Supplementary Material

Eye see what you're saying: Contrastive use of beat gesture and pitch accent affects online interpretation of spoken discourse

Stimulus Norming for Experiments 1 and 2

To ensure that the co-occurrence of beat gesture and contrastive accenting and their local felicity with contrast in critical and filler sentences were perceived as expected, we conducted a norming study on a sample of stimuli from Experiments 1 and 2. This sample of stimuli consisted of 256 screen recordings of 16 experimental trials selected at random from Experiment 1 and 16 filler trials selected at random from Experiment 2. Eight lists of 32 screen recordings were constructed for the norming study to ensure that each trial appeared in every contrast/gesture/accent combination present in its respective trial type and experiment (see Appendix A for complete list of trials used in norming study). 78 participants who did not participate in either Experiment 1 or 2 completed the norming study in return for course credit. Each participant watched the screen recordings in one of the lists described above in random order and rated each of them on a 1 (completely unnatural) – 7 (completely natural) basis for gesture-accent co-occurrence (How well did the speaker's gestures match the speech?) and local felicity of these cues with contrast (How well did the speech style fit the instructions given?).

With respect to gesture-accent co-occurrence, beat gesture and contrastive accenting exerted an interactive effect on ratings such that the presence (M = 5.50, SD = 1.24) or absence (M = 5.52, SD = 1.19) of both cues was perceived as more natural than contrastive accenting in the absence of beat gesture (M = 4.65, SD = 1.57) and beat gesture in the absence of contrastive accenting (M = 3.17, SD = 1.62; see Table S9). With respect to local felicity, a three-way

interaction between contrast type, beat gesture, and contrastive accenting was observed (see Table S10). Examination of descriptive statistics revealed that beat gesture and contrastive accenting, which always occurred in conjunction with the color word, were perceived as most natural when they co-occurred and locally-felicitous with contrast (i.e., in color-contrast sentences; $M = 5.71$, $SD = 1.05$) and least natural when they occurred in the absence of the other and were locally-infelicitous with contrast (i.e., in color + shape-difference sentences; gesture only: $M = 2.75$, $SD = 1.35$, accent only: $M = 2.76$, $SD = 1.27$; in shape-contrast sentences: gesture only: $M = 2.76$, $SD = 1.34$, accent only: $M = 2.85$, $SD = 1.39$; in neither-difference sentences: gesture only: $M = 2.79$, $SD = 1.37$, accent only: $M = 2.80$, $SD = 1.42$). Taken together, these findings confirm that beat gesture and contrastive accenting are perceived as most natural when they co-occur with one another and are locally-felicitous with contrast.

Table S9

Fixed Effect (Top) and Variance (Bottom) Estimates for Multi-Level Model of Naturalness Ratings for Gesture-Accent Co-Occurrence (Observations = 4594). Note: $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Fixed effect	Coefficient	*SE*	*t*	*p*
Intercept	4.70	0.06	73.83	<.001***
Beat gesture	-0.75	0.08	-9.23	<.001***
Contrastive accenting	0.77	0.09	8.94	<.001***
Beat gesture x contrastive accenting	3.22	0.14	22.46	<.001***

Random effect	s^2
Participant	0.46
Participant x beat gesture	0.33
Participant x contrastive accenting	0.42
Item	0.48

Table S10

Fixed Effect (Top) and Variance (Bottom) Estimates for Multi-Level Model of Naturalness Ratings for Local Felicity of Beat Gesture and Contrastive Accenting with Contrast (Observations = 4593).

Note: $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Fixed effect	Coefficient	*SE*	*t*	*p*
Intercept	3.98	0.03	124.18	<.001***
Contrast type 1 (color- vs. color + shape, shape- and neither)	-1.39	0.06	-24.11	<.001***
Contrast type 2 (color- & color + shape vs. shape- and neither)	-0.84	0.05	-15.96	<.001***
Contrast type 3 (color-, color + shape, & shape- vs. neither)	-1.00	0.05	-20.52	<.001***
Beat gesture	-0.31	0.04	-7.47	<.001***
Contrastive accenting	-0.25	0.05	-5.17	<.001***
Contrast type 1 x beat gesture	-1.58	0.12	-13.66	<.001***
Contrast type 2 x beat gesture	-1.23	0.10	-11.76	<.001***
Contrast type 3 x beat gesture	-0.03	0.10	-0.32	0.75
Contrast type 1 x contrastive accenting	-1.60	0.12	-13.88	<.001***
Contrast type 2 x contrastive accenting	-1.25	0.10	-11.89	<.001***
Contrast type 3 x contrastive accenting	0.02	0.10	0.26	0.80
Beat gesture x contrastive accenting	1.95	0.08	23.21	<.001***
Contrast type 1 x beat gesture x contrastive accenting	5.67	0.23	24.50	<.001***
Contrast type 2 x beat gesture x contrastive accenting	2.10	0.21	9.99	<.001***
Contrast type 3 x beat gesture x contrastive accenting	-0.44	0.20	-2.25	.03

Random effect	s^2
Participant	0.21
Participant x contrastive accenting	0.23
Item	0.10

Experiment 1-Experiment 2 Comparison

To directly compare the influences of beat gesture, pitch accent, and local and global felicity on reference resolution during spoken discourse comprehension, we combined the data from Experiments 1 and 2 and analyzed it using a series of linear mixed-effect models publicly available via the following link: https://osf.io/fy6wp/.

