Supplementary Material for

Scene Context-aware Indoor Object Selection and Movement in VR

Outline

- A gallery of tasks in the selection study
- A gallery of tasks in the movement study
- Statistical results of the selection study
- Statistical results of the movement study
- User study analysis report

A gallery of tasks in the selection study

Target objects for selection are highlighted with a blue contour (please zoom in for details)

Non-occluded large object | Non-occluded small object | Partially occluded object | Non-occluded object in dense environment | Partially occluded object in dense environment

A gallery of tasks in the movement study

Target objects for movement are highlighted with a yellow contour

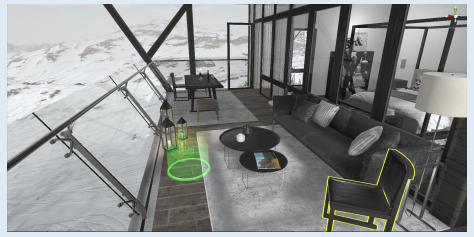
Target placement position are indicated with a green arrow

Moving Depth

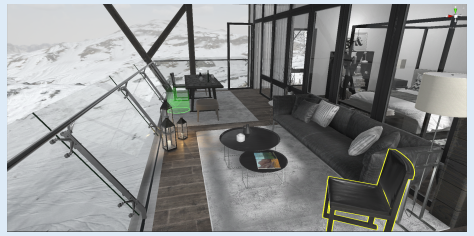
