The Processing of Event Roles in Pictures: A Closer Look at the Agent Advantage Effect

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Tables and Figures

List of Tables

List of Figures

Table of Contents

Summary

This dissertation investigated the Agent advantage effect in static pictures. The Agent advantage effect referred to the finding that observers respond faster to Agents than to Patients when identifying event roles. Across three studies, this dissertation addressed three related questions: first, what temporal processing dynamics underlay the Agent advantage effect; second, whether low-level visual cues such as motion lines modulated the effect; and third, whether the effect remained stable across different action contexts when visual features were held under strict perceptual control.

The first study used eye-tracking method to investigate the temporal dynamics of the Agent advantage effect in the classical two-fish biting paradigm. The behavioural data replicated the standard finding that participants were faster during Agent search than during Patient search. Importantly, the eye-movement data suggested that this asymmetry did not arise from an early attentional bias toward the Agent. First fixations were not preferentially directed toward either event role. Instead, the critical difference emerged at a later stage of processing: during Patient search, the last fixation before response was more likely to land on the Patient, and this last fixation bias strongly correlated with the size of the reaction time asymmetry. These results suggested that the Agent advantage effect is at least partly related to late-stage verification processes, with identifying the Patient requiring additional visual confirmation.

The second study examined whether the Agent advantage effect was modulated by motion lines, a visual cue often associated with the depiction of motion in static images. Across two experiments, one using parallel motion lines and one using orthogonal motion lines, the Agent advantage effect was consistently replicated when there were no motion lines in the pictures. However, results showed that motion lines did not significantly interact with the search task and therefore did not reliably alter the magnitude of the effect. These results highlight the robustness of the effect and suggest that event role processing and motion line perception might operate independently.

The third study tested whether the Agent advantage effect generalized across action contexts. Using visually indistinguishable abstract fish under strict perceptual control, it compared two action contexts, fighting and chasing, while preserving the same local biting relation between the two event roles. A robust Agent advantage effect emerged during fighting actions, but disappeared during chasing actions. This pattern showed that the Agent

advantage effect was not an invariant consequence of any depicted Agent-Patient relation. Instead, its emergence depended on how event role information was extracted within a particular action context. More specifically, the findings suggested that fighting and chasing place different demands on event role processing: fighting may require finer local verification of the overlapping mouth region, whereas chasing may allow a faster global relational parse of the scene.

Taken together, the dissertation showed that the Agent advantage effect in pictures was robust but not unconditional. The findings indicated that the Agent advantage effect was associated with late-stage verification during Patient searches; the presence of motion lines did not impact the effect; and the appearance of the Agent advantage effect was impacted by the action context though the Agent-Patient relation was held constant. More broadly, the dissertation demonstrated that the Agent advantage effect is not a fixed effect of any depicted Agent-Patient relation but rather the outcome of an interaction among event structure, task demands, and the processing dynamics involved in identifying Agents and Patients.

Zusammenfassung

Diese Dissertation untersuchte den Agent Advantage Effect in statischen Bildern. Der Agent Advantage Effect bezeichnet den Befund, dass Beobachter bei der Identifikation von Ereignisrollen schneller auf Agens als auf Patiens reagieren. Über drei Studien hinweg behandelte diese Dissertation drei miteinander verbundene Fragestellungen: erstens, welche zeitlichen Verarbeitungsdynamiken dem Agent Advantage Effect zugrunde liegen; zweitens, ob visuelle Hinweisreize auf niedriger Ebene wie Bewegungslinien den Effekt modulieren; und drittens, ob der Effekt über verschiedene Handlungskontexte hinweg stabil bleibt, wenn visuelle Merkmale unter strenger perzeptueller Kontrolle konstant gehalten werden.

Die erste Studie nutzte Eye-Tracking, um die zeitliche Dynamik des Agent Advantage Effects im klassischen Zwei-Fische-Beißparadigma zu untersuchen. Die Verhaltensdaten replizierten den Standardbefund, dass die Teilnehmenden bei der Agentensuche schneller waren als bei der Patiensuche. Entscheidend war, dass die Blickbewegungsdaten nahelegten, dass diese Asymmetrie nicht auf einer frühen Aufmerksamkeitsverzerrung zugunsten des Agens beruhte. Die ersten Fixationen waren nicht bevorzugt auf eine der beiden Ereignisrollen gerichtet. Stattdessen trat der entscheidende Unterschied in einer späteren Verarbeitungsphase auf: Während der Patiensuche fiel die letzte Fixation vor der Reaktion mit höherer Wahrscheinlichkeit auf das Patiens, und diese Tendenz der letzten Fixation korrelierte stark mit dem Ausmaß der Reaktionszeitasymmetrie. Diese Ergebnisse legen nahe, dass der Agent Advantage Effect zumindest teilweise mit Verifikationsprozessen in späteren Verarbeitungsphasen zusammenhängt, wobei die Identifikation des Patiens zusätzliche visuelle Bestätigung erfordert.

Die zweite Studie untersuchte, ob der Agent Advantage Effect durch Bewegungslinien moduliert wird, einen visuellen Hinweisreiz, der häufig mit der Darstellung von Bewegung in statischen Bildern verbunden ist. Über zwei Experimente hinweg, eines mit parallelen und eines mit orthogonalen Bewegungslinien, wurde der Agent Advantage Effect konsistent repliziert, wenn in den Bildern keine Bewegungslinien vorhanden waren. Die Ergebnisse zeigten jedoch, dass Bewegungslinien nicht signifikant mit der Suchaufgabe interagierten und daher das Ausmaß des Effekts nicht zuverlässig veränderten. Diese Ergebnisse unterstreichen die Robustheit des Effekts und legen nahe, dass die Verarbeitung von

Ereignisrollen und die Wahrnehmung von Bewegungslinien möglicherweise unabhängig voneinander ablaufen.

Die dritte Studie prüfte, ob sich der Agent Advantage Effect über verschiedene Handlungskontexte hinweg verallgemeinern lässt. Unter Verwendung visuell nicht unterscheidbarer abstrakter Fische unter strenger perzeptueller Kontrolle wurden zwei Handlungskontexte verglichen, fighting und chasing, wobei dieselbe lokale Beißrelation zwischen den beiden Ereignisrollen beibehalten wurde. Während sich bei fighting-Handlungen ein robuster Agent Advantage Effect zeigte, verschwand der Effekt bei chasing-Handlungen. Dieses Muster zeigte, dass der Agent Advantage Effect keine unveränderliche Konsequenz jeder dargestellten Agens-Patiens-Relation ist. Vielmehr hing sein Auftreten davon ab, wie die Information über Ereignisrollen innerhalb eines bestimmten Handlungskontexts extrahiert wurde. Genauer gesagt legen die Befunde nahe, dass fighting und chasing unterschiedliche Anforderungen an die Verarbeitung von Ereignisrollen stellen: fighting könnte eine feinere lokale Verifikation im überlappenden Mundbereich erfordern, während chasing eine schnellere globale relationale Analyse der Szene ermöglichen könnte.

Insgesamt zeigte die Dissertation, dass der Agent Advantage Effect in Bildern robust, aber nicht bedingungslos ist. Die Befunde deuten darauf hin, dass der Agent Advantage Effect mit Verifikationsprozessen in späteren Verarbeitungsphasen während der Patiensuche zusammenhängt, dass das Vorhandensein von Bewegungslinien den Effekt nicht beeinflusste und dass das Auftreten des Agent Advantage Effects durch den Handlungskontext beeinflusst wurde, obwohl die Agens-Patiens-Relation konstant gehalten wurde. Allgemeiner zeigt die Dissertation, dass der Agent Advantage Effect keine feste Konsequenz jeder dargestellten Agens-Patiens-Relation ist, sondern vielmehr das Ergebnis eines Zusammenspiels von Ereignisstruktur, Aufgabenanforderungen und den Verarbeitungsdynamiken, die an der Identifikation von Agens und Patiens beteiligt sind.

List of Publications

Published manuscripts

Xu, W., Huff, M., & Papenmeier, F. (2024). A closer look at the Agent advantage effect: An eye-tracking study on event role processing in pictures. *Visual Cognition*, *32*(4), 330–341. https://doi.org/10.1080/13506285.2024.2428468

Xu, W., Papenmeier, F., & Huff, M. (2025). A closer look at the Agent advantage effect: The impact of motion lines. *Visual Cognition*, *33*(5), 299–310. https://doi.org/10.1080/13506285.2025.2573067

Submitted manuscripts

Xu, W., Huff, M., & Papenmeier, F. (2026). The Agent Advantage Effect Is Not Invariant: Evidence From Fighting and Chasing Scenes. *[Manuscript submitted for publication]*

Contributions

The following tables show the contributions of the dissertation author (including all co-authors) to the publications and manuscripts that are part of this dissertation.

Manuscript 1:

Author	Author position	Scientific ideas %	Data generation %	Analysis & Interpretation %	Paper writing %
Wenjia Xu	First	30%	20%	80%	80%
Markus Huff	Second	35%	40%	5%	5%
Frank Papenmeier	Third	35%	40%	15%	15%
Title of paper:		A closer look at the Agent advantage effect: An eye-tracking study on event role processing in pictures.			
Status in publication process:		Published Xu, W., Huff, M., & Papenmeier, F. (2024). A closer look at the Agent advantage effect: An eye-tracking study on event role processing in pictures. *Visual Cognition*, *32*(4), 330–341. https://doi.org/10.1080/13506285.2024.2428468			

Manuscript 2:

Author	Author position	Scientific ideas %	Data generation %	Analysis & Interpretation %	Paper writing %
Wenjia Xu	First	30%	80%	70%	80%
Frank Papenmeier	Second	30%	10%	20%	15%

Markus Huff	Third	40%	10%	10%	5%

Title of paper:	A closer look at the Agent advantage effect: The impact of motion lines.
Status in publication process:	Published Xu, W., Papenmeier, F., & Huff, M. (2025). A closer look at the Agent advantage effect: The impact of motion lines. *Visual Cognition*, *33*(5), 299–310. https://doi.org/10.1080/13506285.2025.2573067

Manuscript 3:

Author	Author position	Scientific ideas %	Data generation %	Analysis & Interpretation %	Paper writing %
Wenjia Xu	First	40%	80%	70%	80%
Frank Papenmeier	Second	40%	10%	20%	15%
Markus Huff	Third	20%	10%	10%	5%

Title of paper:	The Agent advantage effect is not invariant: Evidence from fighting and chasing scenes
Status in publication process:	Submitted Xu, W., Huff, M., & Papenmeier, F. (2026). The Agent Advantage Effect Is Not Invariant: Evidence From Fighting and Chasing Scenes.

Introduction

In daily life, people continuously extract and filter information from their surroundings to understand events. Events are structured segments of experience that unfold within a spatiotemporal framework and include entities, actions, and the relations among them (Radvansky et al., 1998; Zacks, 2020). One important component of events is event roles, including the Agent, who performs an action, and the Patient, who is acted upon (Hafri et al., 2018; Segalowitz, 1982; Verfaillie & Daems, 1996). Event role processing is asymmetric, with Agents typically taking a more salient role than Patients (Isasi-Isasmendi et al., 2023; Segalowitz & Hansson, 1979). This asymmetry is called the Agent advantage effect, that is, human observers respond faster to Agent information than to Patient information (Segalowitz, 1982; Xu et al., 2024, 2025).

Although the Agent advantage effect has been discussed in different domains, including language (Kemmerer, 2012), manual signs (Goldin-Meadow & Feldman, 1977) and visual narratives (Cohn & Paczynski, 2013), research on the Agent advantage effect in static pictures remains relatively limited. As a result, important questions have remained open regarding the conditions under which the effect emerges and the mechanisms that support it. Static pictures are especially useful for addressing this issue because, unlike real-world events, they do not provide unfolding input continuously. Instead, they make it possible to examine which information contained in a single scene is sufficient for the assignment of event roles and for the emergence of the Agent advantage effect. Research on static pictures can therefore help clarify not only whether the Agent advantage effect emerges, but also under which conditions it remains stable or changes.

Against this background, the present dissertation aimed to examine the Agent advantage effect in static pictures to better understand event role processing in visual scenes. In particular, it aimed to address the conditions under which the Agent advantage effect emerged, the extent to which it depended on an interpretable Agent-Patient relation, and the factors that shaped the Agent advantage effect during picture processing. To address these questions, the dissertation combined three work packages that examined the temporal dynamics of the Agent advantage effect, its sensitivity to low-level perceptual cues, and its dependence on higher-level action context. Taken together, these studies aimed to clarify why the Agent advantage effect emerged in controlled static pictures and under which conditions it remained stable.

Event Roles in Event Models

Human observers establish event models based on sensory information to guide their comprehension of the surrounding world (Huff et al., 2014; Zacks et al., 2007). The concept of event models builds on that of situation models. While situation models originally referred to mental representations constructed from text, event models extend this framework to the representation of events derived from text, movies, and real-world experience (Radvansky & Zacks, 2017). Event models are structured representations of an event's internal organisation, including dimensions such as time, space, and the relations between entities involved in the event (Huff et al., 2014; Zacks, 2020). Within this framework, event roles are an essential component because they specify how the participants in an event are related to one another. In particular, the distinction between Agent and Patient provides a basic relational structure for understanding who performs an action and who is affected by it, making event roles a central part of event comprehension in both language and visual narrative (Cohn & Paczynski, 2013; Papenmeier et al., 2019; Xu et al., 2024, 2025). Because event roles structure who does what to whom within an event, they also provide the basis for examining whether some roles are processed more readily than others.

The Agent Advantage Effect in Language and Visual Narratives

Event role processing is not symmetrical. Instead, Agents typically take a more prominent role than Patients. This asymmetry is referred to as the Agent advantage effect (Isasi-Isasmendi et al., 2023; Segalowitz, 1982; Segalowitz & Hansson, 1979; Xu et al., 2024, 2025). That is, human observers respond faster to Agent information than to Patient information (Segalowitz, 1982; Xu et al., 2024, 2025). Segalowitz (1982) was the first to demonstrate and name the Agent advantage effect in static pictures using the two-fish paradigm. Subsequent work has shown that this effect is not restricted to static pictures, but can also be found in language and visual narratives (Cohn & Paczynski, 2013; Kemmerer, 2012; Segalowitz, 1982).

In language research, Agents are generally treated as more prominent than Patients (Clark, 1965; Cohn & Paczynski, 2013). This asymmetry is reflected in the grammatical structure of many languages, where the Agent typically precedes the Patient, for example, in subject-verb-object (SVO) or subject-object-verb (SOV) constructions (Jackendoff, 1975; Keenan, 1976). More broadly, semantic role hierarchies usually assign a privileged status to

the Agent (Jackendoff, 1975). This prominence is also visible in sentence processing. In active sentences, the Agent typically occupies the subject position, whereas in passive sentences, the Agent is often omitted or expressed in a less salient form, such as in a “by” phrase. Correspondingly, readers identify Agents more easily in active than in passive sentences, both in terms of speed and accuracy (Ferreira, 2003).

The Agent advantage effect has also been examined in visual narratives, particularly in comics, where event understanding depended on the integration of meaning across sequential panels (Cohn & Paczynski, 2013). This line of research was closely related to Cohn’s theory of visual narrative grammar, which proposes that visual narratives were not random collections of pictures, but structured systems with both global organisation and hierarchical relations between individual panels (Cohn, 2013; Cohn et al., 2012; Cohn & Paczynski, 2013). Within such a framework, event comprehension depended not only on the interpretation of single panels but also on how panels were combined into a coherent representation of an unfolding event. Against this theoretical background, Cohn and Paczynski (2013) showed that Agent information played a privileged role in visual narrative processing: participants were more likely to use Agents than Patients to anticipate upcoming event structure, and Agents were more central to the initiation of event representations. These findings suggested that the salience of Agents over Patients extended beyond language to sequential visual contexts.

Beyond multi-image visual narratives, the Agent advantage effect has also been reported in single static pictures. Olson and Filby (1972), for example, conducted an experiment using pictures of a truck colliding with a car and asked participants, “What hit?” (targeting the Agent) and “What was hit?” (targeting the Patient). They found that participants located the Agent (the truck) significantly faster than the Patient (the car) (Olson & Filby, 1972). Similarly, Segalowitz (1982) presented participants with pictures of two fish, in which one fish was biting the other, and showed that participants were faster at identifying the Agent than the Patient. These findings are particularly relevant for the present dissertation because they demonstrated that the Agent advantage effect could emerge even when event role information must be extracted from a single visual scene rather than from unfolding language or sequential images. For the present dissertation, this picture-based evidence was especially important because it showed that event role asymmetries could be studied in controlled static scenes.

The Prerequisite of the Agent Advantage Effect: Agent-Patient Relation

One important prerequisite of the Agent advantage effect in pictures is the presence of an interpretable Agent-Patient relation (Segalowitz, 1982). To test whether the effect might be impacted by physical characteristics or spatial configuration, Segalowitz (1982) replaced the contours of the biting fish with the letter "W" and asked participants to search for Agent-like or Patient-like "W"s. Although these displays preserved much of the overall spatial configuration of the original fish pictures, the Agent advantage effect disappeared when the interpretable Agent-Patient relation was removed. This finding suggested that the effect did not emerge simply because one object occupied a particular position relative to another, but rather depended on whether observers could extract a meaningful Agent-Patient relation in which one participant acted on another. Thus, an interpretable Agent-Patient relation appeared to be a necessary precondition of the Agent advantage effect in pictures. At the same time, this finding left open whether the presence of an Agent-Patient relation was also sufficient for the Agent advantage effect to emerge across different picture contexts.