These models included fixed effects of beat gesture (beat, no beat) and pitch accent (contrastive, non-contrastive) to examine how these cues to contrast affected reference

resolution, contrast type (color, color + shape) to examine differential effects of these cues on resolution of referents with a specific contrast vs. a general difference, and experiment (1, 2) to examine differential effects of these cues on reference resolution based on their global felicity as cues to contrast in filler trials, and trial to examine how these effects changed over time, as well as interactions between these factors. In addition, all models included fixed effects of gesture orientation (left, right) and target object side (left, right) and their interaction to examine whether congruency between the side on which beat gesture and the target object occurred affected fixations.

Given our interest in both (a) participants' a priori expectations about beat gesture and contrastive accenting and (b) changes in their interpretations over the course of the experiment, Trial Number was uncentered so that (a) simple effects independent of trial number correspond to effects at trial number 0 (i.e., prior to any within-experiment adaptation) and (b) interactions with trial number reflect change over the course of the experiment. All fixed effects were coded using mean centered (Helmert) contrast coding, with the level mentioned first for each factor coded as -0.5 and the level mentioned second coded as +0.5. In all models, the maximal random effects structure permitting convergence was used.

All models were fit in R using the lmer() function of the *lme4* package (Bates et al., 2015). Null hypothesis significance testing was conducted using the *lmerTest* package (Kuznetsova et al., 2017). For interactions reaching significance, Tukey HSD post-hoc tests were conducted using the *emmeans* package (Lenth, 2019), and comparisons of the effects of beat gesture and pitch accenting within each contrast type and experiment are reported where appropriate.

S.1.1. Trial Onset Interest Period.

Target fixations. We observed a main effect of trial, indicating that, in both Experiments, target fixations decreased over the course of the experiment. We also observed a significant main effect of experiment (see Table S11), indicating that more fixations on targets occurred during the trial onset interest period of critical referring expressions in Experiment 2 ($M = 0.022$, $SD = 0.151$) than Experiment 1 ($M = 0.001$, $SD = 0.018$). Combined with the higher rate of competitor fixations in Experiment 2, reported below, this implies that participants fixated the two potential continuations of critical referring expressions (the color-contrast object and the both-contrast object) at a higher rate in Experiment 2.

We also observed a four-way interaction between beat gesture, contrast type, experiment, and trial, such that the combination of beat gesture and contrast accenting initially favored target fixations to a greater degree in Experiment 2, but this difference declined over the course of the experiment. Since this interaction occurred before the onset of the color word and thus before either beat gesture or contrastive accenting was actually present in the input, and it did not reach significant within the separate analysis of Experiment 2, it is likely spurious; thus, we do not interpret or discuss it further.

Table S11

Fixed Effect (Top) and Variance Estimates (Bottom) for Multi-Level Model of Target Fixations During Trial Onset Interest Period Across Experiments (Observations = 6,242)

Fixed effect	Coefficient	*SE*	*t*	*p*
Intercept	-0.19	0.03	-7.47	< .001***
Contrastive accenting	-0.01	0.02	-0.16	.87
Beat gesture	0.03	0.03	1.27	.20
Contrast type (color-contrast vs. color + shape difference)	-0.01	0.02	-0.10	.92
Experiment (Experiment 2 vs. Experiment 1)	0.42	0.05	8.03	< .001***
Trial	-0.01	0.01	-3.52	< .001***
Contrastive accenting x beat gesture	-0.02	0.05	0.51	.61
Contrastive accenting x contrast type	0.15	0.08	1.88	.06†
Contrastive accenting x experiment	0.04	0.05	0.73	.46
Contrastive accenting x trial	0.01	0.01	0.46	.65
Beat gesture x contrast type	-0.05	0.05	-1.13	.26
Beat gesture x experiment	-0.06	0.05	-1.24	.21
Beat gesture x trial	-0.01	0.01	-0.91	.36
Contrast type x experiment	-0.03	0.05	0.70	.48
Contrast type x trial	-0.01	0.01	-0.88	.38
Experiment x trial	-0.01	0.01	-0.75	.46
Contrastive accenting x beat gesture x contrast type	-0.09	0.10	-0.93	.35
Contrastive accenting x beat gesture x experiment	0.05	0.10	-0.55	.58
Contrastive accenting x beat gesture x trial	-0.01	0.01	-0.07	.94
Contrastive accenting x contrast type x experiment	-0.26	0.16	-1.59	.11
Contrastive accenting x contrast type x trial	-0.01	0.01	-1.48	.14
Contrastive accenting x experiment x trial	-0.01	0.01	-0.54	.59
Beat gesture x contrast type x experiment	0.18	0.10	1.91	.06†
Beat gesture x contrast type x trial	0.01	0.01	0.89	.38
Beat gesture x experiment x trial	0.01	0.01	0.51	.61
Contrast type x experiment x trial	0.01	0.01	1.78	.08†