Small

Large

Small

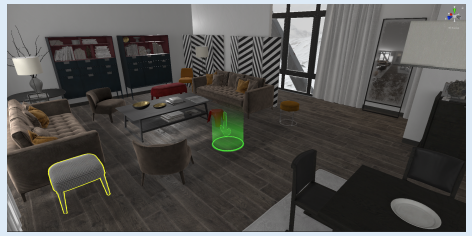


Large



Moving Angle

Small



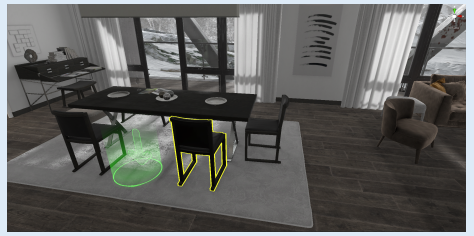
Large

Small

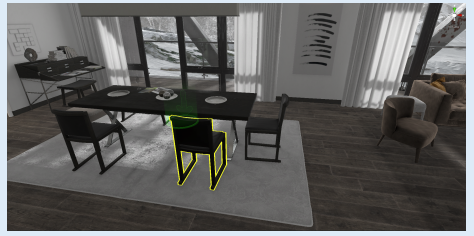
Large

Occlusion of the target position

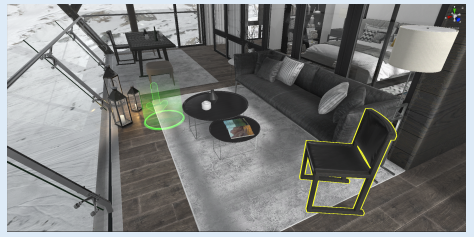
Unoccluded



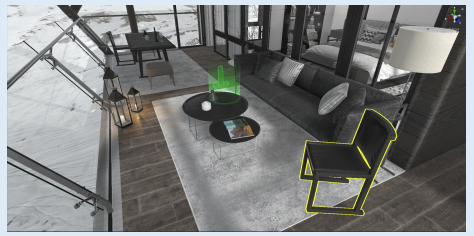
Occluded



Unoccluded

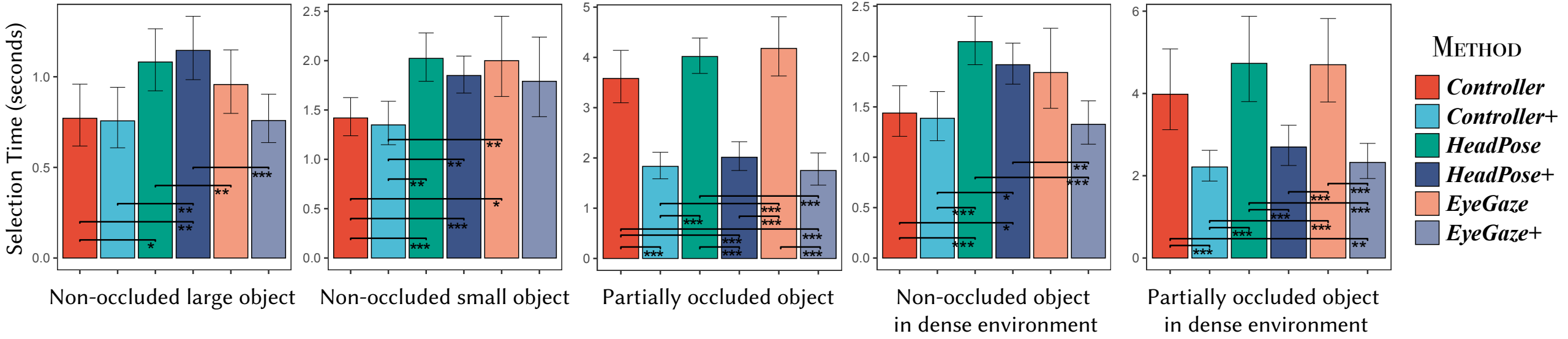


Occluded



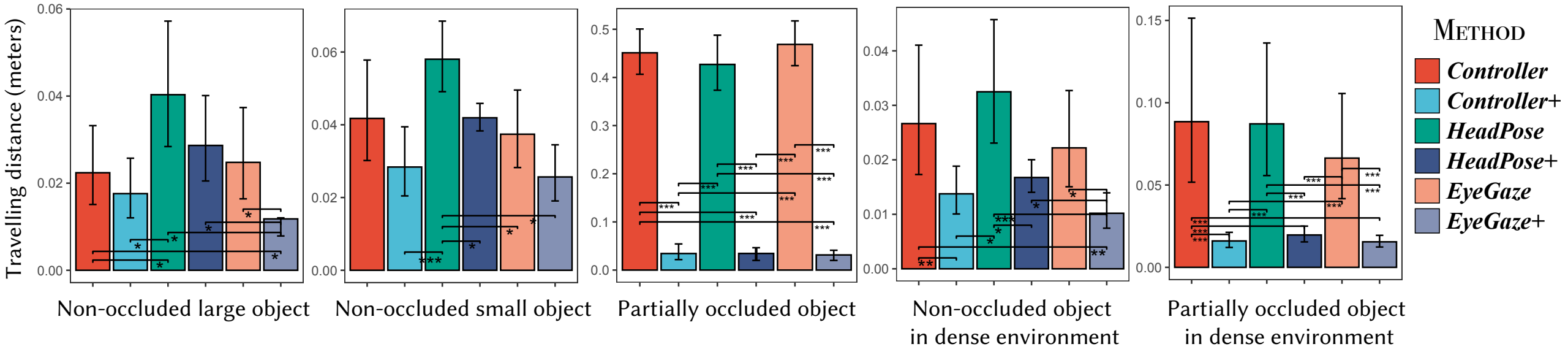
Statistical results of the selection study

*Selection time for methods regarding the interaction conditions with non-occluded large object, non-occluded small object, partially occluded object, non-occluded object in dense environment, and partially occluded object in dense environment. Significant differences are marked with stars (***p<.001, **p<.01 and *p<.05). Error bars indicate the 95% confidence interval.*



