

SHORT AND SWEET**A single unexpected change in target- but not distractor motion impairs multiple object tracking****Hauke S. Meyerhoff**Knowledge Media Research Center Tübingen, Schleichstr. 6, 72076 Tübingen, Germany; e-mail: h.meyerhoff@iwm-kmrc.de**Frank Papenmeier**Department of Psychology, University of Tübingen, Schleichstr. 4, 72076 Tübingen, Germany;
e-mail: frank.papenmeier@uni-tuebingen.de**Georg Jahn**Department of Psychology, University of Greifswald, Franz-Mehring-Str. 47, 17487 Greifswald, Germany;
e-mail: georg.jahn@uni-greifswald.de**Markus Huff**Department of Psychology, University of Tübingen, Schleichstr. 4, 72076 Tübingen, Germany;
e-mail: markus.huff@uni-tuebingen.de

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Abstract. Recent research addresses the question whether motion information of multiple objects contributes to maintaining a selection of objects across a period of motion. Here, we investigate whether target and/or distractor motion information is used during attentive tracking. We asked participants to track four objects and changed either the motion direction of targets, the motion direction of distractors, neither, or both during a brief flash in the middle of a tracking interval. We observed that a single direction change of targets is sufficient to impair tracking performance. In contrast, changing the motion direction of distractors had no effect on performance. This indicates that target- but not distractor motion information is evaluated during tracking.

Keywords: multiple object tracking (MOT), motion direction, target motion, distractor motion.

In everyday life, human observers frequently need to track several objects simultaneously (e.g., when driving a car). In laboratory experiments, this ability is studied with the multiple object tracking (MOT) task. In this task, participants maintain previously selected objects across a period of motion and identify the tracked objects afterward. Typically, tracking capacity is restricted to four or five objects (Pylyshyn & Storm, 1988). Recent work on MOT investigated how participants avoid confusions between targets and distractors. Fencsik, Klieger, and Horowitz (2007) demonstrated that motion information of targets contributes to tracking performance. They asked participants to track objects across brief temporal gaps. The objects were either static or moved before the gap. Performance was better when the objects were moving before the temporal gap, suggesting that motion information is used to extrapolate object positions across gaps. However, motion information is not only used to track objects across temporal gaps. St. Clair, Huff, and Seiffert (2010) observed better tracking performance when a texture on the objects moved aligned with the objects than when the texture moved in the opposite direction. This indicates that the motion of the objects' texture was evaluated in order to predict prospective object locations. In line with this predictive mechanism, Iordanescu, Grabowecky, and Suzuki (2009) observed a bias in represented locations in the direction of motion during tracking. Furthermore, they reported that locations of targets with close distractors are represented more precisely. Taken together, these findings suggest that the direction of target motion is evaluated during tracking in order to avoid confusions with distractors. Regarding distractor processing to avoid confusions with targets, distractor features are used (Bae & Flombaum, 2012); however, no study has yet addressed the role of distractor motion information. In our experiment, we manipulate the motion vector of targets and distractors independently in order to investigate whether target- and distractor motion or target motion information alone contributes to tracking.