What impacts the Agent Advantage Effect: low-level features vs. higher-level features

A central question in research on the Agent advantage effect concerns which properties of a scene drive the prioritization of Agent information over Patient information. One possibility is that the effect is supported by low-level perceptual cues, such as shape and posture information, that make one event role more visually accessible than the other (Hafri et al., 2013, 2018; Segalowitz, 1982). Studies by Hafri et al. (2013) found that observers of dyadic social interactions automatically use shape and posture cues (such as actors' outstretched arms) to assign event roles of Agent and Patient in visual scenes (Hafri et al., 2013, 2018). At the same time, event role processing is unlikely to be determined solely by perceptual cues. Higher-level properties of the depicted interaction, such as animacy, intentionality, and action interpretation, may also shape how Agents and Patients are identified in pictures (Gao et al., 2009; Gao & Scholl, 2011; Isasi-Isasmendi et al., 2023; Scholl & Tremoulet, 2000). For example, studies on chasing have shown that observers can derive role information from relational cues such as directionality and pursuit structure, which support the interpretation of who is acting on whom in the scene (Gao et al., 2009; Gao &

Scholl, 2011). Importantly, these two sources of influence were often difficult to disentangle because natural scenes typically contain both low-level and higher-level features at the same time. Against this background, the present dissertation adopted a more controlled approach to investigate the Agent advantage effect in static pictures. Three more specific questions arose: how the Agent advantage effect unfolded over time during picture processing, whether it was modulated by low-level perceptual cues such as motion lines, and whether it remained stable across different higher-level action contexts.

Time course: the early and late processes of the AAE

Another important question concerned the time course of the Agent advantage effect during picture processing. Previous research suggested that event role information could be extracted rapidly from visual scenes. Hafri et al. (2013, 2018) showed that observers could derive event role information from very brief displays, indicating that Agent-Patient structure could be encoded at early stages of processing. At the same time, studies using brief presentation durations or masking procedures mainly addressed early processing (Hafri et al., 2013, 2018; Isasi-Isasmendi et al., 2023) and left open how event role asymmetries develop when pictures remained visible until response. This limitation was particularly relevant because evidence for the Agent advantage effect in static pictures came from paradigms that emphasised rapid detection, leaving later processing stages less clearly specified (Hafri et al., 2013, 2018; Segalowitz, 1982).

Previous work showed that eye movements could provide fine-grained information about semantic processing in language, pictures, and visual narratives (Foulsham et al., 2016; Isasi-Isasmendi et al., 2023; Kamide et al., 2003). Measuring gaze behaviour during uninterrupted stimulus presentation offered the opportunity to study not only early but also later processes that might contribute to the Agent advantage effect. In particular, it made it possible to examine how gaze was distributed across the two event roles over the course of a trial. This was important because the relative distribution of attention to the Agent and the Patient could change over time, thereby providing a more detailed picture of the temporal dynamics underlying the Agent advantage effect.

This question motivated the first work package of the present dissertation, which used the eye-tracking method in the classical two-fish paradigm to investigate the temporal dynamics of the Agent advantage effect under uninterrupted viewing conditions. More specifically, it examined whether the behavioural asymmetry between Agent and Patient

search was associated with differences in fixation patterns across the course of picture processing.

Low-level features: how motion lines impact the AAE

One specific type of low-level visual cue that may impact the Agent advantage effect in static pictures is motion lines. Motion lines, also referred to as action lines, speed lines, or zip ribbons, are graphic devices used to depict movement in still images by indicating the path or direction of motion (Burr, 2000; Cohn & Maher, 2015; Hacımusaoğlu & Cohn, 2023; Kim & Francis, 1998). Previous research suggested that motion lines could disambiguate motion direction (Francis & Kim, 1999; Kawabe & Miura, 2006; Kim & Francis, 1998) and strengthen the understanding of depicted movement (Cohn & Maher, 2015; Hacımusaoğlu & Cohn, 2023). They were also found to convey the speed of motion in static scenes (Carello et al., 1986; Gillan & Sapp, 2005; Hacımusaoğlu & Cohn, 2023). More broadly, Hacımusaoğlu and Cohn (2023) distinguished perceptual, metaphorical, and lexical interpretations of motion lines, but across these perspectives motion lines are generally treated as meaningful visual cues for representing motion in static images.

This issue was also relevant for research on the Agent advantage effect in the two-fish paradigm. In earlier work, motion-related cues were either absent or not systematically manipulated, and Segalowitz (1982) explicitly argued that motion lines might influence the perceived Agentness of an object and therefore excluded them from the fish stimuli. However, this possibility was not directly tested in the early literature. It therefore remained unclear whether motion lines merely contributed to the depiction of motion in static pictures or whether they could also influence the asymmetry between Agent and Patient in event role processing.

This question motivated the second work package of the present dissertation, which investigated whether motion lines influenced the Agent advantage effect in the two-fish paradigm. To address this issue directly, the study systematically manipulated motion lines behind the Agent, the Patient, or both, and compared two types of motion lines: parallel motion lines and orthogonal motion lines. This design made it possible to test whether low-level perceptual cues reliably modulated the asymmetry between Agent and Patient in event role processing, thereby directly addressing the possibility raised by Segalowitz (1982) that motion lines might influence the Agent advantage effect.

High-level features: how actions impact the AAE

Beyond low-level perceptual cues, the Agent advantage effect may also be shaped by higher-level features of the depicted action. Research on animacy perception showed that observers readily attributed animacy and intentionality even to highly simplified displays (Scholl & Tremoulet, 2000). Likewise, studies on chasing demonstrated that people could extract "who is pursuing whom" from relational information such as directionality, facing relations, and pursuit structure, even when the stimuli were highly minimal (Gao et al., 2009; Gao & Scholl, 2011). These findings suggest that event role processing may depend not only on local perceptual information, but also on how the depicted interaction is interpreted at the level of action meaning.

This issue was particularly relevant for research on the Agent advantage effect in static pictures, because studies using the two-fish paradigm had almost exclusively relied on the same Agent-Patient relation (biting) when investigating the effect (Segalowitz, 1982; Xu et al., 2024, 2025). In Segalowitz's original work (1982), participants viewed pictures of two fish in which one fish was biting the other, and the same basic relation was retained in the later eye-tracking study (Xu et al., 2024) and motion line studies (Xu et al., 2025). Although some visual properties of the stimuli varied across studies, such as surface details or the presence of motion-related cues, the critical Agent-Patient relation remained highly similar: one fish acted on the other through biting (Segalowitz, 1982; Xu et al., 2024, 2025). Thus, previous work showed that an interpretable Agent-Patient relation was important for the emergence of the Agent advantage effect, but it remained unclear whether the effect reflected a general asymmetry in event role processing or whether it also depended on the broader action context in which the same relation was embedded.

This open question could be addressed by keeping the local biting relation constant while varying how the depicted action was construed at the action level. In other words, rather than asking whether different perceptual features altered the Agent advantage effect, one could ask whether the same Agent-Patient relation gave rise to the same processing asymmetry when it was embedded in different action contexts. This approach made it possible to examine whether the Agent advantage effect was tied primarily to the presence of an Agent-Patient relation itself, or whether it was further shaped by the higher-level interpretation of the event. In the present dissertation, this question motivated the third work package, which examined whether the Agent advantage effect remained stable when

the same local biting relation was presented in different action contexts, namely fighting and chasing.

To address this question as directly as possible, the third work package used displays under strong perceptual control, so that the comparison between action contexts was not driven by obvious visual differences between the two event roles. This design made it possible to examine whether the same local biting relation gave rise to the same Agent advantage effect when it was embedded in different higher-level action contexts. In this way, the action manipulation extended earlier work on the two-fish paradigm by asking not only whether an Agent-Patient relation was present, but also whether the same relation supported the same processing asymmetry across different depicted actions.

Summary of the Introduction

Taken together, the literature reviewed in this introduction suggested that the Agent advantage effect in static pictures was robust, but not yet fully understood. Previous research showed that an interpretable Agent-Patient relation was important for the emergence of the Agent advantage effect, but left open how the effect unfolded over time, whether it was modulated by low-level perceptual cues, and whether it remained stable across different higher-level action contexts. The present dissertation addressed these questions through three work packages focusing on temporal dynamics, motion lines, and action context. To provide a concise overview of the empirical work included in this dissertation, Table 1 summarized all conducted experiments and their main design characteristics. It shows how the three work packages addressed complementary aspects of the Agent advantage effect, including temporal processing dynamics, the role of low-level perceptual cues, and the influence of higher-level action context.

Table 1

Overview of the Conducted Experiments and Their Main Independent and Dependent Variables

Research package	Experiment	n	Stimulus material / action context	Main independent variable(s)	Main dependent variable(s)	Eye-tracking measure(s)
A. Temporal dynamics of the Agent advantage effect	A1	16	Classical two-fish biting displays	Search task (Agent search vs. Patient search)	Reaction time	First fixation, last fixation, fixation distribution across trial
B. Low-level perceptual cues: Motion lines	B1	74	Two-fish biting displays with parallel motion lines	Search task (Agent search vs. Patient search); Agent motion lines (with vs. without); Patient	Reaction time	/

Research package	Experiment	n	Stimulus material / action context	Main independent variable(s)	Main dependent variable(s)	Eye-tracking measure(s)
				motion lines (with vs. without)		
B. Low-level perceptual cues: Motion lines	B2	72	Two-fish biting displays with orthogonal motion lines	Search task (Agent search vs. Patient search); Agent motion lines (with vs. without); Patient motion lines (with vs. without)	Reaction time	/
C. Higher-level action context	C1	24	Abstract fish displays: fighting	Search task (Agent search vs. Patient search)	Reaction time	/
C. Higher-level action context	C2	24	Abstract fish displays: chasing	Search task (Agent search vs. Patient search)	Reaction time	/
C. Higher-level action context	C3	84	Abstract fish displays: fighting vs. chasing	Search task (Agent search vs. Patient search); action context (fighting vs. chasing)	Reaction time	/

Note. Sample sizes refer to final samples after exclusions. All experiments used controlled static picture of the two-fish paradigm. Experiment A1 additionally included eye-movement measures. Experiments B1 and B2 manipulated motion lines. Experiments C1-C3 manipulated action context.

Objectives

The overall aim of this dissertation was to investigate the cognitive mechanisms underlying the Agent advantage effect in static pictures. Although previous research showed that observers identified Agents faster than Patients (Segalowitz, 1982), it remained unclear which processes underlay this asymmetry and under what conditions it emerged and remained stable. Building on the classical two-fish paradigm (Segalowitz, 1982), the present dissertation therefore examined the Agent advantage effect from three complementary perspectives: its temporal dynamics during picture processing, its sensitivity to low-level perceptual cues, and its dependence on higher-level action context. By combining one eye-tracking experiment (A1), two motion-line experiments (B1 and B2), and three action-context experiments (C1, C2, and C3), the dissertation aimed to provide a more systematic account of how event role information was extracted from static scenes.

The dissertation addressed three related research questions. First, Experiment A1 asked whether the Agent advantage effect primarily reflected early attention bias or later-stage verification during picture processing. It was hypothesised that participants would respond faster in the Agent search condition than in the Patient search condition, and that eye-movement measures would help investigate how participants' eye movements differed across the search tasks. Second, Experiments B1 and B2 examined whether the Agent advantage effect was modulated by low-level perceptual cues, specifically motion lines. If motion lines contributed to event role asymmetries, an interaction with the search task was expected; if no such interaction occurred, this would suggest that motion line processing and event role identification were relatively distinct under the present task conditions. Third, Experiments C1, C2, and C3 tested whether the Agent advantage effect remained stable when the same local Agent-Patient relation was embedded in different higher-level action contexts, namely fighting and chasing actions. More specifically, C1 examined fighting, C2 examined chasing, and C3 directly compared both action contexts within participants. It was hypothesised that the effect would be replicated in the fighting condition, and that if action context influenced the effect, the difference between Agent search and Patient search would be larger for fighting action than for chasing action.

Taken together, the dissertation was expected to contribute to a more systematic understanding of the Agent advantage effect in static pictures by clarifying its temporal dynamics in A1, testing its sensitivity to low-level perceptual cues in B1 and B2, and

identifying possible boundary conditions in higher-level action context in C1-C3. More broadly, the project aimed to contribute to visual event cognition research by specifying the processing conditions under which the Agent advantage effect emerges, remains stable, or changes in static pictures.

Summary of Results and Discussion

Brief Recap of the Main Findings

The dissertation examined the Agent advantage effect in static pictures from three complementary perspectives: its temporal dynamics during picture processing (Xu et al., 2024), its sensitivity to low-level visual cues (Xu et al., 2025), and its dependence on higher-level action context. Across the three work packages, a coherent overall pattern emerged. On the one hand, the findings replicated that the Agent advantage effect (Segalowitz, 1982; Xu et al., 2024, 2025), which was robust in controlled picture-based two-fish paradigms. Across multiple experiments, participants were repeatedly faster when identifying Agent information than when identifying Patient information, thereby replicating the classical asymmetry originally reported in the two-fish paradigm. On the other hand, the dissertation also showed that this asymmetry was not unconditional. Rather than appearing as a fixed consequence of any depicted Agent-Patient relation, the Agent advantage effect varied depending on how event role information had to be extracted from the visual scene and on the broader action context in which the relation was embedded. In this sense, the three work packages converged on a view of the Agent advantage effect as both reliable and context-sensitive. More specifically, the effect was replicated in the eye-tracking study and in the baseline conditions of the motion line experiments, remained unchanged by the motion line manipulations, and was present in fighting but absent in chasing actions.

The first work package focused on the temporal dynamics of the Agent advantage effect and combined the classical two-fish search task with eye-tracking measures. At the behavioural level, the results replicated the standard finding that participants responded faster in the Agent search condition than in the Patient search condition (Segalowitz, 1982). The eye-movement data, however, showed that this asymmetry was not simply reducible to an early attentional bias towards Agents. In particular, the first fixation analyses revealed no reliable tendency for participants to orient more often towards the Agent than towards the

Patient at the beginning of a trial. Instead, the critical difference emerged later in the trial: during Patient search, participants were more likely to make their last fixation on the Patient fish before responding, whereas no comparable bias occurred during Agent search. Moreover, this late fixation bias was strongly associated with the size of the Agent advantage effect. Taken together, these findings suggested that the asymmetry between Agent and Patient search was at least partly related to late-stage verification processes, especially when the task required the identification of the Patient. Thus, the first work package did not merely replicate the Agent advantage effect, but also clarified that its temporal dynamics were more strongly linked to late-stage verification than to early attention bias.

The second work package examined whether the Agent advantage effect was sensitive to a specific low-level visual cue, namely motion lines. This question was theoretically relevant because motion lines are widely treated as meaningful devices for representing motion in static images (Cohn & Maher, 2015; Hacımusaoğlu & Cohn, 2023), and because Segalowitz had already raised the possibility that such cues might affect the perceived Agentness of an object (Segalowitz, 1982). To address this issue systematically, the second work package manipulated motion lines behind the Agent, the Patient, or both, and contrasted two orientations of motion lines: parallel motion lines and orthogonal motion lines (Xu et al., 2025). Across two experiments, one using parallel motion lines and the other using orthogonal motion lines, the Agent advantage effect was replicated again. However, the motion line manipulations did not reliably change the magnitude of the Agent advantage effect. This pattern indicated that the Agent advantage effect remained stable even when additional motion-related perceptual information was added to the stimuli. In other words, although motion lines may contribute to the depiction of motion in static pictures, they did not substantially alter event role processing in the present task. The second work package therefore highlighted the robustness of the Agent advantage effect with respect to this particular class of low-level perceptual cues (motion lines).

The third work package turned from low-level perceptual cues to higher-level action context and tested whether the Agent advantage effect remained stable when the same local biting relation was embedded in different depicted actions. This work package was theoretically central because previous studies in the two-fish paradigm had almost always relied on the same local biting relation, leaving it unclear whether the Agent advantage effect reflected a general asymmetry in event role processing or whether it also depended

on the broader action interpretation of the scene. To address this question, the third work package compared fighting and chasing actions while preserving the same local biting relation and holding visual features under strong perceptual control. The results showed that the Agent advantage effect was replicated in fighting actions, but disappeared in chasing actions. This dissociation demonstrated that the presence of an Agent-Patient relation alone was not sufficient to guarantee the emergence of the Agent advantage effect in every context. Instead, the results suggested that different action contexts place different demands on event role processing: fighting actions appeared to require finer local verification of the overlapping mouth region, whereas chasing actions might allow a faster and more global relational parse of the scene. In this way, the third work package identified an important boundary condition of the Agent advantage effect and showed that higher-level action structure could shape whether the asymmetry emerged at all.

Taken together, the three work packages converged on the conclusion that the Agent advantage effect in static pictures was reliable in the classical two-fish paradigm, but not equally stable across all controlled variations of it. The first work package showed that the effect was linked primarily to late-stage verification rather than to an early attentional bias. The second work package showed that the Agent advantage effect was not modulated by motion lines. The third work package, however, showed that the effect did not generalise across action contexts: it was present in fighting, but absent in chasing, even though the same local biting relation was preserved. Thus, across the dissertation, the Agent advantage effect proved to be robust, but also sensitive to the conditions under which event role information had to be extracted from the scene.