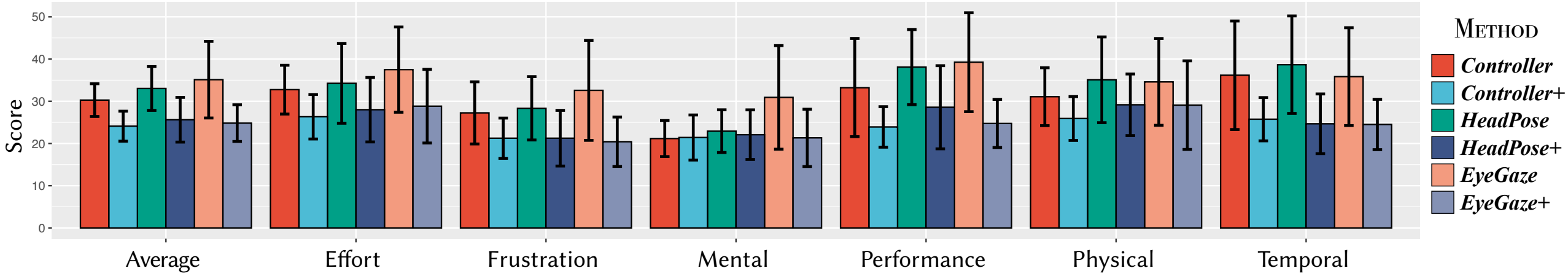
Statistical results of the selection study

*Travelling distance for methods regarding the interaction conditions with non-occluded large object, non-occluded small object, partially occluded object, non-occluded object in dense environment, and partially occluded object in dense environment. Significant differences are marked with stars (***p<.001, **p<.01 and *p<.05). Error bars indicate the 95% confidence interval.*



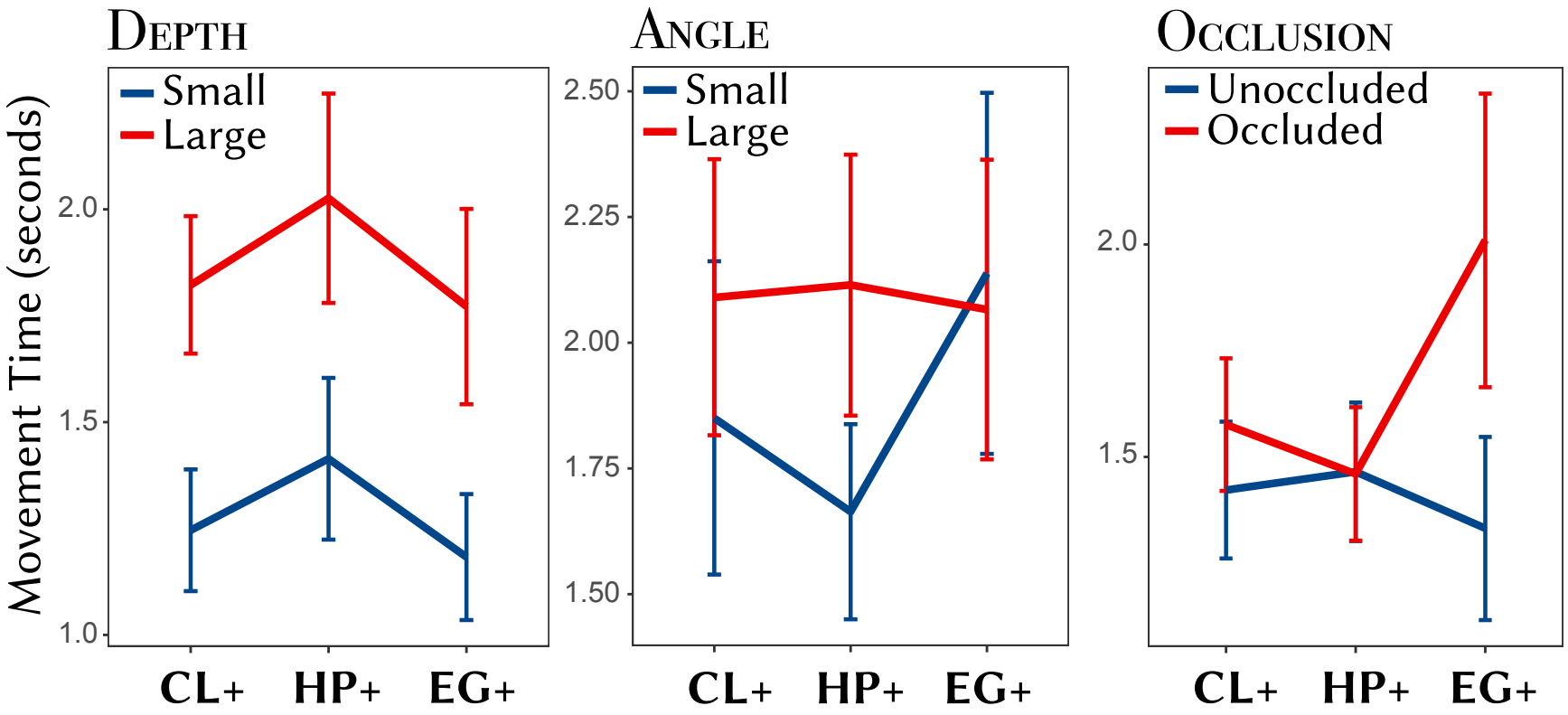
Statistical results of the selection study