Contrastive accenting x beat gesture x contrast type x experiment	0.02	0.20	0.98	.33
Contrastive accenting x beat gesture x contrast type x trial	0.01	0.01	0.67	.51
Contrastive accenting x beat gesture x experiment x trial	0.01	0.01	0.03	.98
Contrastive accenting x contrast type x experiment x trial	0.01	0.01	0.96	.34
Beat gesture x contrast type x experiment x trial	-0.01	0.01	-2.30	.02*
Contrastive accenting x beat gesture x contrast type x experiment x trial	-0.01	0.01	-0.56	.57
Gesture orientation	-0.01	0.02	-3.52	.42
Object side	-0.01	0.02	-0.81	.27
Gesture orientation x object side	-0.01	0.02	-0.37	.71

Random effect	s^2
Participant	0.20
Participant x beat gesture	0.08

Competitor fixations. Again, we also observed a main effect of trial, indicating that fixations decreased over time. We also observed a significant main effect of experiment (see Table S12), indicating that more fixations occurred on competitor objects during the trial onset interest period of critical referring expressions in Experiment 2 (M = 0.022, SD = 0.151) than Experiment 1 (M = 0.002, SD = 0.044); as above, this appears to be driven by a higher overall baseline preference in Experiment 2 for the two potential continuations of critical referring expressions (the color-contrast object and the both-contrast object).

We also observed a four-way interaction between beat gesture, contrast type, experiment, and trial that was the converse of the four-way interaction on target fixations reported above, which is likely spurious for the reasons discussed above.

Table S12

Fixed Effect (Top) and Variance Estimates (Bottom) for Multi-Level Model of Competitor Fixations During Trial Onset Interest Period Across Experiments (Observations = 6,242)

Fixed effect	Coefficient	*SE*	*t*	*p*
Intercept	-0.21	0.03	-7.98	< .001***
Contrastive accenting	-0.11	0.02	-0.47	.64
Beat gesture	0.17	0.03	0.67	.50
Contrast type (color-contrast vs. color + shape difference)	-0.01	0.02	-0.41	.68
Experiment (Experiment 2 vs. Experiment 1)	0.43	0.05	8.33	< .001***
Trial	-0.01	0.01	-2.19	.03*
Contrastive accenting x beat gesture	0.02	0.05	0.50	.62
Contrastive accenting x contrast type	0.10	0.08	1.23	.22
Contrastive accenting x experiment	0.05	0.05	0.96	.34
Contrastive accenting x trial	0.01	0.01	0.55	.58
Beat gesture x contrast type	-0.06	0.05	-1.15	.25
Beat gesture x experiment	-0.03	0.05	-0.64	.52
Beat gesture x trial	-0.01	0.01	-0.12	.90
Contrast type x experiment	-0.01	0.05	-0.52	.61
Contrast type x trial	0.01	0.01	0.62	.53
Experiment x trial	-0.01	0.01	-1.03	.31
Contrastive accenting x beat gesture x contrast type	-0.01	0.10	-0.06	.96
Contrastive accenting x beat gesture x experiment	-0.06	0.10	-0.60	.55
Contrastive accenting x beat gesture x trial	-0.01	0.01	-1.09	.28
Contrastive accenting x contrast type x experiment	-0.19	0.16	-1.17	.24
Contrastive accenting x contrast type x trial	-0.01	0.01	-0.39	.69
Contrastive accenting x experiment x trial	-0.01	0.01	-0.45	.65
Beat gesture x contrast type x experiment	0.15	0.10	1.58	.11
Beat gesture x contrast type x trial	0.01	0.01	1.10	.27
Beat gesture x experiment x trial	-0.01	0.01	-0.16	.87
Contrast type x experiment x trial	0.01	0.01	0.77	.44

Contrastive accenting x beat gesture x contrast type x experiment	0.07	0.20	0.35	.72
Contrastive accenting x beat gesture x contrast type x trial	0.01	0.01	0.08	.94
Contrastive accenting x beat gesture x experiment x trial	0.01	0.01	1.29	.20
Contrastive accenting x contrast type x experiment x trial	0.01	0.01	0.18	.86
Beat gesture x contrast type x experiment x trial	-0.01	0.01	-2.19	.03*
Contrastive accenting x beat gesture x contrast type x experiment x trial	-0.01	0.01	-0.37	.71
Gesture orientation	-0.02	0.01	-1.77	.08†
Object side	-0.01	0.01	-0.85	.39
Gesture orientation x object side	0.01	0.02	0.42	.67

Random effect	s^2
Participant	0.20
Participant x beat gesture	0.07

S.1.2. Color Word Interest Period.