Robustness and Task-Dependence of Agent Advantage Effect in controlled Pictures

Across the work packages of the present dissertation, the Agent advantage effect repeatedly emerged across several controlled picture paradigms, suggesting that it was a robust phenomenon under the present experimental conditions. This conclusion was supported by the fact that the effect was observed not only in the classical two-fish displays, but also in displays with motion line manipulations and in highly controlled abstract fish stimuli. Thus, despite substantial variation in stimulus format, the overall asymmetry between Agent and Patient search remained observable across the dissertation.

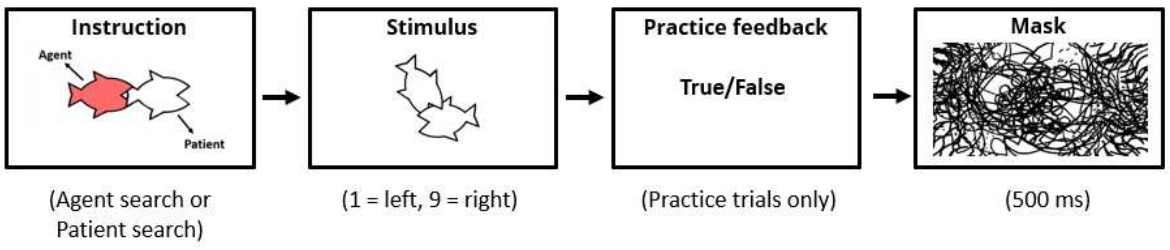
At the same time, this robustness must be understood in relation to the task context in which it was observed. In all studies, participants completed a two-fish search task in which they viewed two fish (see Figure 1), one biting the other, and had to locate either the Agent or the Patient on the left or right side of the display. Because successful performance required participants to determine which fish was acting and which was being acted upon, the task made the extraction of the Agent-Patient relation central to performance. Event role processing therefore did not arise incidentally, but was explicitly required by the structure of the task itself. The repeated observation of the Agent advantage effect should therefore be interpreted as evidence that, within an explicit event role search framework, participants were faster when identifying the Agent than when identifying the Patient.

However, this pattern should not be taken to mean that the Agent advantage effect was invariant across all controlled variations of the paradigm. Rather, the findings showed that its robustness was bounded. The effect remained stable across some manipulations, such as the addition of motion lines, but changed when the processing demands of the stimuli differed more fundamentally, as in the comparison between fighting and chasing actions. In this sense, the Agent advantage effect was robust within the present task framework, yet still sensitive to the specific demands imposed by stimulus configuration and action context.

The later sections, therefore, examine in more detail how this general pattern of robustness was qualified by differences in temporal dynamics, low-level visual manipulation, and higher-level action interpretation.

Figure 1

Schematic overview of the two-fish event role search task used across the dissertation.



Note. Participants were instructed to locate the side (left or right) of the biting fish (Agent search) or the bitten fish (Patient search). Half of the participants performed an Agent search first, followed by a Patient search, and the other half performed a Patient

search first, followed by an Agent search. Participants responded by pressing “1” for a target on the left and “9” for a target on the right. Reaction time was recorded.

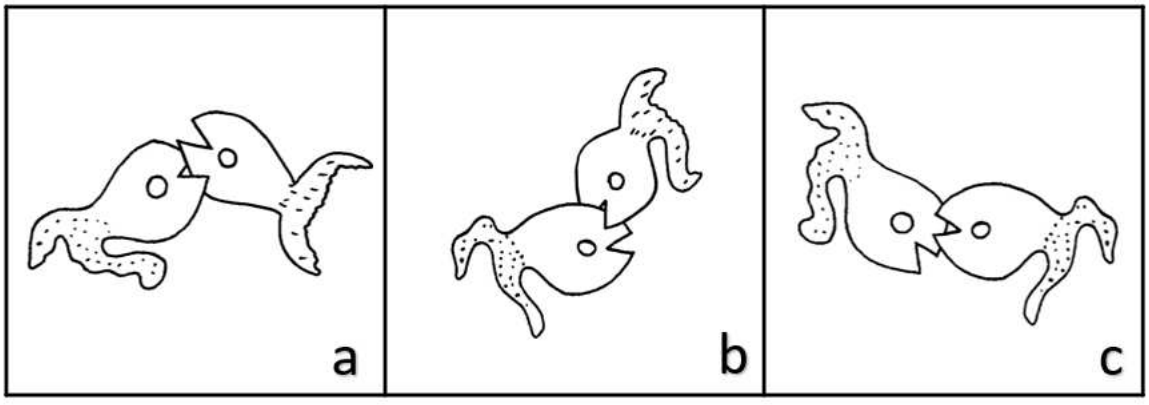
Paper I: Eye-tracking reveals late-stage verification in Patient search

The first work package investigated the temporal dynamics of the Agent advantage effect by combining the classical two-fish search task with the eye-tracking method. The main aim of the study was not only to confirm the presence of the Agent advantage effect in the classical paradigm, but also to clarify how this behavioural asymmetry unfolded over time during picture processing. To address this question, the study examined how participants’ eye movements were related to the behavioural difference in reaction times.

In this study, participants viewed simple line drawings of two fish (see Figure 2), one biting the other, and searched for either the biting fish (Agent) or the bitten fish (Patient). The no-biting action stimuli (see Figure 2C) were created by shifting the centre of the action stimuli tracings to eliminate the biting action content, thus encouraging participants to focus on the biting action rather than other cues, such as the fish's pattern. However, the no-biting trials were not included in our analysis because these stimuli did not contain the critical Agent-Patient relation defined by the biting action and therefore did not depict identifiable Agent and Patient roles.

Figure 2

Sample Stimuli for the Experiment A



Note. (a) the left fish biting the right fish, (b) the right fish biting the left fish, (c) no biting action (filler trials).

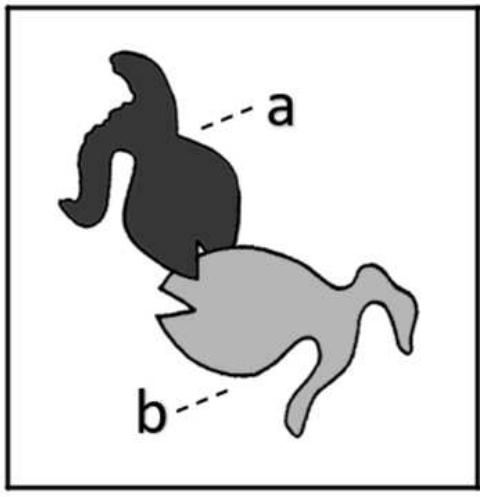
At the behavioural level, the study first replicated the Agent advantage effect (Segalowitz, 1982). Participants responded significantly faster when searching for the Agent (*M* = 987 ms, *SD* = 220) than when searching for the Patient (*M* = 1139 ms, *SD* = 306), *t*(15) =

-2.41, p = .029, d_z = -0.60. This behavioural replication was important because it established that the Agent advantage effect was replicated in the current paradigm before the eye-movement findings were considered.

For the eye-movement analyses, the stimuli were divided into two Areas of Interest (AOIs): the Agent fish (biting fish) and the Patient fish (bitten fish) (see Figure 3). This distinction made it possible to examine whether the first and last fixations were directed towards the Agent or the Patient. Because the main theoretical claim of this work package depended on this contrast, it was helpful to make the AOI structure visually explicit before presenting the fixation results.

Figure 3

Definition of AOI for our Stimuli



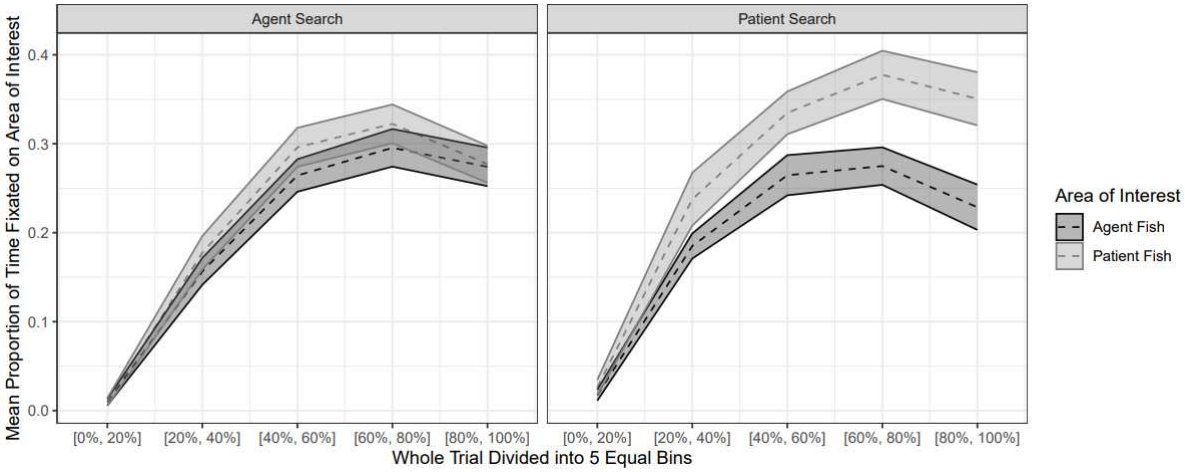
Note. (a) Agent (biting fish), (b) Patient (bitten fish). For illustration, we colored the Agent AOI dark grey and the Patient AOI light grey.

To obtain a first overview of how attention was distributed across the two event roles over the course of a trial, the eye-tracking paper examined the proportion of fixation time on the Agent AOI and the Patient AOI across five equal bins, with each bin accounting for 20% of the overall trial duration (see Figure 4). This analysis provided a descriptive picture of how gaze allocation developed during Agent search and Patient search. At the beginning of a trial, the overall fixation pattern was relatively similar across the two search conditions, with no strong indication that one event role consistently dominated the other. As the trial unfolded, however, the search conditions began to diverge. In particular, during Patient search, it seemed that there might be a higher proportion of fixation on the Patient fish compared to the Agent fish during the Patient search but not the Agent search. This descriptive pattern

was important because it already suggested that the critical asymmetry between Agent and Patient search was more likely to emerge late than early. Thus, before turning to more specific fixation measures, the overall time-course plot already pointed towards a late-stage difference in how participants processed the two event roles.

Figure 4

Mean Proportion of Time Fixated on AOIs During Agent Search and Patient Search.



Note. Error ribbons show the standard error of the mean.

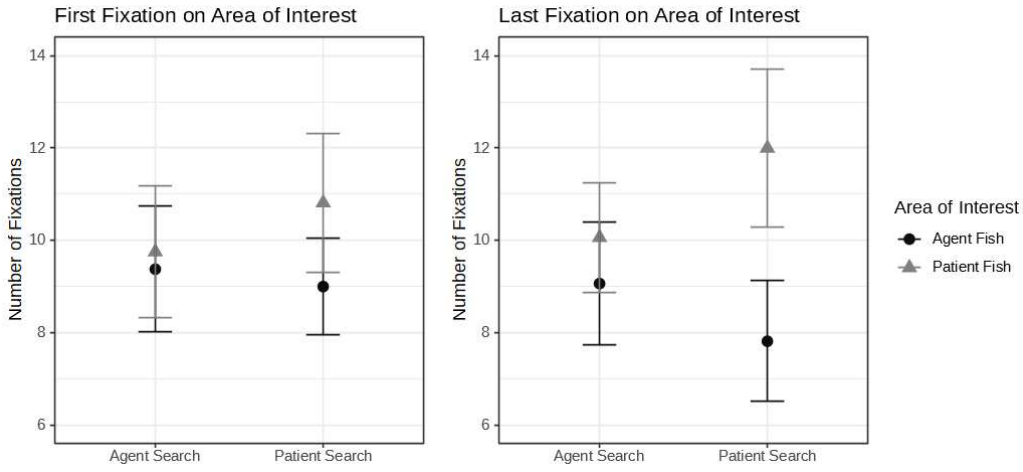
After this descriptive overview, the study turned to more specific fixation measures. The first fixation analyses provided no evidence that the Agent advantage effect was driven by an early attention bias towards the Agent. Participants were not more likely to direct their first fixation to the Agent fish than to the Patient fish, and this pattern did not differ reliably between Agent search and Patient search. To analyze whether the search task influenced whether participants' first fixation toward the fish in each search trial was directed toward the Agent fish or Patient fish, we performed a 2 (search: Agent search, Patient search) x 2 (AOI: Agent fish, Patient fish) repeated measures ANOVA with the dependent measure number of the first fixations (see Figure 5A). This revealed non-significant main effects of search, $F(1, 15) = 1.79$, $p = .201$, $\eta_p^2 = .11$, and AOI, $F(1, 15) = 2.15$, $p = .163$, $\eta_p^2 = .13$, as well as a non-significant interaction of search and AOI, $F(1, 15) = 0.74$, $p = .402$, $\eta_p^2 = .05$. Participants first fixation within a search trial was equally likely to land on either the Agent fish or Patient fish, and this tendency was also not influenced by the search task. Thus, at the beginning of the search task, participants fixated on the Agent fish and Patient fish equally. This finding was theoretically important because it argued against a simple interpretation of the Agent advantage effect as the result of an immediate attentional preference for the Agent. If the effect had primarily reflected an early attention bias, such a bias should already

have appeared in the first fixation measure. Instead, the data suggested that the two event roles were not differentially prioritised at the early stage of visual processing in the present two-fish search task.

The critical asymmetry emerged in the last fixation analyses. During Patient search, participants were significantly more likely to end a trial with a fixation on the Patient fish than on the Agent fish, whereas no comparable bias was observed during Agent search. We performed a 2 (search: Agent search, Patient search) x 2 (AOI: Agent fish, Patient fish) repeated measures ANOVA with the dependent measure number of last fixations (see Figure 5B). This revealed a non-significant main effect of search, $F(1, 15) = 1.79$, $p = .201$, $\eta_p^2 = .11$, a significant main effect of AOI, $F(1, 15) = 6.87$, $p = .019$, $\eta_p^2 = .31$, as well as a significant interaction of search and AOI, $F(1, 15) = 6.34$, $p = .024$, $\eta_p^2 = .30$. We further investigated the significant interaction with paired *t*-Tests. While there was no significant difference between the number of participants' last fixation on the Agent fish or Patient fish during Agent search, $t(15) = -1.01$, $p = .329$, $d_z = -0.25$, participants performed more last fixations toward the Patient fish than the Agent fish during Patient search, $t(15) = -3.14$, $p = .007$, $d_z = -0.79$. This pattern suggested that the behavioural difference between Agent search and Patient search was linked to the late stage of event role processing, close to the moment of decision.

Figure 5

Number of Fixations on AOIs. A: First Fixation of a Search. B: Last Fixation of a Search.



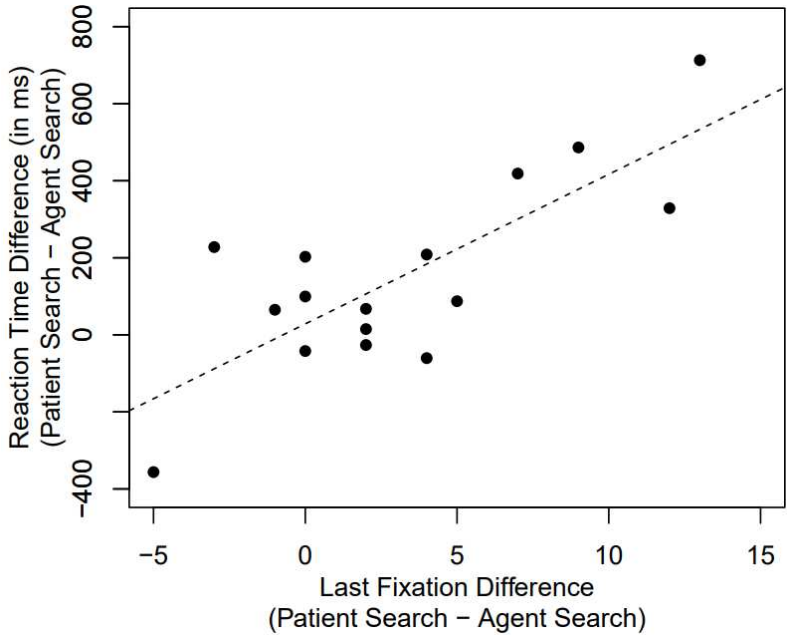
Note. Error bars depict 95% confidence intervals of the mean.

To further examine whether the late fixation pattern was related to the Agent advantage effect, the eye-tracking paper next analysed the relation between the search task effect in reaction times and the search task effect in eye movements (see Figure 6). More specifically, the difference in reaction times between Patient search and Agent search was

correlated with the corresponding difference in the last fixation measure. This analysis revealed a strong positive correlation, $r(14) = .78$, $p < .001$. Thus, the data suggested a strong relation between our eye movement results and reaction time results, with a larger tendency of having more last fixations on the Patient fish than Agent fish during Patient search than Agent search, being related to longer response times for Patient search than Agent search. This result was important because it linked the eye-movement pattern directly to the behavioural asymmetry, showing that the late fixation bias was closely related to the size of the reaction time difference. This association suggested that the reaction time asymmetry was related to late-stage visual processing during the search task. Rather than being an isolated behavioural outcome, the Agent advantage effect appeared to be linked to additional verification involved in identifying the Patient.

Figure 6

Correlation Between Influence of Search Task on Eye Movements and Reaction Times.



Note. Each dot depicts a participant.

