Supplementary Material:
Performance in a Collaborative Search Task: The Role of Feedback and Alignment

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Additional measures influencing attention allocation and gaze alignment

In this section, we examine other bottom-up and top-down measures that may modulate the alignment of the dyads' gaze over time. We mostly aim at explaining the large increase of recurrence rate observed for the No-Feedback and Minimal-Feedback condition in the windowed cross-gaze recurrence at the beginning and at the end of the trial (section: *Gaze Recurrence over Time*).

We look at: (1) the effect of *visual saliency*, which is known to attract attention during early phases of scene processing; (2) the *number of objects* explored by the dyad, which roughly indicate how much scene information was attended, and the related measure of (3) the *probability of the dyad to align gaze onto the same objects at the same time*, which technically represents the recurrence of gaze when delays are not introduced.

These measures were computed over the normalised time-course (101 bins), and means taken in windows of 10 bins each, correct trials only, visualised in Figure 1. We used LME analyses to assess statistical significance between feedback conditions (No-Feedback, Minimal-Feedback, Full Dialogue) over Time (represented as an orthogonal polynomial of order 2), as explained in section: *Analysis*.

We have computed a saliency map of each scene using the classic model by (Itti & Koch, 2000) and extracted the saliency value associated at each fixation location for each interlocutor in the dyad. We find a clear effect of visual saliency whereby the dyad looked more at salient regions at scene onset, especially when feedback is minimal or absent. Moreover, the effect of visual saliency decreases by the end of the trial, but again, significantly less when dyads cannot fully interact (see Panel A of Figure 1 and refer to Table 1 for the model coefficients).

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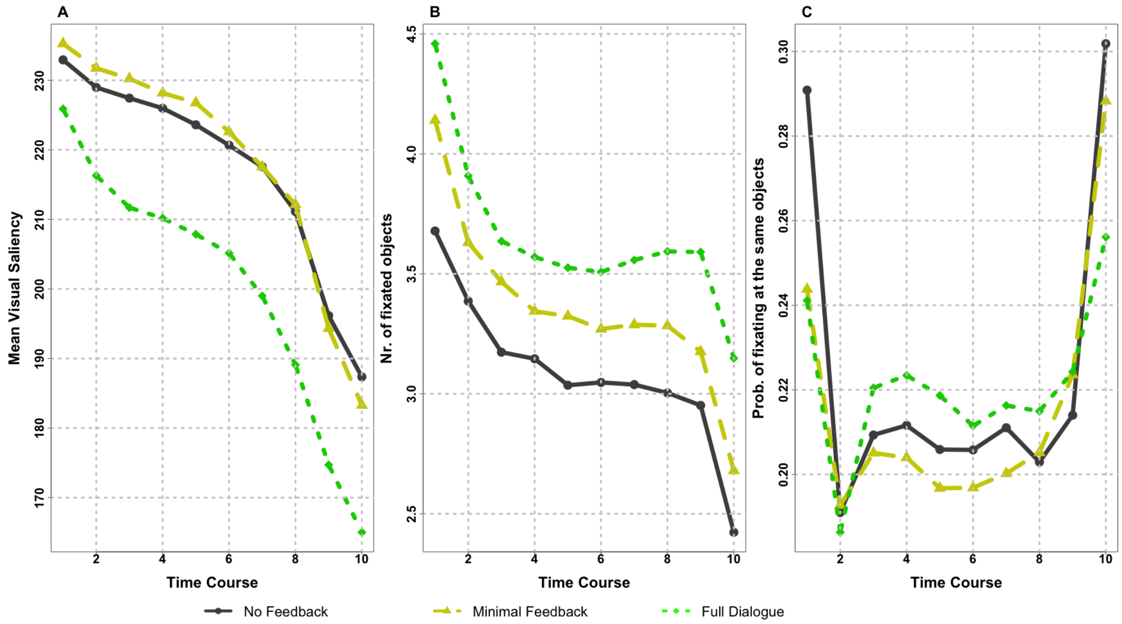


Figure 1. Bottom-up and top-down measures influencing the attentional alignment of the dyad along the time-course during successful interactions (i.e., correct trials only) in the three feedback conditions (No-Feedback: black, tick line; Minimal-Feedback: yellow, dashed line; Full-Dialogue: green, dotted line). (A) visual saliency at the fixation location, (B) the number of fixated objects, (C) the probability of looking at the same objects at the same time. We computed the means of these measures over 101 points of the normalised time-course in 10 windows (10 units each).