Target fixations. We observed a significant 3-way interaction between beat gesture, contrast type, and experiment (see Table S13), which we explored by conducting Tukey HSD-corrected post-hoc tests (see Table S14). These tests revealed that, during color- + shape-difference critical referring expressions in Experiment 1, more target fixations occurred when beat gesture was absent than when beat gesture was present. That is, when the target differed in both color and shape from a previous context object, misleadingly emphasizing the color word with beat gesture reduced anticipatory fixations towards the correct target. This was true only within a linguistic context in which beat gesture was globally felicitous with contrast (Experiment 1); the corresponding effect was not significant within Experiment 2 ($p = .95$). The 3-way interaction was further qualified by a differently-signed interaction with trial, indicating that this effect decreased over the course of the experiment.

Table S13

Fixed Effect (Top) and Variance Estimates (Bottom) for Multi-Level Model of Target Fixations During Color Word Interest Period Across Experiments (Observations = 6,248)

Fixed effect	Coefficient	*SE*	*t*	*p*
Intercept	-0.28	0.03	-10.14	< .001***
Contrastive accenting	-0.01	0.03	-0.43	.67
Beat gesture	0.03	0.03	1.07	.29
Contrast type (color-contrast vs. color + shape difference)	0.02	0.03	0.58	.56
Experiment (Experiment 2 vs. Experiment 1)	0.09	0.05	1.63	.11
Trial	0.01	0.01	1.72	.09†
Contrastive accenting x beat gesture	-0.01	0.05	-0.07	.94
Contrastive accenting x contrast type	-0.08	0.08	-0.89	.37
Contrastive accenting x experiment	-0.07	0.05	-2.67	.008**
Contrastive accenting x trial	0.01	0.01	1.35	.18
Beat gesture x contrast type	0.09	0.05	1.83	.07†
Beat gesture x experiment	-0.25	0.06	-4.23	< .001***
Beat gesture x trial	-0.01	0.01	-0.23	.82
Contrast type x experiment	0.45	0.05	1.38	.17
Contrast type x trial	-0.01	0.01	0.99	.32
Experiment x trial	-0.01	0.01	-1.34	.18
Contrastive accenting x beat gesture x contrast type	0.15	0.11	1.39	.17
Contrastive accenting x beat gesture x experiment	0.15	0.10	1.49	.14
Contrastive accenting x beat gesture x trial	0.01	0.01	0.11	.91
Contrastive accenting x contrast type x experiment	-0.29	0.17	-1.72	.09†
Contrastive accenting x contrast type x trial	0.01	0.01	2.12	.03*
Contrastive accenting x experiment x trial	0.01	0.01	2.24	.34
Beat gesture x contrast type x experiment	-0.40	0.10	-3.93	< .001***
Beat gesture x contrast type x trial	-0.01	0.01	-1.28	.14
Beat gesture x experiment x trial	0.01	0.01	3.59	< .001***
Contrast type x experiment x trial	-0.01	0.01	-0.97	.33

Contrastive accenting x beat gesture x contrast type x experiment	0.14	0.22	0.65	.51
Contrastive accenting x beat gesture x contrast type x trial	-0.01	0.01	-1.70	.08†
Contrastive accenting x beat gesture x experiment x trial	-0.01	0.01	-2.03	.04*
Contrastive accenting x contrast type x experiment x trial	0.01	0.01	2.11	.03*
Beat gesture x contrast type x experiment x trial	0.01	0.01	2.94	.003**
Contrastive accenting x beat gesture x contrast type x experiment x trial	-0.01	0.01	-0.29	.77
Gesture orientation	0.01	0.01	0.66	.51
Object side	-0.01	0.01	-0.12	.91
Gesture orientation x object side	0.03	0.02	1.14	.25

Random effect	s^2
Participant	0.21
Participant x contrastive accenting	0.07
Participant x beat gesture	0.14

Table S14

Tukey HSD-Corrected Post-Hoc Tests for Beat Gesture x Contrast Type x Experiment Interaction in Model of Target Fixations During Color Word Interest Period Across Experiments

Comparison	Estimate	*SE*	*z*-ratio	*p*
No beat, color, Expt. 1 vs. no beat, color, Expt. 2	-0.06	0.06	-1.05	.97
No beat, color + shape, Expt. 1 vs. no beat, color + shape, Expt. 2	-0.16	0.06	-2.68	.13
No beat, color, Expt. 1 vs. no beat, color + shape, Expt. 1	0.07	0.03	2.88	.08†
No beat, color, Expt. 2 vs. no beat, color + shape, Expt. 2	-0.02	0.02	-0.94	.98
No beat, color, Expt. 1 vs. beat, color, Expt. 1	-0.02	0.03	-0.66	.99
No beat, color, Expt. 2 vs. beat, color, Expt. 2	0.01	0.03	0.06	.99
No beat, color + shape, Expt. 1 vs. beat, color + shape, Expt. 1	-0.12	0.03	-3.91	.002**