This interpretation also helped situate the first work package more precisely in relation to earlier literature. Previous work had shown that event roles could be extracted rapidly from visual scenes (Hafri et al., 2013, 2018). In particular, Hafri et al. (2013, 2018) demonstrated that observers could derive Agent-Patient structure even from very brief displays, and Isasi-Isasmendi et al. (2023) reported a preference for first fixations on Agents in more complex action scenes. At first sight, the absence of a first fixation bias in the present study may therefore appear surprising. However, an important difference between

the studies lay in the nature of the stimuli and the information that could be extracted from the periphery. In the present eye-tracking study, the Agent and the Patient were depicted as highly similar fish, such that participants had to rely on the mouth region and the biting relation itself to determine who was acting on whom. By contrast, the scenes used by Isasi-Isasmendi et al. (2023) contained richer and more visually differentiated Agents and Patients, for example, with more distinctive body postures or different levels of animacy (e.g, one person reading a book). Such differences may have made it easier in their study to program an early saccade towards one more animate event role (the person), whereas in the present two-fish task, both fish have a similar level of animacy, and one can only distinguish the event roles based on the Agent-Patient relation. In this sense, the present findings do not contradict earlier evidence for rapid event role extraction, but rather refine it by showing that the temporal dynamics of the Agent advantage effect depend on the paradigm and on how event role information is visually conveyed.

At the same time, the present findings did not imply that early processing played no role in event role perception. Rather, they suggested that early and late processes contributed differently. Early processing may still have supported the rapid apprehension of the scene and the extraction of the basic Agent-Patient relation, but it was not sufficient to explain the reaction time asymmetry observed in the present search task. The decisive difference appeared to lie in what happened afterwards, namely in the verification processes that preceded the response. The last fixation bias during Patient search, together with its strong association with the Agent advantage effect, suggested that participants often needed to continue checking the display before they could finally confirm the Patient role. Importantly, however, the present study did not include a neutral baseline condition, this means that the data cannot fully determine whether the critical pattern reflected additional checking during Patient search, reduced checking during Agent search, or a combination of both. The safest conclusion was therefore that part of the Agent advantage effect in the present paradigm was related to late stage verification, without yet being able to specify the exact balance between Patient-specific costs and Agent-specific advantage.

This conclusion was important not only for interpreting the first work package itself, but also for motivating the following study. If the Agent advantage effect in the classical two-fish task was shaped in part by late-stage verification demands, the next question became which properties of a scene might increase, reduce, or otherwise alter such demands. One

natural next step was low-level visual information. In the present eye-tracking study, the two event roles were deliberately kept highly similar, so that role assignment depended primarily on the biting relation. The next work package therefore asked whether adding a salient low-level cue to the same basic stimuli - namely motion lines - would change the asymmetry between Agent search and Patient search. In this way, the eye-tracking study not only provided a temporal account of the Agent advantage effect, but also established the logic for the next step of the dissertation: testing whether the effect remained stable when the same controlled event role structure was supplemented with additional perceptual information.

Paper II: Motion lines do not modulate the Agent Advantage Effect

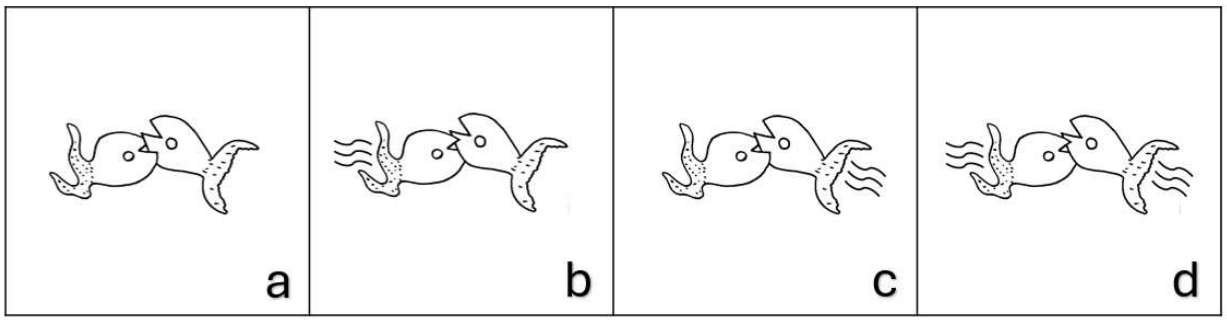
The second work package examined whether the Agent advantage effect in controlled pictures was sensitive to a specific low-level visual cue, namely motion lines. This question was theoretically relevant because motion lines have long been treated as meaningful devices for representing movement in static images (Burr, 2000; Cohn & Maher, 2015; Hacımusaoğlu & Cohn, 2023; Kim & Francis, 1998). Previous research suggested that motion lines could disambiguate motion direction (Francis & Kim, 1999; Hacımusaoğlu & Cohn, 2023; Kawabe & Miura, 2006), strengthen motion understanding (Cohn & Maher, 2015), and convey perceived speed in still scenes (Carello et al., 1986; Gillan & Sapp, 2005; Hacımusaoğlu & Cohn, 2025). At the same time, their role in the two-fish paradigm had remained unresolved. Olson and Filby (1972) had used motion-related visual cues in collision scenes, but these cues were not systematically manipulated. Segalowitz (1982) explicitly raised the possibility that motion lines might influence the perceived Agentness of an object and therefore excluded them from the fish stimuli. The second work package directly addressed this unresolved issue by testing whether adding motion lines behind the Agent, the Patient, or both would change the asymmetry between Agent search and Patient search.

To address this question, the study systematically manipulated motion lines in two experiments. Experiment 1 used parallel motion lines (see Figure 7) aligned with the fish orientation, whereas Experiment 2 (see Figure 8) used orthogonal motion lines of the same quantity and length. In both experiments, participants performed the same two-fish search task as in the previous work package: they identified either the biting fish (Agent search) or the bitten fish (Patient search) and indicated its left-right position by keyboard response 1 (target on the left) or 9 (target on the right). This design made it possible to test not only whether motion lines affected the Agent advantage effect, but also whether the orientation

of the lines mattered. More specifically, the study examined whether adding parallel versus orthogonal motion lines modulated the asymmetry between Agent and Patient search in the classical paradigm.

Figure 7

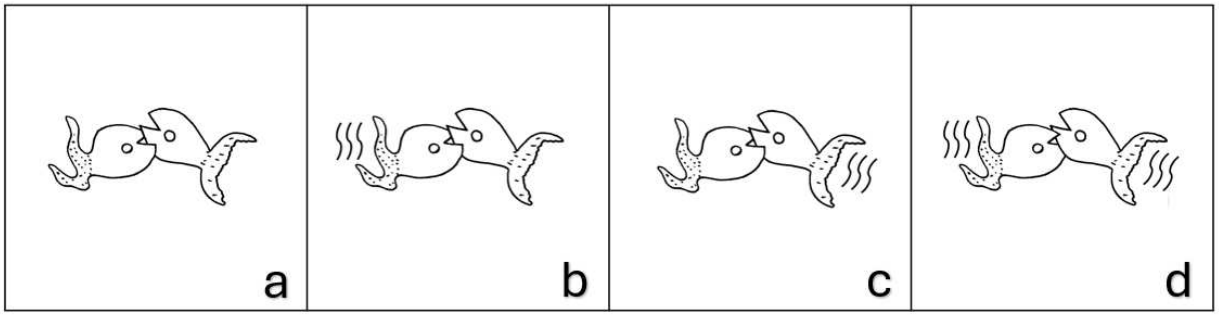
Sample Stimuli for Parallel Motion Line Experiment 1



Note. (a) both Agent fish and Patient fish without parallel motion lines, (b) parallel motion lines behind the Agent's tail, (c) parallel motion lines behind the Patient's tail, and (d) parallel motion lines behind both tails of the Agent and Patient.

Figure 8

Sample Stimuli for the Orthogonal Motion Line Experiment 2



Note. (a) both Agent fish and Patient fish without orthogonal motion lines, (b) orthogonal motion lines behind the Agent's tail, (c) orthogonal motion lines behind the Patient's tail, and (d) orthogonal motion lines behind both tails of the Agent and Patient.

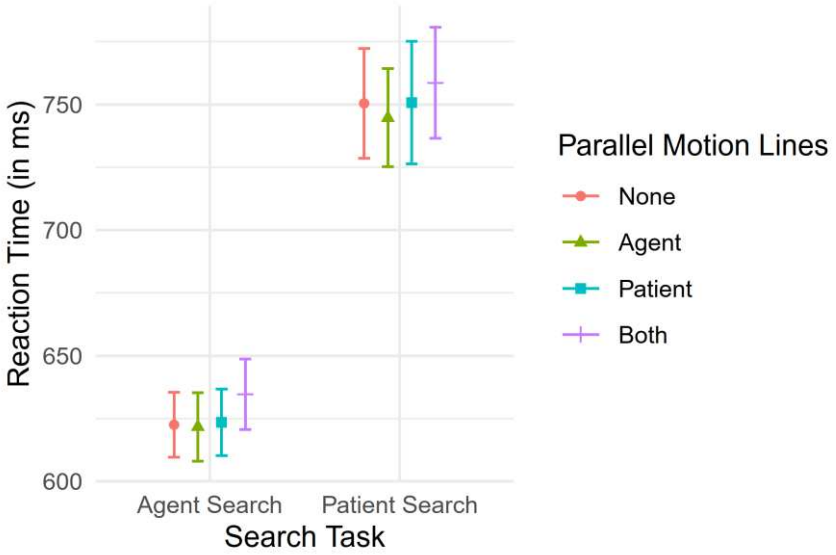
Both experiments replicated the Agent advantage effect. In Experiment 1, participants responded significantly faster during Agent search than during Patient search in the baseline condition without motion lines. More specifically, reaction times were shorter in the Agent search condition (M = 623 ms, SD = 111) than in the Patient search condition (M = 750 ms, SD = 188), $t(73) = -9.33$, $p < .001$, $d_z = -1.08$. The same overall pattern was observed in Experiment 2. Again, participants responded significantly faster during Agent search (M = 665 ms, SD = 139) than during Patient search (M = 755 ms, SD = 199) in the condition without motion lines, $t(71) = -4.71$, $p < .001$, $d_z = -0.55$. This was important because

it showed that the basic Agent advantage effect remained robust when the stimuli were presented without motion lines, thereby establishing the baseline against which the critical motion line manipulations could be evaluated.

The central finding of the second work package, however, was that motion lines did not reliably modulate the Agent advantage effect in either experiment. In Experiment 1, the repeated-measures ANOVA revealed a significant main effect of search (See Figure 9), $F(1, 73) = 96.69$, $p < .001$, $\eta_p^2 = .57$, of Patient parallel motion lines, $F(1, 73) = 4.10$, $p = .047$, $\eta_p^2 = .05$, and a significant two-way interaction of Agent parallel motion lines and Patient parallel motion lines, $F(1, 73) = 5.53$, $p = .021$, $\eta_p^2 = .07$. In contrast, the main effect of Agent parallel motion lines, $F(1, 73) = 0.48$, $p = .490$, $\eta_p^2 = .01$, as well as the two way interactions of search and Agent parallel motion line, $F(1, 73) = 0.36$, $p = .550$, $\eta_p^2 = .00$, search and Patient parallel motion lines, $F(1, 73) = 0.00$, $p = .986$, $\eta_p^2 = .00$, and three-way interaction of search, Agent parallel motion lines and Patient parallel motion lines, $F(1, 73) = 0.02$, $p = .881$, $\eta_p^2 = .00$. were all non-significant. Thus, although Experiment 1 revealed some effects of parallel motion lines on overall reaction times, these effects did not interact with search in a way that would indicate a modulation of the Agent advantage effect. To further clarify the significant interaction between Agent parallel motion lines and Patient parallel motion lines, pairwise comparisons were conducted using paired *t*-tests (see Table 2). These comparisons showed that adding parallel Patient motion lines increased reaction times only when Agent motion lines were already present (Agent vs. Both), but not when no motion lines were present (None vs. Patient). Likewise, compared with pictures without motion lines, reaction times were significantly longer only when parallel motion lines were added behind both the Agent and the Patient (None vs. Both), whereas adding motion lines only behind the Agent (None vs. Agent) or only behind the Patient (None vs. Patient) did not significantly affect reaction times.

Figure 9

Mean Reaction Time in Seconds on Search Task and Parallel Motion Line Conditions



Note. Error bars show the standard error of the mean.

Table 2

Pairwise Comparisons to Investigate the Agent Parallel Motion Lines by Patient Parallel Motion Lines Interaction in Experiment 1

Pairwise Comparison of Parallel Motion Line Conditions	*Difference*				*Cohen's* d_z		
	M	*SE*	*t*(73)	*p*	d_z	*95% CI*	p_{adj}
None vs. Agent	-3.26	5.24	-0.62	.536	-0.07	[-0.30, 0.16]	1.000
None vs. Patient	0.63	3.80	0.16	.870	0.02	[-0.21, 0.25]	1.000
None vs. Both	10.14	3.97	2.56	.013	0.30	[0.06, 0.53]	.063
Agent vs. Patient	3.88	7.00	0.55	.581	0.06	[-0.16, 0.29]	1.000
Agent vs. Both	13.40	4.93	2.72	.008	0.32	[0.08, 0.55]	.049
Patient vs. Both	9.52	5.30	1.80	.077	0.21	[-0.02, 0.44]	.307

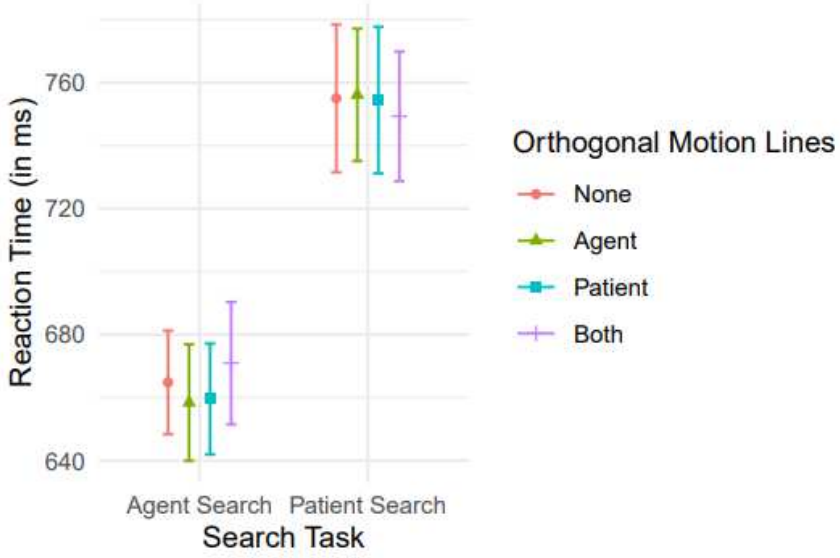
Note. Difference scores are calculated as the second condition minus the first condition. p_{adj} shows Bonferroni-Holm corrected *p* values.

Experiment 2 (See Figure 10) showed a similar overall pattern. Again, there was a significant main effect of search, $F(1, 71) = 31.24$, $p < .001$, $\eta_p^2 = .31$. In contrast, the main effects of Agent orthogonal motion lines, $F(1, 71) = 0.00$, $p = .955$, $\eta_p^2 = .00$, and Patient orthogonal motion lines, $F(1, 71) = 0.00$, $p = .992$, $\eta_p^2 = .00$ were non-significant. Likewise, the two-way interaction of search and Agent orthogonal motion line, $F(1, 71) = 0.25$, $p = .617$, $\eta_p^2 = .00$, of search and Patient orthogonal motion lines, $F(1, 71) = 1.30$, $p = .257$, η_p^2

= .02, and of Agent orthogonal motion lines and Patient orthogonal motion lines, $F(1, 71) = 0.90$, $p = .345$, $\eta_p^2 = .01$, as well as the three-way interaction of search, Agent orthogonal motion lines and Patient orthogonal motion lines, $F(1, 71) = 2.52$, $p = .117$, $\eta_p^2 = .03$. were all non-significant.

Figure 10

Mean Reaction Time in Seconds on Search Task and Orthogonal Motion Line Conditions



Note. Error bars show the standard error of the mean.

Because the critical interactions between search task and motion lines were non-significant in both experiments, additional exploratory Bayesian analyses were conducted to quantify the evidence for the absence of a modulation of the Agent advantage effect by motion lines. For each experiment, the reaction time difference between Patient search and Agent search was calculated as an index of the Agent advantage effect. Bayesian paired-samples *t*-tests were then used to compare the size of this difference between conditions with and without the respective motion lines.

In Experiment 1, which used parallel motion lines, the analyses revealed the following Bayes factors: $BF_{10} = 0.15$ (± 0.09%) for Agent parallel motion lines and $BF_{10} = 0.13$ (± 0.11%) for Patient parallel motion lines. Both indicate moderate evidence in support of the null hypothesis (Lee & Wagenmakers, 2014), suggesting that neither Agent parallel motion lines nor Patient parallel motion lines measurably altered the Agent advantage effect in the present task.

In Experiment 2, which used orthogonal motion lines, the analyses revealed the following Bayes factors: $BF_{10} = 0.15$ (± 0.1%) for Agent orthogonal motion lines and $BF_{10} = 0.24$ (± 0.07%) for Patient orthogonal motion lines. Again, both values indicate moderate

evidence in support of the null hypothesis (Lee & Wagenmakers, 2014), suggesting that orthogonal motion lines also did not measurably alter the Agent advantage effect.