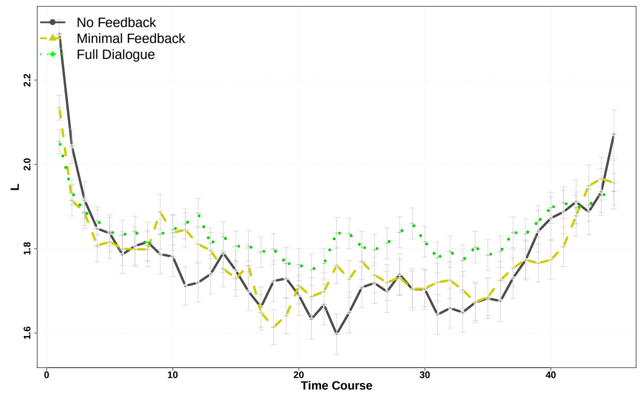
When looking at the number of fixated objects, we found that more objects are fixated by the dyad if they can fully interact (Figure 1, Panel B). Moreover, the dyad restricts the focus of attention on a smaller set of object over time, and this happens more prominently when the interlocutors are engaged in a full-dialogue.

As dyads tend to focus on more objects when they can interact, their overall probability of aligning gaze is smaller (Figure 1, Panel C). Furthermore, the less the exchange of feedback, the more likely is that the dyad would align gaze at the beginning of the trial, possibly on salient region as seen before, and likely on the target object, at the end of it. This result is observed in the positive coefficient for the interaction of No-Feedback and Minimal-Feedback with Time^2 (i.e., an upward bowing trend).

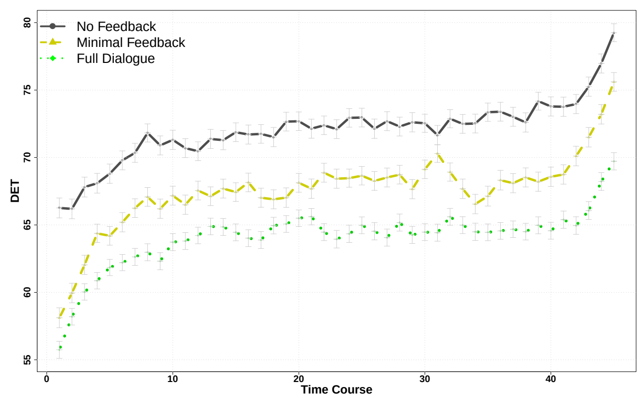
In summary, we confirm that feedback plays a fundamental role on how dyads modulate their attentional allocation to achieve successful detection performances. Crucially, however, absent or minimal feedback forces the dyad to resort more strongly on low-level visual information, and to restrict the focus of attention to smaller set of objects.

Time-course windowed analysis for the C/RQA measures of L, DET and ENTR

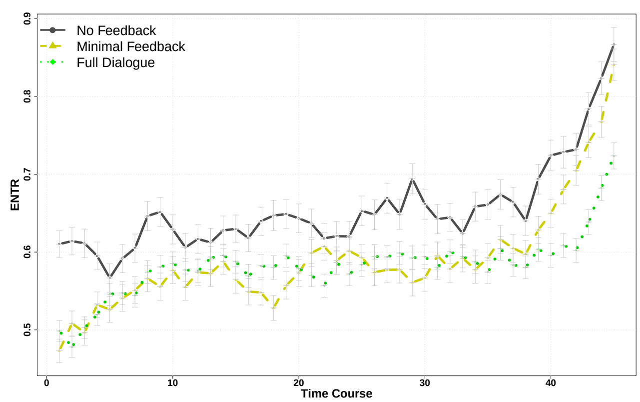
In this section, we examine the windowed time-course of the CRQA measures of line-length (L), determinism (DET) and entropy (ENTR) on correct trials only. Our aim is to provide the reader



(a) Line Length (L)



(b) Determinism (DET)



(c) Entropy (ENTR)

Figure 2. Windowed cross-recurrence of gaze for correct trials only in the three feedback conditions (No-Feedback: black, tick line; Minimal-Feedback: yellow, dashed line; Full-Dialogue: green, dotted line), over time (50 points, which results from moving the window by a step of 2 over 101 points of the normalized scan-patterns).