No beat, color + shape, Expt. 2 vs. beat, color + shape, Expt. 2	0.04	0.03	1.14	.95
Beat, color, Expt. 1 vs. beat, color + shape, Expt. 1	-0.03	0.03	-1.16	.94
Beat, color, Expt. 2 vs. beat, color + shape, Expt. 2	0.01	0.02	0.53	.99
Beat, color, Expt. 1 vs. beat, color, Expt. 2	-0.04	0.05	-0.73	.99
Beat, color + shape, Expt. 1 vs. beat, color + shape, Expt. 2	0.01	0.05	0.07	.99

Competitor fixations. We again observed a three-way interaction between beat gesture, contrast type, and experiment (see Table S15), which we explored by conducting Tukey HSD-corrected post-hoc tests (see Table S16). These tests revealed that, in Experiment 1, more fixations occurred on color-contrast competitors of color- + shape-difference critical referring expressions when beat gesture was present than when beat gesture was absent ($p = .004$). That is, within a linguistic context in which beat gesture was globally felicitous with contrast, the presence of beat gesture during a color word misled comprehenders into anticipating the color-contrast competitor of critical referring expressions differing in both color and shape from a previous context referring expression. This was not in the case in Experiment 2 ($p = .98$).

We also observed two other interactions. First, an interaction between contrastive accenting and experiment indicated that contrastive accenting led to fewer competitor fixations in Experiment 2, independent of whether the color word had contrastive accenting or not. That is, in the experiment in which contrastive accenting was no longer a globally felicitous cue to contrast, contrastive accenting discouraged competitor fixations regardless of whether a contrastive accent was present. By contrast, in Experiment 1, in which contrastive accenting was a globally-felicitous cue to contrast, the absence of contrastive accenting led to more competitor fixations than its presence (see Table S17).

Second, a three-way interaction of contrastive accenting, contrast type, and trial number indicated that, across experiments, the presence of contrastive accenting on the color word led to fewer fixations on the color- + shape-competitors (consistent with a contrastive interpretation), but that this difference declined over the course of the experiments.

Table S15

Fixed Effect (Top) and Variance Estimates (Bottom) for Multi-Level Model of Competitor Fixations During Color Word Interest Period Across Experiments (Observations = 6,248)

Fixed effect	Coefficient	*SE*	*t*	*p*
Intercept	-0.27	0.03	-10.29	< .001***
Contrastive accenting	-0.02	0.03	-0.71	.48
Beat gesture	-0.02	0.03	-0.64	.52
Contrast type (color-contrast vs. color + shape difference)	0.05	0.03	1.86	.06†
Experiment (Experiment 2 vs. Experiment 1)	0.10	0.05	1.97	.05†
Trial	0.01	0.01	1.71	.09†
Contrastive accenting x beat gesture	-0.04	0.05	-0.75	.45
Contrastive accenting x contrast type	-0.06	0.08	-0.71	.48
Contrastive accenting x experiment	-0.14	0.01	-2.80	.005**
Contrastive accenting x trial	0.01	0.01	1.85	.06†
Beat gesture x contrast type	0.06	0.05	1.26	.21
Beat gesture x experiment	0.14	0.06	2.44	.02*
Beat gesture x trial	0.01	0.01	1.83	.07†
Contrast type x experiment	-0.03	0.05	0.49	.62
Contrast type x trial	-0.01	0.01	-0.90	.37
Experiment x trial	-0.01	0.01	-1.49	.14
Contrastive accenting x beat gesture x contrast type	0.03	0.11	0.27	.79
Contrastive accenting x beat gesture x experiment	0.14	0.10	1.38	.17
Contrastive accenting x beat gesture x trial	0.01	0.01	0.61	.54
Contrastive accenting x contrast type x experiment	-0.21	0.16	-1.30	.20
Contrastive accenting x contrast type x trial	0.01	0.01	2.25	.02*
Contrastive accenting x experiment x trial	0.01	0.01	1.70	.09†
Beat gesture x contrast type x experiment	-0.26	0.10	-2.50	.01*
Beat gesture x contrast type x trial	-0.01	0.01	-0.64	.52
Beat gesture x experiment x trial	0.01	0.01	1.34	.18
Contrast type x experiment x trial	-0.01	0.01	-0.51	.61

Contrastive accenting x beat gesture x contrast type x experiment	0.35	0.22	1.61	.11
Contrastive accenting x beat gesture x contrast type x trial	-0.01	0.01	-0.51	.61
Contrastive accenting x beat gesture x experiment x trial	-0.01	0.01	-1.55	.12
Contrastive accenting x contrast type x experiment x trial	0.01	0.01	0.76	.44
Beat gesture x contrast type x experiment x trial	0.01	0.01	1.41	.16
Contrastive accenting x beat gesture x contrast type x experiment x trial	-0.01	0.01	-1.47	.14
Gesture orientation	-0.01	0.01	0.73	.47
Object side	0.02	0.01	1.49	.14
Gesture orientation x object side	-0.04	0.02	-1.72	.09†