Taken together, these results suggested that motion lines did not change the Agent advantage effect itself. If motion lines had directly increased the salience of one event role over the other, they should have interacted with the search task and thereby altered the magnitude of the asymmetry between Agent search and Patient search. This did not occur in either experiment. Instead, the findings indicated that participants primarily relied on the Agent-Patient relation itself, that is, the biting action, rather than on the additional motion-related information provided by the lines. In this respect, the second work package showed that the Agent advantage effect in the classical two-fish task was relatively stable against this particular low-level perceptual manipulation.

At the same time, the data do not imply that motion lines were completely irrelevant for processing the displays. In Experiment 1, there was a significant main effect of Patient parallel motion lines, $F(1, 73) = 4.10$, $p = .047$, $\eta_p^2 = .05$, as well as a significant interaction between Agent parallel motion lines and Patient parallel motion lines, $F(1, 73) = 5.53$, $p = .021$, $\eta_p^2 = .07$. More specifically, reaction times tended to increase when parallel motion lines were added behind both fish. However, because these effects did not interact with the search task, they cannot be interpreted as changes in the Agent advantage effect itself. Instead, they suggested that parallel motion lines may have influenced more general aspects of picture processing, such as visual complexity or the perceived intensity of the depicted action, without altering the core asymmetry between Agent search and Patient search.

This finding also helped situate the second work package in relation to the broader literature on motion lines. Previous work has shown that motion lines can facilitate the perception of motion direction and speed in static images (Carello et al., 1986; Cohn & Maher, 2015; Francis & Kim, 1999; Gillan & Sapp, 2005; Hacımusaoğlu & Cohn, 2023). The present findings, however, suggested that such perceptual cues do not automatically impact the event role asymmetries. One plausible explanation was that, in the present task, the critical information for identifying the Agent and the Patient was already sufficiently specified by the Agent-Patient relation (biting action) itself. Because the motion lines were positioned behind the tails rather than at the crucial interaction point (mouth area), they may have functioned only as supplementary visual elements rather than as cues central to event role assignment. In this sense, the second work package suggested that, under the

present task requirements, processing the event roles and processing the motion lines were at least relatively independent.

Within the broader dissertation, the contribution of the second work package was therefore to further narrow the range of plausible explanations for the Agent advantage effect in controlled pictures. The first work package had shown that the effect was associated more strongly with late-stage verification during Patient search than with an early bias. The second work package added that this asymmetry remained stable despite the addition of motion lines, even though motion lines were meaningful cues in many other visual contexts. Taken together, these findings suggested that the Agent advantage effect in the two-fish task was anchored more strongly in the processing of the Agent-Patient relation itself than in supplementary low-level motion-related cues. This conclusion also motivated the next step of the dissertation. If adding a low-level visual cue, such as motion lines, did not reliably change the effect, then the more important source of variation might lie at a higher level of scene interpretation. The third work package, therefore, turned from low-level perceptual manipulations to the broader action context of the depicted interaction and asked whether the Agent advantage effect would remain equally stable when the same local Agent-Patient relation was embedded in different actions.

Paper III: Agent Advantage Effect is present in fighting but absent in chasing

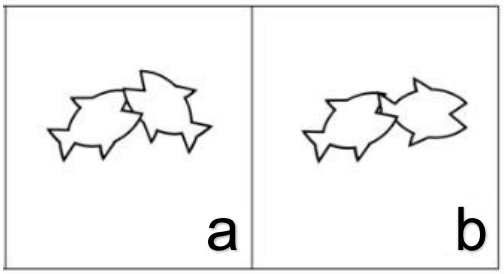
The third work package examined whether the Agent advantage effect remained stable when the same local Agent-Patient relation was embedded in different higher-level action contexts. This comparison was theoretically important because previous studies using the two-fish paradigm had consistently investigated the Agent advantage effect on the basis of the same local biting Agent-Patient relation (Segalowitz, 1982; Xu et al., 2024, 2025). The open question was therefore whether the Agent advantage effect was tied specifically to this biting relation or whether it could generalise across different depicted actions. At the same time, to retain comparability with the earlier literature, the present study did not remove the biting relation. Instead, it kept the same local Agent-Patient relation constant while varying the broader action context in which that relation was embedded, namely fighting versus chasing actions.

Methodologically, the critical feature of this work package was its strict perceptual control. In both action contexts, the Agent and the Patient were depicted as visually indistinguishable abstract fish outlines (see Figure 11). The local biting relation was

preserved in both conditions, but the broader action context differed: in the fighting condition, the two fish appeared in a face-to-face configuration, whereas in the chasing condition, they appeared in a face-to-tail configuration. Thus, any difference in the Agent advantage effect across the two conditions could not be attributed to visual featural differences between the Agent and the Patient, but instead had to be interpreted in relation to the broader event structure supported by the pictures.

Figure 11

Sample Stimuli for Study 3



Note. (a) The fighting stimuli, and (b) the chasing stimuli.

The third work package consisted of three experiments that together tested whether the Agent advantage effect would remain stable across fighting and chasing actions. Experiment 1 focused on the fighting condition and examined whether the Agent advantage effect could be replicated with abstract fish stimuli under strict perceptual control. Experiment 2 then tested the chasing condition using the same general task logic and the same local biting relation, but embedded in a face-to-tail action context. Finally, Experiment 3 directly compared fighting and chasing within participants, thereby testing more rigorously whether any difference between the two action contexts would be replicated when both were included in the same experiment. Taken together, these three experiments made it possible to establish a fighting baseline, test the chasing condition separately, and then directly compare both action contexts within a unified design.

The first important result was that the Agent advantage effect was replicated in the fighting condition. In Experiment 1, participants responded significantly faster during Agent search (M = 660 ms, SD = 102) than during Patient search (M = 787 ms, SD = 182), $t(23) = -4.41$, $p < .001$, $d_z = -0.9$. This finding was important because it showed that the classical Agent advantage effect did not depend on the richer surface details of the earlier fish

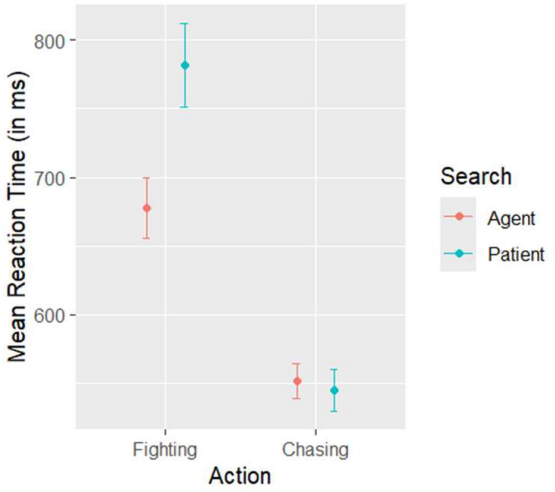
stimuli. Even when the two event roles were reduced to highly controlled abstract fish outlines, the asymmetry still emerged, provided that the same local biting relation was embedded in the fighting display. In this respect, Experiment 1 established a critical baseline for the third work package: under strict perceptual control, the Agent advantage effect could still be replicated.

The second important result was that the Agent advantage effect was not replicated in the chasing condition. In Experiment 2, participants again performed the same search task, but the same local biting relation was now embedded in a chasing configuration. Under these conditions, reaction times in Agent search (M = 657 ms, SD = 347) and Patient search (M = 668 ms, SD = 377) did not differ significantly, $t(23) = -0.27$, $p = .788$, $d_z = -0.06$. Thus, although the local Agent-Patient relation was preserved, the usual asymmetry between faster Agent search and slower Patient search disappeared. This result was theoretically striking because it showed that the mere presence of the same local biting relation was not sufficient to guarantee the emergence of the Agent advantage effect. Instead, the broader action context in which that relation was embedded appeared to matter.

This conclusion was strengthened by Experiment 3, which directly compared fighting and chasing within participants. Here, the critical result was a significant interaction between action type and search task. The repeated-measures ANOVA revealed significant main effects of search, $F(1, 83) = 25.41$, $p < .001$, $\eta_p^2 = .23$, and action, $F(1, 83) = 133.15$, $p < .001$, $\eta_p^2 = .62$, indicating that reaction times were faster overall in the chasing condition (M = 548 ms, SD = 119) than in the fighting condition (M = 730 ms, SD = 233). Most importantly, the interaction between search and action was also significant, $F(1, 83) = 44.52$, $p < .001$, $\eta_p^2 = .35$. Follow-up tests showed that an Agent advantage effect in the fighting condition, with faster responses during Agent search (M = 678 ms, SD = 203) than during Patient search (M = 782 ms, SD = 278), $t(83) = -6.83$, $p < .001$, $d_z = -0.75$. For the chasing condition, in contrast, there was no significant difference between the Agent search (M = 552 ms, SD = 114) and the Patient search (M = 545 ms, SD = 140), $t(83) = -0.68$, $p = .497$, $d_z = 0.07$, thus the Agent advantage effect was not replicated in the chasing condition. This within-participant replication was especially important because it ruled out the possibility that the contrast between the first two experiments merely reflected differences between samples or testing contexts. Instead, it confirmed that the presence versus absence of the Agent advantage effect depended on the action context itself (see Figure 12).

Figure 12

Mean Reaction Time in Milliseconds on Search Task and Action Conditions



Note. Error bars show the standard error of the mean.

These findings challenged the idea that the presence of an interpretable Agent-Patient relation would be sufficient for the Agent advantage effect to emerge. In the present experiments, both action contexts preserved the same local biting Agent-Patient relation, yet the Agent advantage effect was replicated only in the fighting condition and disappeared in the chasing condition. This pattern suggested that the local Agent-Patient relation remained important, but was not by itself sufficient to guarantee the same behavioural asymmetry across different depicted actions. What also mattered was how that relation was embedded in the broader action context of the scene.

One plausible interpretation was that the same local Agent-Patient relation was processed differently in the two action contexts because the two scenes placed different demands on event role identification. In the fighting condition, correct role assignment depended on resolving a fine-grained local relation at the mouths, that is, determining which fish was biting and which fish was being bitten. Under such conditions, participants may have needed more careful local inspection, which provided a natural explanation for why reaction times were slower overall while still producing a robust Agent advantage effect. In the chasing condition, by contrast, the face-to-tail arrangement and shared heading direction may have provided a strong global structure for the interaction. Chasing is a canonical animate interaction in which role assignment is strongly constrained by relational cues such as directionality, facing relations, and pursuit structure (Gao et al., 2009; Gao & Scholl, 2011; Scholl & Tremoulet, 2000). In the present displays, this global relational

structure may have allowed participants to derive the overall interaction more quickly, without relying on the same degree of fine-grained checking that was required in the fighting condition. This interpretation also fits the overall faster reaction times in chasing and the absence of an Agent advantage effect under those conditions.

The third work package suggested that the Agent advantage effect in static pictures was not determined only by whether an Agent-Patient relation was present, but also by the higher-level action context in which that relation was embedded. In this sense, the present findings extended the earlier two-fish literature by showing that the same local relation could give rise to different behavioural outcomes depending on how the depicted action was structured. More specifically, the fighting condition appeared to preserve the kind of local event role processing that supported the Agent advantage effect, whereas the chasing condition appeared to support a faster global relational parse that did not produce the same asymmetry between Agent search and Patient search. This made the third work package the clearest evidence in the dissertation that higher-level action context constituted a genuine source of variation in the Agent advantage effect.

Taken together, the third work package showed that the Agent advantage effect in controlled static pictures depended not only on the presence of an interpretable Agent-Patient relation, but also on the broader action context in which that relation was embedded. The following section therefore brings the three work packages together and considers what they jointly revealed about the conditions under which the Agent advantage effect emerged, remained stable, or disappeared.

General Discussion

Taken together, the three work packages showed that the Agent advantage effect in static pictures was robust, but not unconditional. Across the dissertation, the effect was repeatedly replicated in controlled versions of the classical two-fish paradigm, which confirmed that observers were generally faster to identify Agent information than Patient information. At the same time, the dissertation also showed that this asymmetry did not emerge equally under all conditions. Rather than being a fixed consequence of depicting an Agent-Patient relation, the Agent advantage effect depended on how event role information was processed within a given task and scene structure. In this sense, the present dissertation refined the interpretation of the Agent advantage effect by showing that its emergence was systematic, but also context-sensitive. One central proposal of this dissertation is that the

Agent advantage effect reflects, at least in part, differences in the verification demands involved in identifying Agents and Patients in static scenes.

In the present dissertation, the late-stage verification referred to the additional visual and decisional checks performed when the target event role could not be identified solely on the basis of an initial global interpretation of the scene. This process was “late-stage” in the sense that it reflected in gaze behaviour before the response, rather than in the initial attention bias response to the picture. It was “verification” in the sense that observers appeared to use this later processing stage to confirm the identity of the target event role before making a decision. Importantly, this account didn't imply that event roles were only processed late. Previous research showed that event role information could be extracted rapidly from visual scenes (Hafri et al., 2013, 2018; Isasi-Isasmendi et al., 2023). Rather, the present findings suggested that rapid extraction might be followed by additional checking when the task required observers to identify the less accessible role or when the local relation between event participants required more precise inspection.

The first two work packages helped narrow the range of plausible explanations for this effect. The first work package suggested that the Agent advantage effect in the classical two-fish task was linked more strongly to late-stage processing than to a simple early attentional bias. More specifically, the critical asymmetry did not emerge in the first fixation measure, but in the last fixation measure and in its close relation to the reaction time difference. This pattern suggested that part of the Agent advantage effect was associated with late-stage verification during Patient search. The second work package then showed that adding motion lines did not reliably modulate this asymmetry, regardless of whether the lines were parallel or orthogonal. These findings suggested that the Agent advantage effect in the two-fish paradigm was anchored more strongly in the processing of the Agent-Patient relation itself than in supplementary low-level motion-related cues. Although low-level visual information could affect more general aspects of picture processing, it did not appear to be the main source of the asymmetry between Agent and Patient search.

The third work package extended this conclusion by showing that the same Agent-Patient relation could give rise to different behavioural outcomes when embedded in different higher-level action contexts. Under strict perceptual control, the Agent advantage effect was replicated in fighting, but disappeared in chasing, even though both conditions preserved the same local biting relation. This pattern suggested that the presence of an

interpretable Agent-Patient relation may have been necessary, but was not by itself sufficient to guarantee the same Agent advantage effect across different depicted actions. What also mattered was how that relation was embedded in the broader action structure of the scene. One plausible interpretation was that fighting required more careful local inspection because correct role assignment depended on resolving a fine-grained overlap relation at the mouths, whereas chasing supported a more rapid global relational parse on the basis of face-to-tail arrangement and shared heading direction (Gao et al., 2009; Gao & Scholl, 2011; Scholl & Tremoulet, 2000). In terms of the verification account, fighting may have increased the need for local late-stage verification, especially during Patient search, whereas chasing may have reduced this need by allowing observers to derive the relational structure of the scene more globally. In this sense, the third work package provided the clearest evidence in the dissertation that higher-level action context constituted a genuine source of variation in the Agent advantage effect.

This interpretation also generates more specific predictions for future eye-tracking research. If fighting scenes require fine-grained local verification, they should produce gaze patterns similar to those observed in the first work package: last fixations should be directed more often toward the Patient or the local contact region before the response, particularly during Patient search. In contrast, if chasing scenes support a faster global relational parse, this late Patient-directed fixation bias should be reduced or absent. Chasing scenes might instead produce earlier gaze guidance based on the directional structure of the scene, for example, an early bias toward the leading fish or faster transitions between the pursuing and pursued fish. These predictions remain speculative, but they illustrate how the behavioural dissociation between fighting and chasing can be linked back to the temporal processing account developed from the eye-tracking results.

More broadly, the present dissertation suggested that the Agent advantage effect in static pictures should not be understood as a fixed or automatic preference for Agents whenever an Agent-Patient relation is present. Instead, the findings pointed to the Agent advantage effect as a context-sensitive outcome of visual event processing, whose emergence depends on how event role information is extracted, verified, and embedded within the overall structure of a scene. Across the three work packages, the effect remained robust in the classical two-fish paradigm, but it was also qualified by the temporal dynamics of event role processing, by the limited influence of supplementary low-level motion cues,

and by the higher-level action context in which the same local relation was embedded. The dissertation therefore shifts the interpretation of the Agent advantage effect from a general Agent-priority account toward a more constrained processing account: Agents are not necessarily prioritised in all static depictions of Agent-Patient relations; rather, the advantage emerges when the task and scene structure make Patient identification more dependent on additional verification. More generally, the present findings contribute to a broader understanding of visual event cognition by showing that event role asymmetries in static scenes are shaped not only by the presence of an Agent-Patient relation, but also by the way this relation is processed within a particular perceptual and action context.

Limitations and future directions

Several limitations should be considered when interpreting the findings of the present dissertation. First, although the three work packages together clarified important conditions under which the Agent advantage effect emerged, remained stable, or disappeared, the paradigm used throughout the dissertation was deliberately highly controlled. This was a strength because it made it possible to isolate the contribution of event role structure, motion line manipulations, and action context under tightly constrained conditions. At the same time, such control also limited the range of visual scenes to which the findings could be directly generalised. The stimuli were simplified line drawings of fish, and the tasks required explicit event role search. It therefore remained open to what extent the same pattern would be obtained in more naturalistic scenes containing richer object information, more complex actions, or less constrained viewing conditions. In this sense, the present dissertation prioritised explanatory precision over ecological breadth.