NASA-TLX results of the selection study. Error bars indicate the 95% confidence interval.



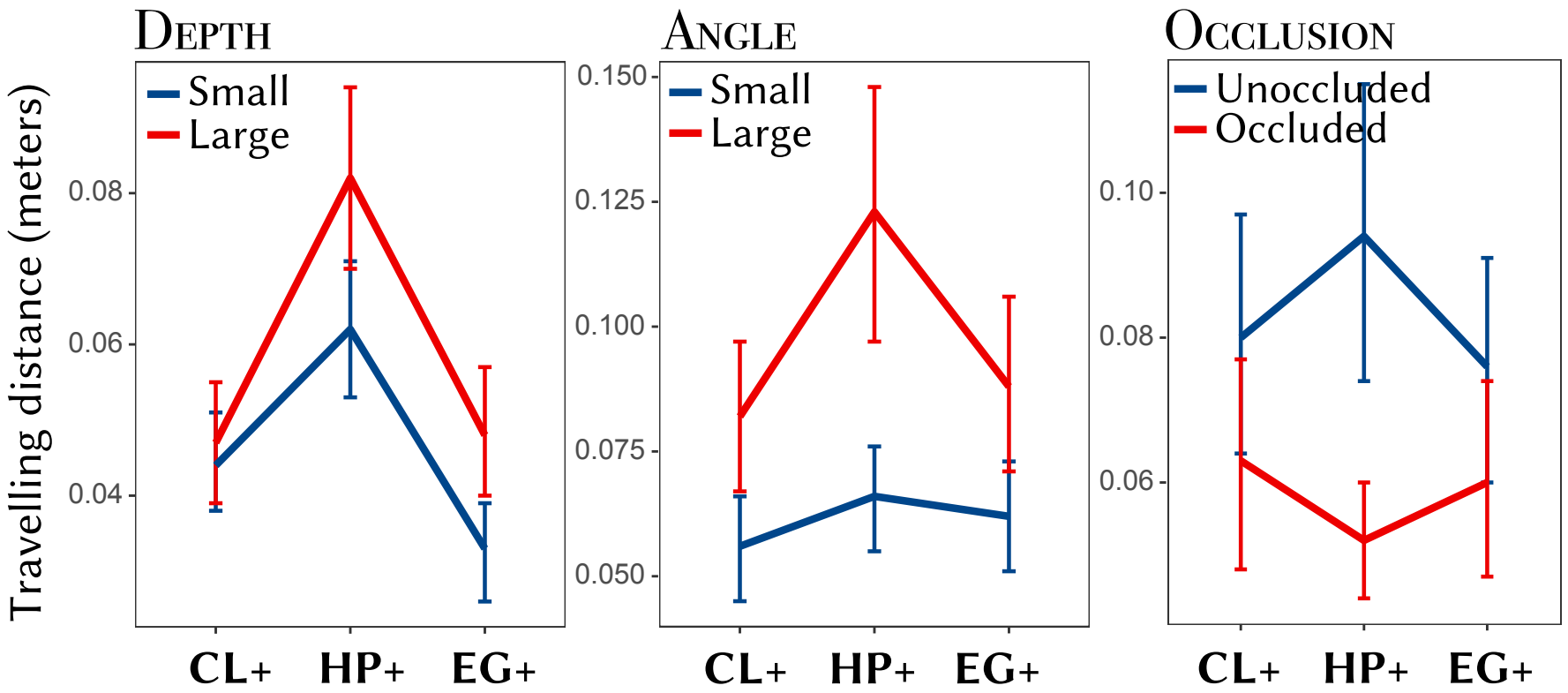
Statistical results of the movement study

The movement time for methods on different levels of moving depth (left), moving angle (middle) and occlusion of target position (right). "CL+" represents Controller+, "HP+" represents HeadPose+, and "EG+" stands for EyeGaze+. Error bars indicate the 95% confidence interval.