Random effect	s^2
Participant	0.20
Participant x beat gesture	0.12

Table S16

Tukey HSD-Corrected Post-Hoc Tests for Beat Gesture x Contrast Type x Experiment Interaction in Model of Competitor Fixations During Color Word Interest Period Across Experiments

Comparison	Estimate	*SE*	*z*-ratio	*p*
No beat, color, Expt. 1 vs. no beat, color, Expt. 2	-0.11	0.06	-1.93	.53
No beat, color + shape, Expt. 1 vs. no beat, color + shape, Expt. 2	-0.12	0.06	-2.20	.35
No beat, color, Expt. 1 vs. no beat, color + shape, Expt. 1	-0.01	0.02	-0.06	.99
No beat, color, Expt. 2 vs. no beat, color + shape, Expt. 2	-0.02	0.02	-0.69	.99
No beat, color, Expt. 1 vs. beat, color, Expt. 1	-0.01	0.03	-0.46	.99
No beat, color, Expt. 2 vs. beat, color, Expt. 2	0.01	0.03	0.19	.99
No beat, color + shape, Expt. 1 vs. beat, color + shape, Expt. 1	-0.11	0.03	-3.80	.004**
No beat, color + shape, Expt. 2 vs. beat, color + shape, Expt. 2	0.03	0.03	0.98	.98

Beat, color, Expt. 1 vs. beat, color + shape, Expt. 1	-0.10	0.03	-14.09	.001**
Beat, color, Expt. 2 vs. beat, color + shape, Expt. 2	0.01	0.02	0.34	.99
Beat, color, Expt. 1 vs. beat, color, Expt. 2	-0.09	0.05	-1.74	.66
Beat, color + shape, Expt. 1 vs. beat, color + shape, Expt. 2	0.02	0.05	0.43	.99

Table S17

Tukey HSD-Corrected Post-Hoc Tests for Contrastive Accenting x Experiment Interaction in Model of Competitor Fixations During Color Word Interest Period Across Experiments

Comparison	Estimate	*SE*	*z*-ratio	*p*
No accent, Expt. 1 vs. accent, Expt. 1	-0.06	0.02	-3.59	.002**
No accent, Expt. 1 vs. no accent, Expt. 2	-0.10	0.05	-2.10	.15
Accent, Expt. 1 vs. accent, Expt. 2	-0.04	0.05	-0.75	.88
No accent, Expt. 2 vs. accent, Expt. 2	0.01	0.02	0.51	.96

S.1.3. Shape Word Interest Period.

Target fixations. We observed some baseline differences in reference resolution across experiments. Specifically, a significant main effect of Experiment (see Table S18), indicated, during the shape word of critical referring expressions, more target fixations occurred in Experiment 1 (M = 1.010, SD = 0.727) than Experiment 2 (M = 0.010, SD = 0.098). In addition, a significant main effect of contrast type indicated that more target fixations occurred during color-contrast critical referring expressions (M = 0.555, SD = 0.756) than during color- + shape-difference critical referring expressions (M = 0.478, SD = 0.686). These main effects interacted, which we explored by conducting Tukey HSD-corrected post-hoc tests (see Table S19). These tests revealed that the difference in target fixations between color-contrast and color- + shape-difference trials was driven by Experiment 1 ($p < .001$) rather than Experiment ($p = .91$). This two-way interaction was further qualified by a differently-signed interaction with trial such that these differences diminished slightly over the course of the experiment. We also observed a main effect of trial number and a significant interaction of trial number and experiment such that target fixations declined over the course of the experiment, especially in Experiment 1.

We turn now to the effects of our critical manipulations. We observed a significant three-way interaction of contrastive accenting, beat gesture, and experiment such that the combination of contrastive accenting and beat gesture especially elevated target fixations in Experiment 2 (although none of the Tukey HSD-corrected post-hoc tests reached significance). Note that this effect was independent of whether the target was a color-contrast target or color- + shape-difference target ; that is, it is consistent with the notion that beat gesture and contrastive accenting increased general attention to the target in Experiment 2 rather than receiving a contrastive interpretation in particular. This interaction was qualified by a differently-signed

interaction with trial, indicating that these differences decreased over the course of the experiment.

In addition to the effects of the main factors of interest, we observed main effects of gesture orientation and target object side as well as an interaction between them for target fixations during the shape word interest period. This result suggests that participants were more likely to fixate targets that appeared on the side of the array congruent with the orientation of beat gestures when processing shape words in critical referring expressions.