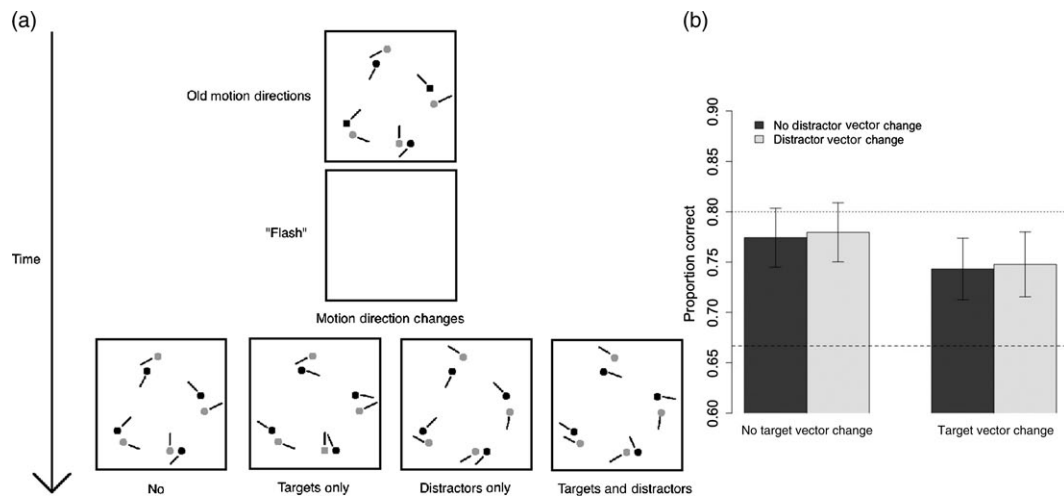


Figure 1. (a) Schematic illustration of the experimental conditions. Black dots indicate targets; gray dots indicate distractors. Objects were visually indistinguishable during the experiment. The lines indicate the motion direction; they were not visible during the experiment. During a brief flash, motion directions of the targets and/or distractors were changed unpredictably. (b) Tracking performance across the different conditions; only direction changes of targets impaired tracking performance. The error bars indicate the SEM.

We asked 11 students to track four targets among 8 white discs (0.7° diameter) moving within a gray wireframe against a black background ($15.4^\circ \times 15.4^\circ$, Figure 1a) for 8 s. The discs moved on linear paths with a constant speed of 4° of visual angle per second and were reflected when they touched the border. Once during each trial, the motion direction of targets, distractors, neither, or both were changed to new (random) motion directions. The initial object positions and motion directions were arranged so that each target was close to one distractor (1.5–3.5 object diameters; center-to-center) in the middle of each trial because locations of crowded objects are represented more precisely (Iordanescu et al., 2009). The minimum distance between two targets was eight object diameters. In order to avoid potential transients of the direction changes, the display turned white (i.e., flash) for 100 ms during the direction changes. All objects remained stationary during this period. After each trial, participants selected all tracked objects. Participants performed 20 practice trials and 120 experimental trials. If motion information is used during tracking, even a single change in the motion direction of targets should impair performance. Furthermore, we are interested in whether the motion direction of distractors is also used to avoid confusions between targets and distractors.

We analyzed the data (Figure 1b) using a repeated-measures ANOVA. Tracking performance declined when targets changed their motion direction, $F(1, 10) = 9.57$, $p = 0.011$, $\eta_p^2 = 0.49$. In contrast, when distractors changed their motion direction, performance remained unaffected, $F(1, 10) < 1$. There was no interaction between both variables, $F(1, 10) < 1$. Thus, our results indicate that only motion information of targets is evaluated during tracking whereas motion information of distractors is not.

Our results replicate previous work suggesting that target motion information is used during tracking (Fencsik et al., 2007; Iordanescu et al., 2009). We extend these findings by showing that only one unpredictable change of the motion direction of targets is sufficient to impair tracking performance. Furthermore, our results indicate that motion information of distractors is irrelevant for target tracking. Thus, MOT theories that address the role of distractors need to explain why feature (Bae & Flombaum, 2012) but not motion information of distractors is used to prevent target–distractor confusions. A possibility is that only information that allows the immediate establishment of object correspondence helps to reject distractors during tracking. This suggestion would be in line with the observation that motion information of approximately two objects only can be used to maintain tracked objects (Fencsik et al., 2007). Thus, the capacity for processing motion information might already be exceeded by the targets.

In our experiment, the distance between targets and distractors was small. This should have enhanced the probability of observing effects of changes in the motion direction because spatial proximity increases the precision of object representations (Iordanescu et al., 2009). Thus, it seems unlikely that distractor motion information contributes to tracking in general. Note that the objects did not

move during the flash. Thus, motion information was not necessary to extrapolate object positions across the flash. Instead, the motion trajectories might have been used to predict object positions (Meyerhoff, Papenmeier, & Huff, [in press](#); St. Clair et al., [2010](#)).

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