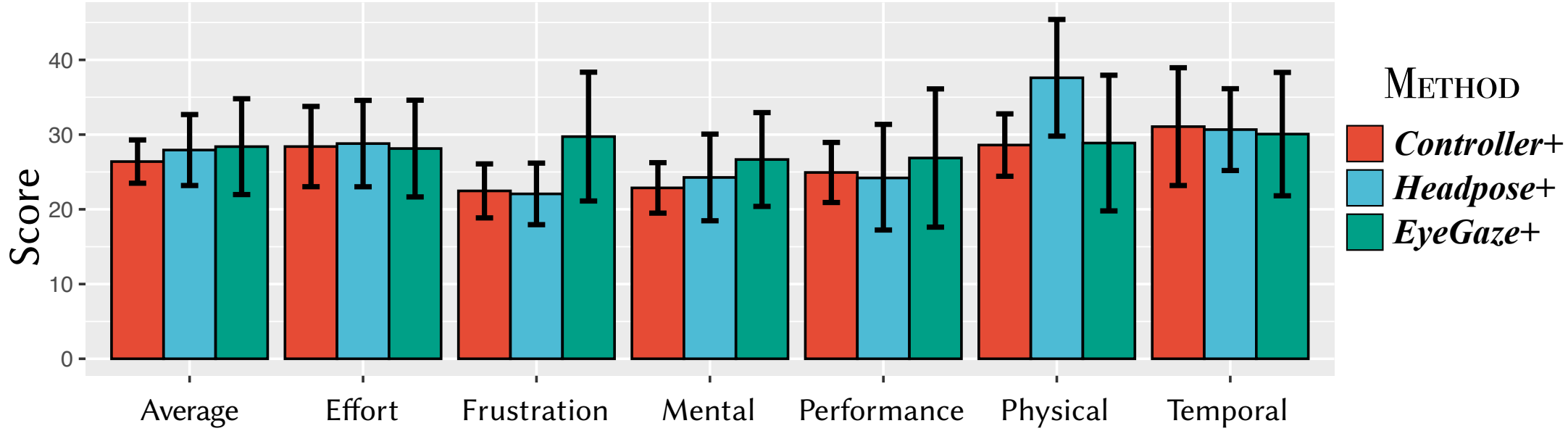
Statistical results of the movement study

The travelling distance for methods on different levels of moving depth (left), moving angle (middle) and occlusion of target position (right). "CL+" represents Controller+, "HP+" represents HeadPose+, and "EG+" stands for EyeGaze+. Error bars indicate the 95% confidence interval.



Statistical results of the movement study

NASA-TLX results of the movement study. Error bars indicate the 95% confidence interval.



User study analysis report: Experiment 1

*P-values of post-hoc analysis for **selection time***

Condition: Non-occluded Large Object							
Method	Mean (Seconds)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	0.771	——	1.000	0.029	0.007	1.000	1.000
Controller+	0.757	1.000	——	0.083	0.003	1.000	1.000
HeadPose	1.081	0.029	0.083	——	1.000	1.000	0.003
HeadPose+	1.146	0.007	0.003	1.000	——	1.000	<0.001
EyeGaze	0.957	1.000	1.000	1.000	1.000	——	0.922
EyeGaze+	0.759	1.000	1.000	0.003	<0.001	0.922	——

Condition: Non-occluded Small Object							
Method	Mean (Seconds)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	1.419	——	1.000	<0.001	0.006	0.045	0.315
Controller+	1.349	1.000	——	<0.001	0.001	0.002	0.101
HeadPose	2.023	<0.001	<0.001	——	1.000	1.000	1.000
HeadPose+	1.849	0.006	0.001	1.000	——	1.000	1.000
EyeGaze	2.000	0.045	0.002	1.000	1.000	——	1.000
EyeGaze+	1.791	0.315	0.101	1.000	1.000	1.000	——