Table S18

Fixed Effect (Top) and Variance Estimates (Bottom) for Multi-Level Model of Target Fixations During Shape Word Interest Period Across Experiments (Observations = 6,236)

Fixed effect	Coefficient	*SE*	*t*	*p*
Intercept	-0.17	0.03	-5.01	< .001***
Contrastive accenting	0.02	0.04	0.37	.71
Beat gesture	0.02	0.04	0.52	.60
Contrast type (color-contrast vs. color + shape difference)	-0.25	0.04	-6.15	< .001***
Experiment (Experiment 2 vs. Experiment 1)	-0.23	0.07	-3.39	< .001***
Trial	-0.01	0.01	-5.93	< .001***
Contrastive accenting x beat gesture	-0.13	0.08	-1.70	.09†
Contrastive accenting x contrast type	0.02	0.11	0.15	.88
Contrastive accenting x experiment	-0.10	0.08	-1.21	.23
Contrastive accenting x trial	0.01	0.01	0.16	.87
Beat gesture x contrast type	-0.10	0.08	-1.25	.21
Beat gesture x experiment	-0.01	0.09	-0.04	.96
Beat gesture x trial	-0.01	0.01	-0.28	.78
Contrast type x experiment	0.56	0.08	6.98	< .001***
Contrast type x trial	0.01	0.01	2.03	.04*
Experiment x trial	0.01	0.01	7.05	< .001***
Contrastive accenting x beat gesture x contrast type	0.23	0.17	1.38	.17
Contrastive accenting x beat gesture x experiment	0.32	0.16	2.05	.04*
Contrastive accenting x beat gesture x trial	0.01	0.01	1.97	.05*
Contrastive accenting x contrast type x experiment	-0.30	0.22	-1.35	.18
Contrastive accenting x contrast type x trial	0.01	0.01	1.68	.09†
Contrastive accenting x experiment x trial	0.01	0.01	1.36	.17
Beat gesture x contrast type x experiment	0.08	0.16	-0.51	.61
Beat gesture x contrast type x trial	0.01	0.01	2.22	.03*
Beat gesture x experiment x trial	0.01	0.01	0.15	.88
Contrast type x experiment x trial	-0.01	0.01	-3.48	< .001***

Contrastive accenting x beat gesture x contrast type x experiment	-0.63	0.33	-1.91	.06†
Contrastive accenting x beat gesture x contrast type x trial	-0.01	0.01	-0.15	.88
Contrastive accenting x beat gesture x experiment x trial	-0.01	0.01	-2.50	.01*
Contrastive accenting x contrast type x experiment x trial	0.01	0.01	0.33	.74
Beat gesture x contrast type x experiment x trial	-0.01	0.01	-1.06	.29
Contrastive accenting x beat gesture x contrast type x experiment x trial	0.01	0.01	1.56	.12
Gesture orientation	-0.01	0.02	-0.49	.62
Object side	0.01	0.02	-0.53	.59
Gesture orientation x object side	0.22	0.04	6.17	< .001***

Random effect	s^2
Participant	0.25
Participant x contrastive accenting	0.12
Participant x beat gesture	0.17

Table S19

Tukey HSD-Corrected Post-Hoc Tests for Contrast Type x Experiment Interaction in Model of Target Fixations During Shape Word Interest Period Across Experiments

Comparison	Estimate	*SE*	*z*-ratio	*p*
Color, Expt. 1 vs. color + shape, Expt. 1	0.34	0.03	10.48	< .001***
Color, Expt. 1 vs. color, Expt. 2	0.15	0.06	2.43	.07†
Color + shape, Expt. 1 vs. color + shape, Expt. 2	-0.17	0.06	-2.85	.02*
Color, Expt. 2 vs. color + shape, Expt. 2	0.01	0.02	0.66	.91

Competitor fixations. We observed a significant main effect of experiment (see Table S20), indicating that, during the shape word of critical referring expressions, competitor fixations occurred more in Experiment 2 ($M = 0.337$, $SD = 0.560$) than Experiment 1 ($M = 0.013$, $SD = 0.121$). We also observed significant baseline effects of trial number (more competitor fixations over the course of the experiment) and contrast type (more fixations to color- + shape-difference competitors to color-contrast targets than the reverse).

Critically, we also observed a significant three-way interaction between contrastive accenting, contrast, and experiment, which we explored by conducting Tukey HSD-corrected post-hoc tests (see Table S21). These tests revealed that, in Experiment 1, contrastive accenting increased competitor fixations on the color-contrast competitor of color- + shape-difference critical referring expressions. By comparison, no such effect existed in Experiment 2 ($p = .99$). These results show that, when contrastive accenting is globally felicitous with contrast in filler items, it is interpreted as a cue to contrast when it occurs in critical referring expressions, misleading comprehenders into considering the color-contrast competitor when resolving referring expressions differing in both color and shape from a previous context referring expression. By comparison, when contrastive accenting became a globally infelicitous cue in Experiment 2, this effect vanished.

In addition to the effects of the main factors of interest, we observed main effects of gesture orientation and target object side as well as an interaction between them for fixations on competitor objects during the shape word interest period. This result suggests that participants were more likely to fixate competitor objects that appeared on the side of the array congruent with the orientation of beat gestures when processing shape words in critical referring expressions.