Second, the three work packages did not all provide the same type of evidence about processing mechanisms. The first work package directly measured gaze behaviour and therefore made it possible to link the Agent advantage effect to temporal dynamics during the search task. By contrast, the second and third work packages relied primarily on reaction times and accuracy. As a result, some of the explanations proposed for these later studies remained inferential. For example, the interpretation that fighting required more fine-grained local inspection whereas chasing supported a more rapid global relational parse was consistent with the behavioural pattern, but it was not directly tested with eye tracking measures in the action study itself. Future eye-tracking studies could therefore test whether fighting scenes produce a late Patient-directed fixation bias similar to that observed in the

first work package, and whether this bias is reduced or absent in chasing scenes. Such studies could also examine whether chasing leads to earlier gaze guidance based on the directional structure of the scene, for example, toward the leading fish or through faster transitions between the pursuing and pursued fish. Similarly, the conclusion that motion lines did not modulate the Agent advantage effect was behaviourally clear, but the present data could not determine at which stage motion line information was processed or why it failed to alter the asymmetry between Agent and Patient search. Future studies should therefore combine the present manipulations with temporally sensitive methods, such as eye-tracking or brief-presentation paradigms, to determine more directly how action context and low-level perceptual cues influence the time course of event role processing.

Third, the interpretation of the first work package itself remained subject to an important limitation. Although the eye-tracking data suggested that the Agent advantage effect was associated more strongly with the need for additional attention when identifying the patient, the study did not include a more neutral baseline condition. Consequently, it remained unclear whether the critical pattern reflected increased final checking during Patient search, reduced checking during Agent search, or a combination of both. This point mattered not only for the interpretation of the eye-tracking findings themselves, but also for the broader dissertation, because the first work package provided the temporal framework within which the later motion-line and action findings were interpreted. An important next step would therefore be to include a more neutral comparison condition that would make it possible to distinguish more precisely between Patient-related costs and Agent-related advantage.

Fourth, the present dissertation focused on speeded event role identification responses and therefore captured one specific manifestation of event role processing. While this approach was appropriate for examining the Agent advantage effect as originally defined in the two-fish paradigm, it left open how the same manipulations would influence other outcome measures, such as free descriptions, explicit event interpretations, or broader event representations. This limitation was particularly relevant for the third work package. The disappearance of the Agent advantage effect in chasing did not necessarily imply that participants failed to perceive an Agent-Patient structure or that chasing did not support a meaningful event representation. Rather, it showed that the chasing scenes did not produce the same asymmetry in the present search-based measure. Future work should therefore

complement speeded search tasks with tasks that assess how observers verbally encode or describe the scenes, for example, by examining whether fighting and chasing displays differentially bias which event role is mentioned first or more explicitly. Such measures would help determine whether the present findings reflected a broader shift in event representation or a more task-specific change in event role identification.

Finally, the present dissertation also opened several broader theoretical directions. One important question was whether the dissociation between fighting and chasing would generalise beyond the current fish displays to other actions and other kinds of stimuli. Another was whether low-level and high-level factors might interact under conditions different from those used here. For example, although motion lines did not modulate the Agent advantage effect in the present task, they may still matter in scenes where the event structure is more ambiguous or where directional motion cues are more central to role assignment. More generally, the present findings suggested that future research should move beyond asking whether the Agent advantage effect existed, and instead ask under which combinations of perceptual structure, action context, and task demands it was most likely to emerge. In this way, the current dissertation provided not only a more constrained account of the Agent advantage effect in static pictures, but also a framework for identifying the conditions under which the effect should be expected to remain robust or to vary.

Conclusion

The present cumulative dissertation examined the Agent advantage effect in static pictures from three complementary perspectives: its temporal dynamics during picture processing, its sensitivity to low-level visual cues, and its dependence on higher-level action context. Across the three work packages, the findings showed that the Agent advantage effect was a robust but not unconditional phenomenon. In controlled versions of the classical two-fish paradigm, observers were repeatedly faster to identify Agent information than Patient information. At the same time, the dissertation also showed that this asymmetry did not emerge equally under all conditions. Rather than being a fixed consequence of depicting an Agent-Patient relation, the Agent advantage effect depended on how event role information was processed within a given task and scene structure.

More specifically, the first work package showed that the Agent advantage effect in the classical two-fish task was associated more strongly with the need for additional late-

stage verification when identifying the patient. The second work package demonstrated that motion lines did not reliably modulate the effect, suggesting that supplementary low-level motion-related cues were not sufficient to alter the asymmetry between Agent and Patient search in the present paradigm. The third work package showed that the same local Agent-Patient relation could produce different behavioural outcomes when embedded in different action contexts: the Agent advantage effect was preserved in fighting but disappeared in chasing. Taken together, these findings suggested that the Agent advantage effect in static pictures was anchored not only in the presence of an interpretable Agent-Patient relation, but also in the verification demands and processing dynamics created by the broader structure of the scene.

In this sense, the present dissertation moved the interpretation of the Agent advantage effect beyond the question of whether it existed, and towards a more precise account of when it emerged, what sustained it, and under which conditions it changed. The dissertation therefore contributed to a more differentiated understanding of event role processing in static pictures by showing that the Agent advantage effect was neither a trivial by-product of low-level visual features nor a universal consequence of any depicted Agent-Patient relation. Instead, it was best understood as a context-sensitive asymmetry in visual event role processing whose expression depended on the interaction between relational structure, task demands, verification requirements and higher-level action context.

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Appendices

Appendix A: Manuscript 1

Appendix B: Manuscript 2

Appendix C: Manuscript 3

Appendix A: Manuscript 1

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A closer look at the agent advantage effect: An eye-tracking study on event role processing in pictures

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ABSTRACT

The agent advantage effect refers to observers responding faster to someone acting (the agent) than to the person or thing acted upon (the patient). An eye-tracking study investigated this effect in an ecologically valid context. Participants viewed images of two fish, one biting the other, and searched for the agent or the patient, pressing a corresponding button. Reaction times and eye movements were recorded. Participants responded faster when searching for the agent, replicating the agent advantage effect. Eye-tracking data showed that participants' last fixations were more likely on the patient fish during patient search, a bias not found in first fixations or during agent search. A strong correlation between last fixations and reaction times suggests that the agent advantage effect may partly arise from extra cognitive resources spent on identifying the patient. These findings support that additional attention is required when identifying the patient, contributing to the agent advantage effect.

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Living in a complex and dynamic world, people must extract and filter crucial information from daily events to understand their surroundings. In everyday experiences, the concept of event roles emerges as an essential component in perceiving human action (Zacks, 2020). Event roles include agents and patients. The agent is the performer of the action, and the patient is the person or thing being acted upon (Hafri et al., 2018; Segalowitz, 1982; Verfaillie & Daems, 1996). Human observers respond faster to the agent than to patient information (agent advantage effect; Segalowitz, 1982). While the effect has been widely found in language (Kemmerer, 2012), manual signs (Goldin-Meadow & Feldman, 1977), and picture stories (Cohn & Paczynski, 2013), its temporal dynamic remains largely unknown. We conducted an eye-tracking experiment to investigate the temporal structure of the agent advantage effect in pictures and to investigate the relation between eye-movements and reaction times.

When trying to understand their daily environment, human observers represent the incoming sensory information in event models, thus guiding comprehension (Huff et al., 2014; Zacks et al., 2007). The concept of event models has evolved from the concept of situation models. While situation models refer to constructing event representations from narrative texts (Zwaan & Radvansky, 1998), event models construct event representations from text, movies, and reality (Radvansky & Zacks, 2017). Event models are also structured fragments derived from the event's internal makeup, including the time, space, and character relationships (Huff et al., 2014; Zacks, 2020). Research has shown that event models are built quickly in event comprehension and that an essential component of this is the event role, including the agent and the patient (Cohn & Pacynski, 2013; Papenmeier et al., 2019; Stawarczyk et al., 2021).

There is an asymmetry in the processing of agents and patients, with the agent taking the dominant role (Isasi-Isasmendi et al., 2023; Segalowitz & Hansson, 1979). This tendency to focus on the performer of an action (the agent), followed by the person or object being acted upon (the patient), is known as

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the agent advantage effect (Segalowitz, 1982). The preference for agents is observed in both language (Kemmerer, 2012) and visual representations (Cohn & Pacynski, 2013), and agents are prioritised throughout human development stages (Cohn & Paczynski, 2013; Galazka & Nyström, 2016; Segalowitz & Hansson, 1979).

According to linguistic theories, agents are preferred over patients (Clark, 1965; Cohn & Paczynski, 2013). The subject-verb-object (SVO) or subject-object-verb (SOV) structures of different languages place the agent before the patient, which is related to the sequential order of semantic roles in the grammatical structure (Jackendoff, 1975; Keenan, 1976). In the vast majority of semantic role hierarchies, the agent is consistently prioritised (Jackendoff, 1975). In active sentences, for example, the agent is the subject of the sentence, which is a salient grammatical position. In passive sentences, the agent is usually omitted or placed in a less salient position, such as the prepositional phrase "by X." This can make it difficult for readers to identify the agent, which can be important for understanding the causal structure of a sentence. And indeed, people identify the agent in active sentences significantly faster than in passive sentences and with a lower error rate (Ferreira, 2003). Further, the preference for agents in language comprehension is also influenced by cultural (Maass & Russo, 2003; Segalowitz & Galang, 1978) and age-related (Dobel et al., 2007) factors.

There is also evidence of an agent advantage effect in visual narratives such as comics (Cohn & Paczynski, 2013). Cohn proposed a theory of visual narrative grammar (Cohn, 2013; Cohn et al., 2012), which is similar to language, with an overarching structure as well as a hierarchical structure of individual units. The panels that make up a visual narrative can be understood individually or in combination, and when the individual panel systems are combined, an event representation is constructed. While investigating the processing of event roles (i.e., the role of agents and patients) in visual narratives, Cohn and Paczynski (2013) discovered that participants predicted upcoming events primarily based on agents rather than patients. Moreover, they observed that it was the agents, not the patients, that initiated the construction of event representations. This suggests that agents are more salient and easier to process than patients.

The agent advantage effect occurs not only in (visual) narratives but even in single pictures. For example, Olson and Filby (1972) conducted an experiment using pictures of a truck colliding with a car. They found that participants were able to identify the agent (the truck) significantly faster than the patient (the car). Similarly, Segalowitz (1982) presented participants with pictures of two fish biting each other and asked them to identify the agent (or patient) of the action. The results showed that participants were faster at identifying the agent than the patient. Participants can identify event roles in pictures very fast, even with image presentations as short as 37 and 73 ms (Hafri et al., 2013). Further, the categorisation of objects into event roles occurs spontaneously, even when attention is directed towards other features, such as colour, of the objects (Hafri et al., 2018). Despite the overall preference for agents during the early processing of pictures, this effect can also be modulated by task and language demands (Isasi-Isasmendi et al., 2023).

One important prerequisite of the agent advantage effect in visual narrative is the presence of agent-patient relations. To control for the potential possibility that it could be the physical characteristic, instead of agent-patient relations, correlated with the agent advantage effect, Segalowitz (1982) used the letter "W" to replace the contours of the biting fish and asked the participants to search for the agent-like Ws or patient-like Ws. Although the "W" pictures contained all the spatial configurational features except for the agent-patient relation compared to the fish pictures, the agent advantage effect disappeared (Segalowitz, 1982), which indicates that the agent-patient relation should be the prerequisite of the agent advantage effect.

Many studies have demonstrated a preference for agents in pictures at the early encoding stages of processing visual information (Hafri et al., 2013; Isasi-Isasmendi et al., 2023; Segalowitz, 1982). Importantly, those studies used visual masks to interrupt information processing. In particular, the visual masks required participants to process the information and react accordingly within a limited time as short as 37 or 73 ms (Hafri et al., 2013), and 300 ms (Isasi-Isasmendi et al., 2023). Although that short exposure time helped a lot in studying the early stage of the cognitive process (the agent preference), the contribution of later processes (i.e., the time period before

people make the decision) remains to be understudied. Yet, these later information processing stages might be important in situations with higher ecological validity, such as generating bridging inferences when reading comics (e.g., Huff et al., 2020).

Measuring gaze behaviour during uninterrupted stimulus presentation offers the opportunity to study not only early but also later processes that might be important for the participants' decisions. It specifically enables the determination of the distribution of gaze on the different event roles, contributing to our understanding of processes involved in narrative comprehension, such as inference generation (Huff et al., 2020). Attention resources are distributed on both event roles during the search task (Isasi-Isasmendi et al., 2023; Segalowitz, 1982). The relative distribution of attention on the different event roles – agent and patient – might change during a search trial, indicating differential contributions of bottom-up and top-down influences. It can help to reveal more of the agent advantage effect, primarily if the effect is only related to the agent or both event roles contributed to the effect, or it might be an accumulated result over time. The visual attention resources on event roles could be impacted by other physical features, such as outstretched extremities (Hafri et al., 2018). To eliminate the potential impact of physical features, the role of the agent and patient should also be strictly controlled. Compared to other studies' stimulus pictures, which contain lower-level and higher-level characteristics and actions that might impact the cognitive process (Hafri et al., 2013), we used simple stimuli containing only one action. Thus, the result should only be related to the agent advantage effect. As it is essential to discover the attention resources, one related question should be, how can we study the process without interruption and still collect enough data to analyze? One possible way is to run an eye-tracking study.

Eye-tracking studies play an important role in studying semantic relations in language (Kamide et al., 2003), pictures (Foulsham et al., 2016), and visual narratives (Altmann & Kamide, 2009). These studies have provided valuable insights into how individuals allocate visual attention and process the semantic content of visual stimuli. For example, Altmann and Kamide (2009) used eye-tracking methods to investigate the relationship between linguistic and mental representations in visual scenes (pictures), thus revealing that language mediates the dynamic updating of individual event representations. Further, Foulsham et al. (2016) used eye-tracking methods to investigate the comprehension process of comic strips. They found that the pictures were understood more quickly and had fewer fixations when the comic strips were presented in their original order compared to a random order (see also Frith & Robson, 1975). Recently, there was a study investigating the preference for agents in pictures with the help of eye-movements (Isasi-Isasmendi et al., 2023). There was a preference for first fixations on the agent rather than the patient. Further, eye-movements were influenced by task and language, such as Basque-speaking participants looking at the agent more than Spanish-speaking participants (Isasi-Isasmendi et al., 2023). Interrupting the presentation of the picture by a mask (Hafri et al., 2013; Isasi-Isasmendi et al., 2023) provides evidence of the early processes of the processing of event roles in pictures. Yet, the potential contribution of later processes to the agent-advantage effect still remains unclear. Understanding the late processes is crucial because it's related to the higher cognitive functions that integrate and interpret sensory information, which eventually influences behavioural outcomes (VanRullen & Thorpe, 2001). With the present study, we decided to further investigate the agent advantage effect during natural (uninterrupted) viewing by studying eye-movements, thus focusing on the temporal dynamics of the whole process underlying the agent advantage effect and the visual attention resource distributed on both the event roles, thus, to investigating both early and late processes underlying the agent advantage effect.

Experimental overview

The literature reviewed suggests that the agent advantage effect exists across different modalities (for example, verbal, pictorial) and media types (for example, narration, comic books). Building on the work of Segalowitz (1982), we used an eye-tracking approach to investigate the temporal dynamics of the agent advantage effect. Participants were presented with line drawings of two fish, with one fish biting the other. The biting fish represents the agent, and the bitten fish represents the patient.

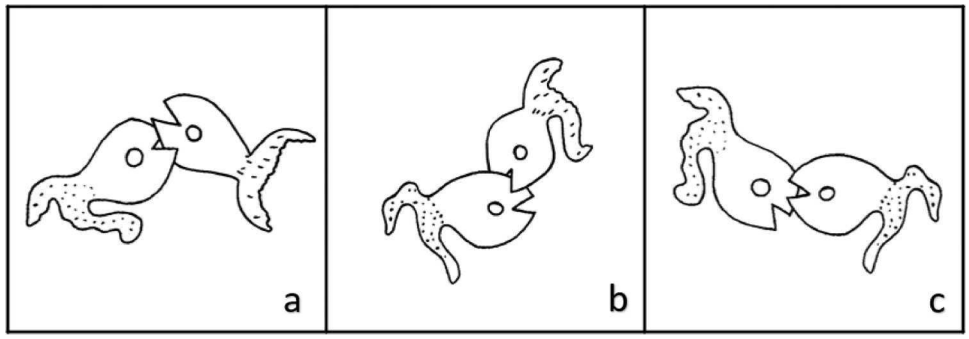

Figure 1. Sample Stimuli for the Experiment.
Note. (a) the left fish biting the right fish, (b) the right fish biting the left fish, (c) no biting action (filler trials).

While the participants searched for the agent or patient of the action, we measured reaction times and eye-movements. We expected to find that participants' reaction times in the agent search conditions are faster than in the patient search condition, replicating the agent advantage effect (Segalowitz, 1982). In addition, we used eye tracking to measure participants' fixations on the agent and patient fish. We then related the fixations to the search task (agent search vs. patient search), which allowed us to investigate how participants' eye-movements differed depending on the search task.

Methods

Participants

Sixteen participants were recruited from the University of Tübingen. All participants were female and aged between 20 and 34 years ($M = 23.5$, $SD = 3.90$). Participants reported normal or corrected-to-normal vision, no colour vision impairment, and signed an informed consent form. The sample size was large enough to detect effects with a size (d_z) of 0.75 with a power of 80 per cent.