User study analysis report: Experiment 1

*P-values of post-hoc analysis for **selection time***

Condition: Partially Occluded Object							
Method	Mean (Seconds)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	3.581	——	<0.001	1.000	<0.001	0.936	<0.001
Controller+	1.832	<0.001	——	<0.001	1.000	<0.001	1.000
HeadPose	4.018	1.000	<0.001	——	<0.001	1.000	<0.001
HeadPose+	2.014	<0.001	1.000	<0.001	——	<0.001	1.000
EyeGaze	4.178	0.936	<0.001	1.000	<0.001	——	<0.001
EyeGaze+	1.750	<0.001	1.000	<0.001	1.000	<0.001	——

Condition: Non-occluded Object in Dense Environment Object							
Method	Mean (Seconds)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	1.439	——	1.000	<0.001	0.018	0.108	1.000
Controller+	1.387	1.000	——	<0.001	0.012	0.294	1.000
HeadPose	2.148	<0.001	<0.001	——	0.998	1.000	<0.001
HeadPose+	1.919	0.018	0.012	0.998	——	1.000	0.001
EyeGaze	1.841	0.108	0.294	1.000	1.000	——	0.200
EyeGaze+	1.327	1.000	1.000	<0.001	0.001	0.200	——

User study analysis report: Experiment 1

*P-values of post-hoc analysis for **selection time***

Condition: Partially Occluded Object in Dense Environment							
Method	Mean (Seconds)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	3.981	——	<0.001	0.827	0.102	1.000	0.005
Controller+	2.213	<0.001	——	<0.001	0.496	<0.001	1.000
HeadPose	4.732	0.827	<0.001	——	<0.001	1.000	<0.001
HeadPose+	2.698	0.102	0.496	<0.001	——	<0.001	1.000
EyeGaze	4.699	1.000	<0.001	1.000	<0.001	——	<0.001
EyeGaze+	2.323	0.005	1.000	<0.001	1.000	<0.001	——

User study analysis report: Experiment 1

*P-values of post-hoc analysis for **travelling distance***

Condition: Non-occluded Large Object							
Method	Mean (Meters)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	0.022	——	1.000	0.029	1.000	1.000	0.035
Controller+	0.018	1.000	——	0.030	0.280	1.000	0.481
HeadPose	0.040	0.029	0.030	——	0.091	0.343	<0.001
HeadPose+	0.287	1.000	0.280	0.091	——	1.000	<0.001
EyeGaze	0.024	1.000	1.000	0.343	1.000	——	0.008
EyeGaze+	0.118	0.035	0.481	<0.001	<0.001	0.008	——

Condition: Non-occluded Small Object							
Method	Mean (Meters)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	0.042	——	0.308	0.300	1.000	1.000	0.160
Controller+	0.028	0.308	——	<0.001	0.357	1.000	1.000
HeadPose	0.058	0.300	<0.001	——	0.021	0.030	<0.001
HeadPose+	0.042	1.000	0.357	0.021	——	1.000	0.050
EyeGaze	0.037	1.000	1.000	0.030	1.000	——	0.332
EyeGaze+	0.026	0.160	1.000	<0.001	0.050	0.332	——

User study analysis report: Experiment 1

*P-values of post-hoc analysis for **travelling distance***

Condition: Partially Occluded Object							
Method	Mean (Meters)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	0.451	——	<0.001	1.000	<0.001	1.000	<0.001
Controller+	0.034	<0.001	——	<0.001	1.000	<0.001	1.000
HeadPose	0.427	1.000	<0.001	——	<0.001	0.819	<0.001
HeadPose+	0.035	<0.001	1.000	<0.001	——	<0.001	1.000
EyeGaze	0.468	1.000	<0.001	0.819	<0.001	——	<0.001
EyeGaze+	0.031	<0.001	1.000	<0.001	1.000	<0.001	——