Table 1

Coefficients of mixed-effects models for the dependent variables of Visual Saliency, Nr. of Fixated Objects, and Probability of Gaze Alignment at time zero, organized across columns, and modeled as a function of the predictors Feedback *(sum-coded, with Full-Dialogue as the reference level for No-Feedback and Minimal-Feedback) and* Time *represented as an orthogonal polynomial of order two ($Time^1$ and $Time^2$). We report coefficient* β*, standard error, t-value and associated p-value. Random effects included are Dyad and Scene.*

	L			DET			ENTR		
Fixed Effect	β	SE	t	β	SE	t	β	SE	t
Intercept	192.66	6.02	31.9	3.64	0.06	59.2	0.22	0.008	27.57
$Time^1$	-54.39	0.97	-55.7	-0.78	0.03	-25.9	0.01	0.008	2.19
$Time^2$	-13.3	0.97	-13.62	0.33	0.03	11.1	0.02	0.008	3.32
No-Feedback	27.71	6.97	3.97	-0.61	0.12	-4.94	0.002	0.01	0.23
Minimal-Feedback	24.41	7.31	3.34	-0.32	0.11	-2.78	-0.007	0.01	-0.73
$Time^1$:No-Feedback	13.14	1.48	8.86	-0.06	0.04	-1.51	-0.006	0.01	-0.51
$Time^1$:Minimal-Feedback	7.27	1.43	5.06	-0.17	0.04	-3.99	0.01	0.01	1.15
$Time^2$:No-Feedback	-1.85	1.48	-1.25	-0.31	0.04	-7.24	0.06	0.01	4.9
$Time^2$:Minimal-Feedback	-5.28	1.43	-3.67	0.2	0.04	-4.75	0.04	0.12	3.48

$^{\circ}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

with a more complete picture of the dynamics of gaze alignment underlying successful detection performance.

When dyads are limited in the information that can be exchanged (Minimal-Feedback), or cannot interact (No-Feedback), we observe shorter L. This means that they can maintain gaze aligned for shorter periods of time (see Table 2). Moreover, we find a significant interaction between No-Feebdack and $Time^2$, which indicates the bowing trend, i.e., large increase at the beginning and end of the trial (see section , for additional insights on the factors responsible to such a trend). This result corroborates what observed in the recurrence rate reported in the main text, section: *Gaze Recurrence over Time*.

When looking at Determinism (DET), we find it significantly higher in the No-Feedback condition, as compared to both Minimal-Feedback and Full-Dialogue. Moreover, it increases over Time, substantially more for the Minimal-Feedback condition. This result indicates that despite the periods of alignment are shorter when dyad cannot fully interact, they are nevertheless build up more stably along the course of trial as compared to when dyads can establish a normal dialogue. This result also corroborates the overall pattern of results presented in the main text (section: *Gaze Alignment*). The possibility of exchanging information helps the dyad to divide their search space, hence making their gaze alignment less predictable.

Finally, we find higher ENTR for the No-Feedback condition, as compared to Full-Dialogue, with Minimal-Feedback being the condition with the smaller ENTR. Over time, however, the alignment of gaze in the No-Feedback and Minimal-Feedback condition becomes more entropic than Full-Dialogue. As argued in the main text, Full-Dialogue helps the dyad to establish a more regular pattern of alignment.

In summary, these results confirm, over the time-course, the main trends observed when

Table 2
Windowed cross-recurrence of gaze on correct trials. Coefficients of mixed-effects model of line length (L), determinism (DET), and entropy (ENTR), modeled as a function of the predictors Feedback *(sum-coded, with Full-Dialogue as the reference level for No-Feedback and Minimal-Feedback), and* Time *represented as an orthogonal polynomial of order two ($Time^1$ and $Time^2$). We report coefficient β, standard error, t-value and associated p-value. Random effects included are Dyad and Scene.*

	L			DET			ENTR		
Fixed Effect	β	SE	t	β	SE	t	β	SE	t
Intercept	1.83	0.02	77.64	70.46	1.32	53.58	0.64	0.02	32.03
$Time^1$	-0.11	0.1	-1.07	14.34	1.39	10.35	0.33	0.04	7.73
$Time^2$	0.6	0.08	7.81	-3.52	1.3	-2.7	0.1	0.04	2.64
No-Feedback	-0.02	0.01	-2.77	5.02	0.11	47.1	0.06	0	20.73
Minimal-Feedback	-0.02	0.01	-4.06	-0.45	0.1	-4.31	-0.02	0	-7.17
$Time^1$:No-Feedback	-0.02	0.04	-0.56	0.29	0.7	0.41	0.02	0.02	1.04
$Time^1$:Minimal-Feedback	-0.02	0.04	-0.6	2.13	0.68	3.31	0.08	0.02	4.41
$Time^2$:No-Feedback	0.26	0.04	7.11	2.12	0.69	3.07	0.07	0.02	4.10
$Time^2$:Minimal-Feedback	-0.02	0.04	-0.6	-1.44	0.68	-2.12	0.01	0.02	0.76

$^{\circ}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

cross-recurrence quantification analysis is applied to the trial as a whole.

References

Itti, L., & Koch, C. (2000). A saliency-based search mechanism for overt and covert shifts of visual attention. *Vision Research*, *40*(10-12), 1489–1506.