Apparatus

The experiment was programmed in *PsychoPy Experiment Builder (v1.80.04)* (Peirce, 2007, 2009). An SMI RED eye tracker was used for binocular tracking at a sampling rate of 60 Hz (i.e., capturing 60 images per second) for each eye. We used a 60 Hz monitor (1280×1024 pixels; 37.6×30.1 cm) for the presentation of the stimuli. A headrest was used to stabilise the participants' head position, and participants' eyes were approximately 63 cm from the display. Each image subtended 20.7° visual angle horizontally and 13.6° vertically.

Stimuli material

The stimulus material consisted of line drawings of two fish depicting one of three actions: the left fish biting the right fish, the right fish biting the left fish, and no biting action (see Figure 1). We created 12 pictures with the agent on the left and 12 pictures with the agent on the right. We varied the orientation and length of the fish bodies and tails across the pictures to keep participants focused on the "biting" action rather than the other cues in the pictures. Based on those 24 pictures, we created another 12 pictures with no biting action (see Figure 1C). The no biting action stimuli were created by modifying the centre of the action stimuli tracings to eliminate the biting action content, thus encouraging the participants to focus on the biting action instead of paying attention to the other cues. However, the no biting trials were not included in our analysis due to the reason that there was no agent-patient relation (biting action) within these stimuli, thus leading to no event role of agent and patient within the pictures. All stimuli were presented at a size of 784×512 pixels.

Procedure and design

The experiment started with a 9-point binocular calibration and validation procedure, which was repeated until the validation procedure reported a deviation of each eye's X and Y coordinates being less than 0.8 degrees of visual angle. Then, participants were instructed about the search task. Participants were instructed to locate the side (left or right) of the biting fish (agent search) or bitten fish (patient

search). Half of the participants performed an agent search first, then followed by a patient search, and the other half of the participants performed a patient search first then followed by an agent search. Each search comprised 12 practice trials and 36 experimental trials (12 x agent on the left side, 12 x agent on the right side, 12 x no biting action). Participants responded using the keyboard, pressing "1" if the search target appeared on the left side, pressing "9" if the search target appeared on the right side, and pressing the space bar if the picture contained no biting action. Before the start of the second search task, participants saw a text message telling them that a new instruction follows and that they should read it carefully. Both search tasks presented the same pictures, with the pictures being horizontally and vertically flipped for the second search task. The order of pictures was randomised for each task and participant. Please note that for each biting action, there are two possible versions of how it could appear: either with the upper part of the agent's mouth on top of the patient fish or with the lower part of the agent's mouth on top of the patient fish. We presented half the pictures with one version and the other half with the alternative version, then counterbalanced the picture versions across participants.

At the beginning of each trial, a fixation cross appeared in the centre of the screen. Participants were required to fixate on it. Once the eye tracker confirmed that the participants' eye-movements were on the fixation cross, the fixation cross disappeared, and the trial started. The stimulus picture randomly appeared in either the upper or lower half of the screen, and participants were allowed to move their eyes freely. The stimulus picture was presented until the participant responded using the keyboard. Note that during the practice trials the stimulus picture was presented for a maximum duration of 5 s, and participants received feedback on either the correctness of their response or them being too slow to respond. During the experimental trials, the stimulus picture always appeared until response, and participants received no feedback.

After the participants finished both search tasks, the experiment ended. The experiment lasted around 20 min.

The experiment was a one factorial within-subjects design: we manipulated search task (agent search, patient search) and added no biting trials as filler trials.

Results

Search task performance

We first analyzed participants' performance in indicating the location of the agent fish or patient fish in our experiment. Participants showed a high correct response rate for indicating the location of the agent fish during agent search ($M = .98$, $SD = .03$) as well as for indicating the location of the patient fish during patient search ($M = .96$, $SD = .05$). There was no significant difference in participants' correct response rates between the two search conditions as indicated by a paired t-test, $t(15) = 1.07$, $p = .304$, $d_z = 0.27$. For all remaining analyses, we analyzed the trials with correct responses only. Note that there were three trials (3 of 746 trials, 0.4%) with a correct response but no fixation data. Those trials were removed from all eye-movement analyses.

Replication of agent advantage effect in reaction times

We analyzed participants' reaction times for correct responses with a paired t-test. With a reaction time benefit of 152 ms, the participants' reaction time in the agent search condition ($M = 987$ ms, $SD = 220$) was significantly shorter than in the patient search condition search ($M = 1139$ ms, $SD = 306$), $t(15) = -2.41$, $p = .029$, $d_z = -0.60$. Thus, our reaction time data replicated the agent advantage effect (Segalowitz, 1982). Nevertheless, our response times were notably longer when compared to the findings of Segalowitz (1982) because our stimuli were presented randomly above or below the fixation cross instead of presenting the stimuli in the centre of the screen.

Eye-Movements

Spatial accuracy

To ensure the quality of the eye-movement data, we ran a validation after the eye-tracker calibration to determine the spatial accuracy of the eye-movement data. This confirmed a good spatial accuracy across participants (deviation of x-coordinates of left eye: $M = 0.32$ degree of visual angle, $SD = 0.18$; deviation of y-coordinates left eye: $M = 0.47$ degree of visual angle, $SD = 0.15$; deviation of x-coordinates of right eye: $M = 0.28$ degree of visual angle, $SD = 0.16$;

deviation of y-coordinates of right eye: $M = 0.50$ degree of visual angle, $SD = 0.18$).

Fixation detection

All our eye-movement analyses are based on fixations. We detected fixations using a dispersion-threshold identification (I-DT) algorithm (Salvucci & Goldberg, 2000) with fixation radius as the dispersion measure (Blignaut, 2009). We used a maximum fixation radius of 1 degree of visual angle and a minimum fixation duration of 100 ms. Before running the fixation detection algorithm on the gaze samples, we averaged the locations of the binocular gaze samples. When calculating the average, we included only the data where the coordinates of the gaze samples of both eyes were less than 150 pixels apart from one another to ensure that we never calculate the average across invalid data.

Overall fixation duration and number of fixations

We first investigated whether the task of identifying the location of the agent fish or patient fish influenced the overall fixation durations and the number of fixations. We used paired *t*-tests to compare participants' mean fixation duration and participants' mean number of fixations between agent search and patient search. There was no significant difference in mean fixation duration between the agent search ($M = 280$ ms, $SD = 41$) and the patient search ($M = 303$ ms, $SD = 72$) conditions, $t(15) = -1.43$, $p = .173$, $d_z = -0.36$. Regarding the number of fixations, we also observed no significant difference between the agent search ($M = 3.02$, $SD = 0.42$) and patient search ($M = 3.29$, $SD = 0.58$) conditions, $t(15) = -2.00$, $p = .064$, $d_z = -0.50$. Although the number of fixations was not significant, it should be noted that even if it was significant, this could be explained by participants spending an additional 152 ms for the patient search condition compared to the agent search condition. Therefore, our subsequent analyses focused on the distribution of gaze between the agent fish and patient fish over time rather than on the raw fixation counts.

Fixations on agent fish vs. Patient fish

In the next step, we investigated the fixations on the agent and patient fish depending on the search condition (i.e., agent search vs. patient search). Therefore, we matched each fixation with our Areas of Interest (AOIs). AOIs are used to explore the relationship between gaze behaviour and the visual environment (Holmqvist et al., 2023). For our stimuli, we divided the fish into two AOIs: agent (biting fish) and patient (bitten fish) (see Figure 2).

To get a first descriptive impression of participants' fixations towards the agent fish and patient fish, we divided each trial into five equal bins, with each bin accounting for 20% of the overall trial duration. For each bin, we determined the mean proportion of time participants fixated on the agent fish and patient fish during both the agent search and the patient search (see Figure 3). This suggested that at the beginning of the trial, the proportion of fixation on the agent fish and the patient fish was similar during both the agent search and the patient search. However, towards the end of the search task, just before participants made their decision, it seemed that there might be a higher proportion of fixation on the patient fish compared to the agent fish during the patient search but not the agent search. To quantify this descriptive impression, we next analyzed the number of fixations on the agent fish and patient fish based on search condition (agent search vs. patient search), once for the first fixation on an AOI within the trial and once for the last fixation on an AOI within a trial.

First Fixation on Agent Fish vs. Patient Fish. To analyze whether the search task influenced whether participants' first fixation towards the fish in each search trial was directed towards the agent fish or patient fish, we performed a 2 (search: agent search, patient search) x 2 (AOI: agent fish, patient fish) repeated measures ANOVA with the dependent measure number of fixations (see Figure 4A). This revealed non-significant main effects of search, $F(1,$

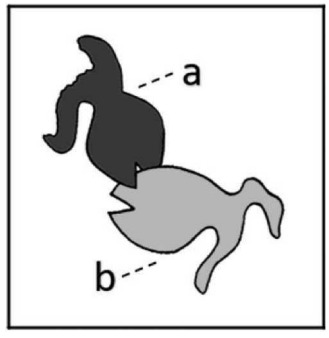

Figure 2. Definition of AOI for our Stimuli.

Note. (a) agent (biting fish), (b) patient (bitten fish). For illustration, we coloured the agent AOI dark grey and the patient AOI light grey.

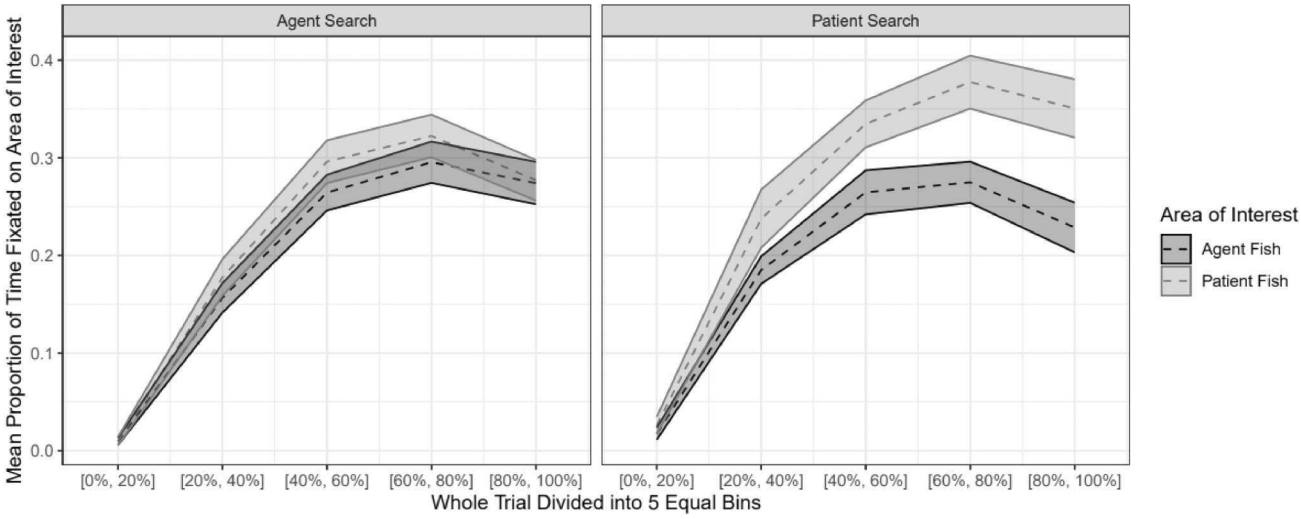

Figure 3. Mean Proportion of Time Fixated on AOIs During Agent Search and Patient Search.
Note. Error ribbons show the standard error of the mean.

15) = 1.79, $p = .201$, $\eta_p^2 = .11$, and AOI, $F(1, 15) = 2.15$, $p = .163$, $\eta_p^2 = .13$, as well as a non-significant interaction of search and AOI, $F(1, 15) = 0.74$, $p = .402$, $\eta_p^2 = .05$. Participants first fixation within a search trial was equally likely to land on either the agent fish or patient fish, and this tendency was also not influenced by the search task. Thus, at the beginning of the search task, participants fixated on the agent fish and patient fish equally.

Last Fixation on Agent Fish vs. Patient Fish. We analyzed the last fixation that landed on one of the two fish before participants made their decision (see Figure 4B). We performed a 2 (search: agent search, patient search) x 2 (AOI: agent fish, patient fish) repeated measures ANOVA with the dependent measure number of fixations. This revealed a non-significant main effect of search, $F(1, 15) = 1.79$, $p = .201$, $\eta_p^2 = .11$, a significant main effect of AOI, $F(1, 15) = 6.87$, $p = .019$, $\eta_p^2 = .31$, as well as a significant interaction of search and AOI, $F(1, 15) = 6.34$, $p = .024$, $\eta_p^2 = .30$. We further investigated the significant interaction with paired *t*-Tests. While there was no significant difference between the number of participants' last fixation on the agent fish or patient fish during

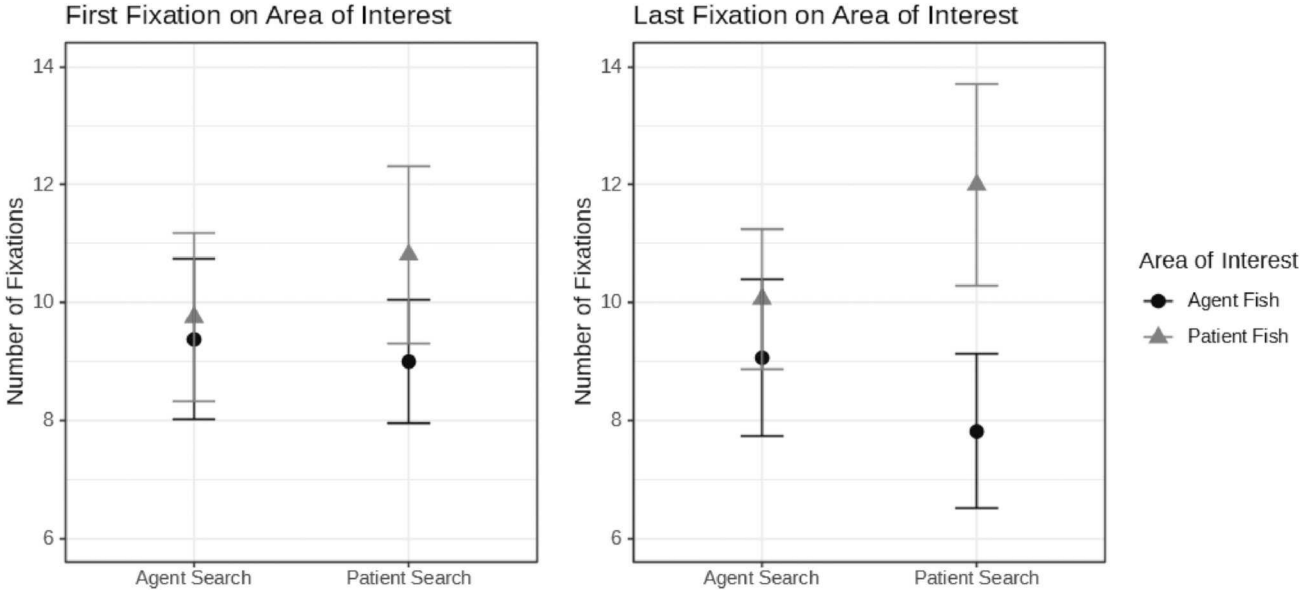

Figure 4. Number of Fixations on AOIs. A: First Fixation of a Search. B: Last Fixation of a Search.
Note. Error bars depict 95% confidence intervals of the mean.

agent search, $t(15) = -1.01$, $p = .329$, $d_z = -0.25$, participants performed more last fixations towards the patient fish than agent fish during patient search, $t(15) = -3.14$, $p = .007$, $d_z = -0.79$.

Relation Between Reaction Times and Eye-Movements. We observed longer reaction times when participants searched for the patient fish than agent fish, and we also observed that the longer reaction times in the patient search condition were associated with more fixations that were directed to the patient fish. With this analysis, we tried to investigate whether our findings based on eye-movements and reaction times were related to one another. More specifically, we were interested in whether those participants that showed a stronger influence of the search task on their last fixation towards the patient fish were also the participants that showed a stronger agent advantage effect in reaction times. Therefore, we calculated two measures for each participant. As an index of the strength of the eye-movement effect during the last fixation, we performed the following calculations: First, we calculated the difference between the number of fixations on the patient fish and agent fish for both search tasks separately. Thereafter, we calculated the difference between those two scores as our index of the eye-movement effect, which was the last fixation difference (patient search minus agent search). As an index of the strength of the reaction time effect, we calculated the difference in reaction times between patient search and agent search, which was reaction time difference (patient search minus agent search). We then correlated these two measures (see Figure 5), which revealed a strong positive correlation, $r(14) = .78$, $p < .001$. Thus, the data suggest a strong relation between our eye-movement results and reaction time results, with a larger tendency of having more last fixations on the patient fish than agent fish during patient search than agent search being related to longer response times for patient search than agent search. This indicates that the tendency of participants to perform a last fixation towards the patient fish during patient search might in part explain the agent advantage effect typically observed with reaction time data.

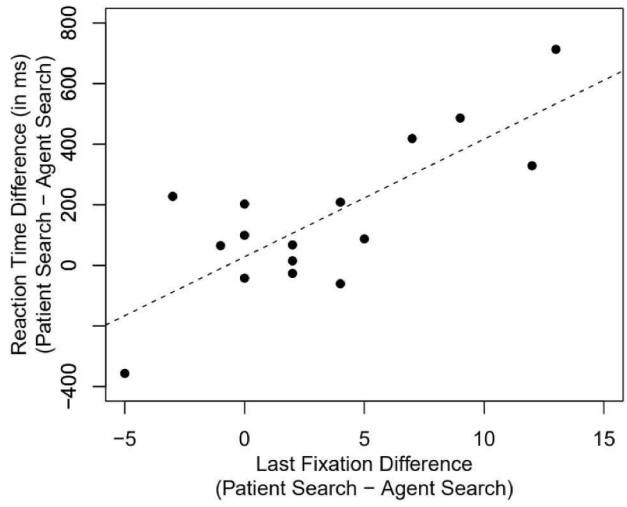

Figure 5. Correlation Between Influence of Search Task on Eye-Movements and Reaction Times.