Condition: Non-occluded Object in Dense Environment Object							
Method	Mean (Meters)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	0.027	——	0.001	1.000	0.236	1.000	0.001
Controller+	0.014	0.001	——	<0.001	1.000	0.176	1.000
HeadPose	0.032	1.000	<0.001	——	0.003	0.153	<0.001
HeadPose+	0.017	0.236	1.000	0.003	——	1.000	0.046
EyeGaze	0.022	1.000	0.176	0.153	1.000	——	0.012
EyeGaze+	0.010	0.001	1.000	<0.001	0.046	0.012	——

User study analysis report: Experiment 1

*P-values of post-hoc analysis for **travelling distance***

Condition: Partially Occluded Object in Dense Environment							
Method	Mean (Meters)	Controller	Controller+	HeadPose	HeadPose+	EyeGaze	EyeGaze+
Controller	0.088	——	<0.001	1.000	<0.001	1.000	<0.001
Controller+	0.016	<0.001	——	<0.001	1.000	<0.001	1.000
HeadPose	0.087	1.000	<0.001	——	<0.001	1.000	<0.001
HeadPose+	0.020	<0.001	1.000	<0.001	——	<0.001	1.000
EyeGaze	0.066	1.000	<0.001	1.000	<0.001	——	<0.001
EyeGaze+	0.015	<0.001	1.000	<0.001	1.000	<0.001	——

User study analysis report: Experiment 2

Movement time: no significant Method×Depth effect was found (F(2,58)=0.063, p=0.939, η_p^2 =0.002). Method had a significant main effect on the movement time (F(2,58)=7.649,p=0.001, η_p^2 =0.209).

P-values of post-hoc analysis Condition: Large and Small Depth				
Method	Mean (Seconds)	Controller+	HeadPose+	EyeGaze+
Controller+	1.534	——	0.021	1.000
HeadPose+	1.720	0.021	——	0.004
EyeGaze+	1.477	1.000	0.004	——

Movement time: A significant interaction effect of Method×Angle was found (F(1.43,41.46)=7.110,p=0.005, η_p^2 =0.197). Method had a significant effect only under small angle condition (F(2,58)=6.929,p=0.002)).

P-values of post-hoc analysis Condition: Small Angle				
Method	Mean (Seconds)	Controller+	HeadPose+	EyeGaze+
Controller+	1.850	——	0.170	0.222
HeadPose+	1.644	0.170	——	0.003
EyeGaze+	2.138	0.222	0.003	——

User study analysis report: Experiment 2

Movement time: a significant interaction effect of Method×Occlusion was found ($F(1.33,38.64)=12.774$, $p<0.001$, $\eta_p^2=0.306$). Method had a significant effect on movement time when moving an object onto occluded target position ($F(1.23,35.59)=6.67$, $p=0.01$).

P-values of post-hoc analysis Condition: Occluded				
Method	Mean (Seconds)	Controller+	HeadPose+	EyeGaze+
Controller+	1.576	——	0.365	0.096
HeadPose+	1.460	0.365	——	0.016
EyeGaze+	2.010	0.096	0.016	——

Travelling distance: no significant Method×Depth effect was found ($F(2,58)=2.612$, $p=0.082$, $\eta_p^2=0.083$). Method had a significant main effect on the movement time ($F(2,58)=62.891$, $p<0.001$, $\eta_p^2=0.684$).

P-values of post-hoc analysis Condition: Large and Small Depth				
Method	Mean (Meters)	Controller+	HeadPose+	EyeGaze+
Controller+	0.045	——	0.004	0.002
HeadPose+	0.072	0.004	——	0.003
EyeGaze+	0.040	0.002	0.003	——

User study analysis report: Experiment 2

Travelling distance: a significant interaction effect of Method×Angle was found ($F(2,58)=8.047$, $p=0.001$, $\eta_p^2=0.217$). Method had a significant effect only under large angle condition ($F(1.475,42.764)=18.923$, $p<0.001$).

P-values of post-hoc analysis Condition: Large Angle				
Method	Mean (Meters)	Controller+	HeadPose+	EyeGaze+
Controller+	0.082	——	<0.001	0.460
HeadPose+	0.123	<0.001	——	0.001
EyeGaze+	0.088	0.460	0.001	——

Thank you!