Table S20

Fixed Effect (Top) and Variance Estimates (Bottom) for Multi-Level Model of Competitor Fixations During Shape Word Interest Period Across Experiments (Observations = 6,236)

Fixed effect	Coefficient	*SE*	*t*	*p*
Intercept	-0.74	0.03	-28.84	< .001***
Contrastive accenting	0.03	0.04	0.80	.42
Beat gesture	0.01	0.03	0.02	.98
Contrast type (color-contrast vs. color + shape difference)	0.11	0.03	3.29	.001**
Experiment (Experiment 2 vs. Experiment 1)	0.91	0.05	17.67	< .001***
Trial	0.01	0.01	2.56	.01*
Contrastive accenting x beat gesture	0.08	0.06	1.23	.22
Contrastive accenting x contrast type	0.13	0.08	1.54	.13
Contrastive accenting x experiment	0.06	0.07	-0.89	.37
Contrastive accenting x trial	0.01	0.01	0.42	.68
Beat gesture x contrast type	-0.11	0.06	-1.69	.09†
Beat gesture x experiment	0.04	0.06	0.61	.54
Beat gesture x trial	-0.01	0.01	-0.24	.81
Contrast type x experiment	-0.15	0.07	-2.24	.03*
Contrast type x trial	-0.01	0.01	-0.89	.38
Experiment x trial	-0.01	0.01	-0.74	.46
Contrastive accenting x beat gesture x contrast type	-0.09	0.13	-0.70	.48
Contrastive accenting x beat gesture x experiment	-0.02	0.13	-0.16	.87
Contrastive accenting x beat gesture x trial	-0.01	0.01	-1.37	.17
Contrastive accenting x contrast type x experiment	-0.39	0.17	-2.30	.02*
Contrastive accenting x contrast type x trial	0.01	0.01	0.16	.87
Contrastive accenting x experiment x trial	0.01	0.01	-0.08	.94
Beat gesture x contrast type x experiment	-0.19	0.13	-1.49	.14
Beat gesture x contrast type x trial	0.01	0.01	1.64	.10
Beat gesture x experiment x trial	0.01	0.01	0.16	.87
Contrast type x experiment x trial	-0.01	0.01	-0.44	.66

Contrastive accenting x beat gesture x contrast type x experiment	0.20	0.25	0.88	.38
Contrastive accenting x beat gesture x contrast type x trial	0.01	0.01	1.27	.20
Contrastive accenting x beat gesture x experiment x trial	-0.01	0.01	-0.42	.68
Contrastive accenting x contrast type x experiment x trial	0.01	0.01	0.75	.45
Beat gesture x contrast type x experiment x trial	0.01	0.01	1.12	.26
Contrastive accenting x beat gesture x contrast type x experiment x trial	-0.01	0.01	-0.34	.74
Gesture orientation	0.01	0.01	0.60	.55
Object side	0.01	0.01	0.88	.38
Gesture orientation x object side	-0.07	0.03	-2.55	.01*

Random effect	s^2
Participant	0.18
Participant x contrastive accenting	0.16

Table S21

Tukey HSD-Corrected Post-Hoc Tests for Contrastive Accenting x Contrast Type x Experiment Interaction in Model of Competitor Fixations During Shape Word Interest Period Across Experiments

Comparison	Estimate	*SE*	*z*-ratio	*p*
No accent, color, Expt. 1 vs. no accent, color, Expt. 2	-0.94	0.06	-15.12	< .001***
No accent, color + shape, Expt. 1 vs. no accent, color + shape, Expt. 2	-0.91	0.06	-14.70	< .001***
No accent, color, Expt. 1 vs. no accent, color + shape, Expt. 1	-0.03	0.07	-0.43	.99
No accent, color, Expt. 2 vs. no accent, color + shape, Expt. 2	-0.01	0.03	-0.16	.99
No accent, color, Expt. 1 vs. accent, color, Expt. 1	0.08	0.07	1.15	.95
No accent, color, Expt. 2 vs. accent, color, Expt. 2	-0.01	0.04	-0.32	.99
No accent, color + shape, Expt. 1 vs. accent, color + shape, Expt. 1	-0.22	0.07	-3.27	.02*
No accent, color + shape, Expt. 2 vs. accent, color + shape, Expt. 2	0.01	0.04	0.01	.99
Accent, color, Expt. 1 vs. accent, color + shape, Expt. 1	-0.32	0.06	-4.95	< .001***
Accent, color, Expt. 2 vs. accent, color + shape, Expt. 2	0.01	0.03	0.24	.99

Accent, color, Expt. 1 vs. accent, color, Expt. 2	-1.02	0.06	-17.19	$< .001^{***}$
Accent, color + shape, Expt. 1 vs. accent, color + shape, Expt. 2	-0.70	0.06	-11.52	$< .001^{***}$