights in closed and open information boards: A comparison of children and adults. *Acta Psychologica*, 153, 74-86. DOI: 10.1016/j.actpsy.2014.09.008
- Rosenthal, R., & Rosnow, R.L. (1985). *Contrast analysis*. Cambridge: Cambridge University Press.

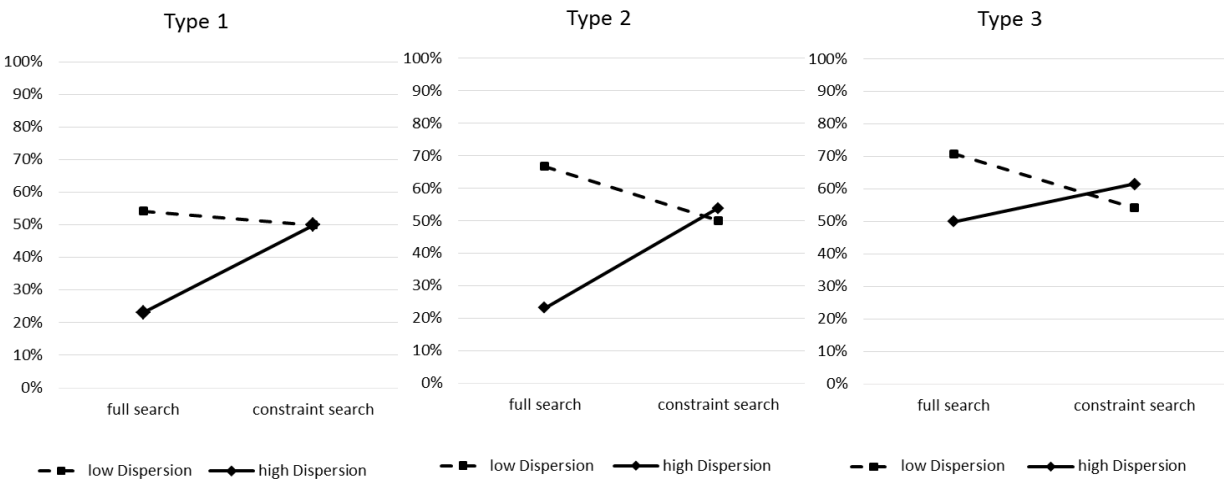
Figure Caption

Figure 1: Percentages of individuals following the high validity cue's prediction in the majority of trials ($> 75\%$).

Preschoolers



Elementary Schoolers



Adults

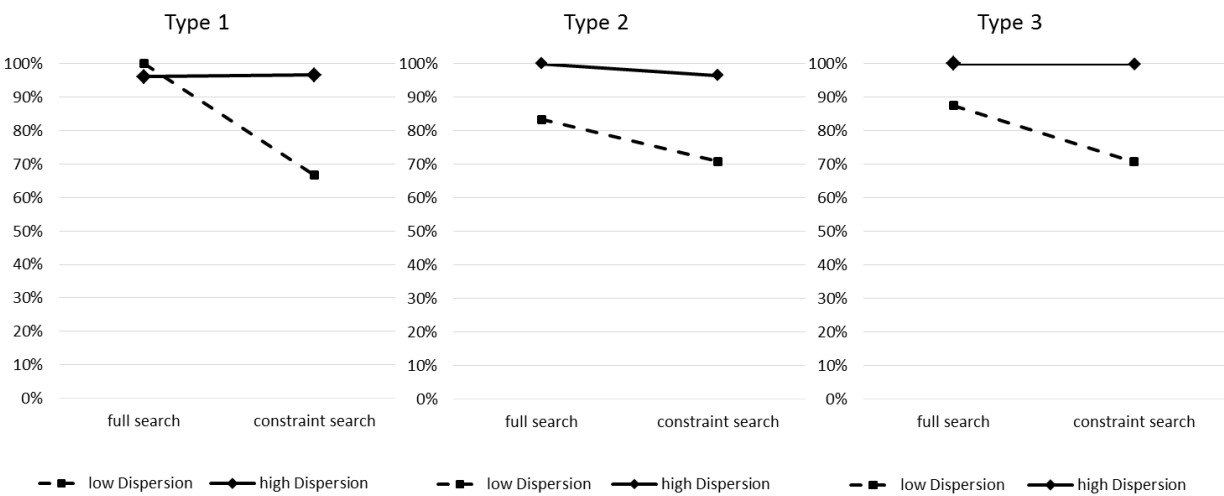


Figure 1