Note. Each dot depicts a participant.

Discussion

With this eye-tracking study, we investigated the agent advantage effect in pictures. Thereby, the aim of the study was twofold: first, we tried to replicate the agent advantage effect in reaction times (Segalowitz, 1982), and second, we tried to investigate the temporal dynamics of the agent advantage effect based on the eye-movement data. As predicted, we observed faster reaction times when participants searched for the agent than when participants searched for the patient, thus replicating the results reported by Segalowitz (1982). Regarding eye-movements, we observed that participants' last fixation that landed on one of the two fish before they made their decisions was preferentially directed towards the patient fish rather than the agent fish during the patient search. In contrast, for agent search during the last fixation as well as for agent and patient search during the first fixation, there was no bias towards one of the two fish. We also observed a strong correlation between the impact of the search task on reaction times and the impact of the search task on participants' eye-movements during the last fixation.

Our reaction time data support the idea that identifying the patient in a picture takes longer than identifying the agent in a picture (Olson & Filby, 1972; Segalowitz, 1982). Interestingly, this seems to apply both to the identification of the location of the agent or patient (i.e., "Where is the agent / patient located? Left or Right?"; our present experiment; Segalowitz, 1982) as well as to the identification of the identity of the agent or patient (i.e., "What hit / What was hit? Car or Truck?"; Olson & Filby, 1972).

Faster responses for agent information than patient information occurred not only when participants' attention was directed to the agent or patient before the onset of a picture (Olson & Filby, 1972; Segalowitz, 1982) but also when participants recognised whether a presented object appeared in a previously shown picture (Isasi-Isasmendi et al., 2023). That is, the recognition of previously seen objects was faster for objects that were the agent rather than the patient in the previously shown picture (Isasi-Isasmendi et al., 2023). This indicates that the agent advantage effect is a rather general bias in perception.

It should be noted, however, that the time required for processing agents in pictures also depends on the aims of the task and level of processing required. More specifically, at a lower level of processing – such as searching for event roles within single pictures – reaction times are typically faster for agents than patients (Segalowitz, 1982; our experiment). However, when tasks involve more complex processing – such as comprehending the narrative in a comic – agents are processed slower than patients, because agents trigger the building of event models, which involves a higher level of cognitive engagement (Cohn & Paczynski, 2013; Hafri et al., 2018).

Based on our eye-movement data, we learned more about the process underlying the agent advantage effect in pictures. Interestingly, although there was no significant difference in the overall number of fixations between the agent search and the patient search (note, the *p*-value for the no significant overall number of fixations equals .064, the effect might be marginal), our results indicated that the differences between the agent search and patient search were not primarily determined by the first fixation within a trial. Instead, it was the last fixation participants performed before they made a decision that was different between agent search and patient search. That is, during the patient search, participants preferred landing more last fixations on the patient fish rather than the agent fish, while there was no bias for one of the two fish during the agent search. The size of this bias of last fixations towards the patient fish was also associated with the size of the agent advantage effect in reaction times. This suggested that the agent advantage effect in reaction times might not only be related to the prioritised processing of the agent as discussed in previous research (e.g., Isasi-Isasmendi et al., 2023; Olson & Filby, 1972; Segalowitz, 1982) but it might also be caused by the late process (VanRullen & Thorpe, 2001). That is, before making a decision during the patient search, participants might need to double-check until they finally find the patient fish.

While we found that differences in the last fixation between agent search and patient search might contribute to the agent advantage effect, it remains unclear whether this is due to more last fixations towards the patient fish (relative to the agent fish) during patient search or fewer last fixations towards the patient fish (relative to the agent fish) during agent search. One potential solution to this issue would be to compare these results to a baseline. This baseline should meet two criteria: first, it should reflect the distribution of last fixations on the event roles after participants have fully processed the agent-patient relation; second, it should occur in a natural context, independent of any task that biases attention towards one of the two event roles. However, our current data do not provide a suitable baseline for the following reasons. First, the last fixations from the filler trials cannot be used as the baseline because there was no biting action within the stimuli, which means there were no agent-patient relation leading to no event roles within the stimuli. Second, we used a search task biasing attention towards the agent fish or the patient fish. Future studies should establish a neutral baseline condition to discern if patient search requires additional visual verification or if agent search minimises this need, providing further insight into the fixation patterns associated with the agent advantage effect.

While Isasi-Isasmendi et al. (2023) observed that participants had a strong preference for looking towards the agent rather than the patient during the first fixation on an action scene, the number of first fixations on the agent and patient did not differ within our experiment. At first sight, this might seem surprising, given that both studies applied similar eye-tracking methods. Specifically, both of the studies instructed participants to focus their attention on a central fixation cross at the beginning of each trial, then a picture appeared in the periphery, and the first fixation was measured. However, there are some important differences between the two studies that might explain the different findings. First, while the pictures were visible until response

in our study, the pictures were only visible for 300 ms followed by mask in the study of Isasi-Isasmendi et al. (2023). Thus, one might argue that this caused extra pressure to quickly encode the pictures in the study of Isasi-Isasmendi et al. (2023). However, participants in our study also tried to identify the target location as quickly as possible, rendering this explanation rather unlikely. Second, we presented action scenes with the agent and patient looking very similar to each other. In contrast, Isasi-Isasmendi et al. (2023) presented action scenes of agents and patients that looked very different, such as a woman pouring water into a cup or a woman kicking a man. Thus, for our study, participants had to focus near the mouth to identify which fish was the agent or patient. In the Isasi-Isasmendi et al. (2023) study, participants were likely able to quickly discriminate event roles based on physical features such as outstretched extremities (Hafri et al., 2013). Those physical features were probably easier to identify in the periphery than the mouth of the fish, thus allowing participants to strategically programme their first saccade towards the agent or patient in the Isasi-Isasmendi et al. (2023) study but not our study. Third, the agent and patient were both animate in our study, whereas in the Isasi-Isasmendi et al. (2023) study, the patient was sometimes animate (e.g., another person) and sometimes inanimate (e.g., a book). Thus, participants might be prone to direct their first fixation towards an animate object, which is partially correlated with the agent in the Isasi-Isasmendi et al. (2023) study but uncorrelated with event role in our study. Indeed, Isasi-Isasmendi et al. (2023) report that the bias of first fixations being directed towards the agent rather than the patient was largely reduced for the stimuli that presented animate patients in their study. However, despite its large reduction, Isasi-Isasmendi et al. (2023) argued that the agent bias was still present even if the patient was animate. It remains to be resolved to what extent these three aforementioned aspects (masking, physical features, animacy) might contribute to the bias of first fixations being directed towards the agent rather than the patient.

In our study, we used pictures showing two fish in a "bite" relationship, and we also used the word "bite" in our experimental instructions. It would be interesting for future studies to investigate whether part of the agent advantage effect as observed in our study might also be related to observers instinctively paying more attention to potentially dangerous objects due to the human instinct that "biting" is dangerous. According to Wilson et al. (2022), agent-based event representations are common in modern humans and have deep evolutionary roots, as research on primates and other species indicates. Thus, replacing the action "biting" with "kissing" or "cleaning" might cause a reduction of the agent advantage effect as the agent is no longer perceived as being dangerous.

The main goal of the study was to explore the underlying process of the agent advantage effect on a very fundamental level. We utilised well-established, simplified stimuli, which helped us control for any potential influences that might have arisen from using new stimuli. However, since the agent advantage effect is prevalent in many complex and more naturalistic visual scenes, it is also important to study the agent advantage effect beyond simple actions and within more complex visual scenes. Due to the wide appearance of the agent advantage effect, we understand our study as the starting point. Further research is necessary, for example, by studying the contribution of lower-level properties (e.g., motion lines known from Comic research; Cohn & Maher, 2015) or higher-level representations (e.g., event category; Hafri et al., 2018).

In summary, we replicated the agent advantage effect (Segalowitz, 1982), that is participants responded faster for agent search than for patient search. Further, based on our eye-movement data, we found a large preference for last fixations being directed towards the patient fish rather than agent fish within the patient search but not the agent search. This bias in eye-movements was strongly related to our reaction time results, thus suggesting that part of the agent advantage effect might be explained by participants spending extra resources in identifying the patient.

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Data availability statement

Data and analysis scripts (for the statistical programming language R) have been made publicly available via the Open

Science Framework (OSF) and can be accessed at https://osf.io/m63bz/

[NOTE: This is a private view only link for the review process only. We will make the project public once the manuscript is accepted for publication]

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix B: Manuscript 2

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A closer look at the agent advantage effect: The impact of motion lines

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ABSTRACT

The Agent advantage effect refers to observers responding faster to someone performing an action (the Agent) than to the person or thing acted upon (the Patient). This research investigates whether the presence of motion lines behind the Agent or Patient influences the Agent advantage effect. Participants viewed pictures of two fish, one biting the other, and searched for either the Agent or Patient. They pressed the corresponding button, and their reaction time was recorded. Experiment 1 used parallel motion lines aligned with the direction of motion, whereas Experiment 2 used orthogonal motion lines. Both experiments replicated the Agent advantage effect, but motion lines did not significantly alter its magnitude. These results highlight the robustness of the effect and suggest that event role processing and motion line perception might operate independently.

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Agent advantage effect; agent; patient; motion lines

In daily life, people extract and filter information from their surroundings to understand life events. One important component of events is event roles, which include the Agent (the performer of the action) and the Patient (the person or thing being acted upon) (Hafri et al., 2018; Segalowitz, 1982; Verfaillie & Daems, 1996). Human observers tend to prioritise the processing of Agent information compared to the Patient information (Agent advantage effect, Segalowitz, 1982), which has been widely found in different areas, such as language (Kemmerer, 2012) and comics (Cohn & Paczynski, 2013). Despite extensive research, the processes underlying the visual "Agent Advantage Effect" remain underexplored. While research has explored the processing of event roles in visual contexts using eye-tracking methods (Isasi-Isasmendi et al., 2023; Xu et al., 2024) and with well-designed materials (Hafri et al., 2013, 2018; Isasi-Isasmendi et al., 2023; Xu et al., 2024), the potential influence of visual properties towards the processing of event roles has also been highlighted, such as animacy (Isasi-Isasmendi et al., 2023; Xu et al., 2024) and physical features (Hafri et al., 2013; Isasi-Isasmendi et al., 2023; Xu et al., 2024). Building on this foundation, we took a step back and used simple schematic stimuli to further investigate the processing of event roles within the Agent advantage effect. Specifically, we studied how the presence of motion lines impacts the Agent advantage effect in still pictures, thus contributing to a deeper understanding of the cognitive mechanisms underlying event role processing.

Human observers establish event models based on sensory information to guide their comprehension of the daily surroundings (Huff et al., 2014; Zacks et al., 2007). The concept of event models evolved from that of situation models, which construct event representations from text, movies, and reality (Radvansky & Zacks, 2017), and structure fragments derived from the event's internal makeup, including the time, space, and character relationships (Huff et al., 2014; Zacks, 2020). One essential component of event models is the event role, including the Agent and the Patient (Cohn & Paczynski, 2013; Papenmeier et al., 2019; Xu et al., 2024).

Research has revealed a processing asymmetry between Agents and Patients, with Agents typically taking a more salient role during event comprehension (Isasi-Isasmendi et al., 2023; Segalowitz &

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Hansson, 1979; Xu et al., 2024). This asymmetry reflects the prominent role Agents play in structuring event understanding and aligns with findings across linguistic theories (Clark, 1965; Cohn & Paczynski, 2013; Kemmerer, 2012) and in visual representations (Cohn & Paczynski, 2013; Segalowitz & Hansson, 1979; Xu et al., 2024).

Regarding visual representations, the prioritization of Agents has been explored in single pictures and comics (Cohn & Paczynski, 2013; Olson & Filby, 1972; Segalowitz, 1982; Xu et al., 2024). Olson and Filby (1972) conducted an experiment using pictures of a truck colliding with a car and asked participants, "What hit?" (targeting the Agent) and "What was hit?" (targeting the Patient). They found that participants located the Agent (the truck) significantly faster than the Patient (the car). Similarly, Segalowitz (1982) presented participants with pictures of two fish biting each other and asked them to identify the Agent (or Patient) of the action. The results showed that participants were faster at identifying the Agent than the Patient. Agents are not only more salient and easier to process but also trigger the constructions and predictions of events. Cohn and Paczynski (2013) conducted experiments with Peanuts comics and presented participants with panels showing either Agents or Patients in preparatory states (i.e., before the action was completed) and asked them whether they could make predictions about the upcoming action based on the panels. The results showed that Agents play a central role in building event structures.

The recognition of the event roles is rapid and the visual system recovers a number of properties which may be relevant to assigning event roles (e.g., Hafri et al., 2013, 2018). The event roles can be identified in pictures very fast, even with brief exposures as short as 37 and 73 ms, which suggests a fast and automatic visual process (Hafri et al., 2013). Also, Rolfs et al. (2013), showed that causal interactions, such as one object launching another, trigger retinotopically specific visual adaptation, suggesting that basic Agent-Patient relations can be encoded at early stages of visual processing. Visual features such as shape and posture also play an important role in event roles assignments (Hafri et al., 2013; Vettori et al., 2025). Recent findings further confirm that event roles can be spontaneously assigned based solely on posture and positioning, even when the task does not require such processing, highlighting the automaticity and perceptual basis of thematic role representation in vision (Vettori et al., 2025). Studies by Hafri et al. (2013) found that observers of dyadic social interactions automatically use shape and posture cues (such as actors' outstretched arms) to assign event roles of Agent and Patient.

In order to better control the potential impact of the stimulus, we decided to use materials that were originally developed by Segalowitz to show the Agent advantage effect (Segalowitz, 1982; Segalowitz & Hansson, 1979) and that we adapted for an eye-tracking study (Xu et al., 2024), in which both the Agent and the Patient were depicted as fish, thereby maintaining similarity in appearance and animacy. Participants were able to recognize the event roles only after fully processing the Agent-Patient relation, such as the biting action depicted in the images (Segalowitz, 1982; Xu et al., 2024). This Agent-Patient relation is a crucial prerequisite for observing the Agent advantage effect (Segalowitz, 1982; Xu et al., 2024). It is only when an Agent-Patient relation is present within the pictures, for example, an Agent biting a Patient, that the Agent advantage effect emerges. Conversely, pictures that solely depicted spatial configurations without clear Agent-Patient relations (i.e., letter "W" stimuli mimicking the biting action) did not elicit this effect (Segalowitz, 1982).

Building upon this controlled setup, our present study investigated the role of motion lines for event role processing. Motion lines (action lines, speed lines, or zip ribbons) are the lines drawn behind the mover to indicate the action path (Burr, 2000; Cohn & Maher, 2015; Hacımusaoğlu & Cohn, 2023; Kim & Francis, 1998). Hacımusaoğlu and Cohn (2023) proposed three ways to understand the meaning of motion lines: perceptual, metaphorical, and lexical interpretations. Regarding the visual perception perspective, motion lines are rooted in low-level visual processing mechanisms. Specifically, they are thought to mimic motion streaks, spatial signals aligned with the direction of movement, arising from temporal integration in the primary visual cortex when tracking fast-moving stimuli (Cohn & Maher, 2015; Geisler, 1999; Hacımusaoğlu & Cohn, 2023). In this view, motion lines are not symbolic but iconic, directly tied to biological perceptual processes. The metaphorical account, in contrast,

argues that motion lines are visual metaphors derived from natural path marks, such as tracks left by vehicles or waves in water (Hacımusaoğlu & Cohn, 2023). These are not linked to perceptual systems per se, but to embodied experience with the physical world. Motion lines serve to "make the invisible visible" by symbolically referencing these natural traces in a static medium (Hacımusaoğlu & Cohn, 2023). The lexical perspective suggested motion lines as learned graphic conventions; the meaning of the motion lines is based on comprehension with shared common patterns, which leads to cross-cultural differences between visual lexicons (Cohn, 2013; Hacımusaoğlu & Cohn, 2023).

Motion lines can disambiguate the direction of motion (Francis & Kim, 1999; Hacımusaoğlu & Cohn, 2023; Kawabe & Miura, 2006), strengthen the understanding of motion (Cohn & Maher, 2015), and indicate the speed of motion (Carello et al., 1986; Gillan & Sapp, 2005; Hacımusaoğlu & Cohn, 2025). Kim and Francis (1998) conducted an ambiguous motion display and figured out that motion lines contributed to motion percepts and disambiguated motion direction. Furthermore, compared to no motion lines, motion lines speed up the understanding of motion (Cohn & Maher, 2015; Hacımusaoğlu & Cohn, 2023, 2025). Cohn and Maher (2015) compared participants' viewing times across conditions with normal lines (motion lines showed path), no lines (motion lines removed from image), and anomalous lines (motion lines were reversed compared to normal lines). They found that the shortest viewing times occurred when participants viewed images with normal lines, followed by no lines, and the longest times were observed with anomalous lines (Cohn & Maher, 2015). Motion lines also indicate the speed of motion (Carello et al., 1986; Gillan & Sapp, 2005; Hacımusaoğlu & Cohn, 2025). Hacımusaoğlu and Cohn (2025) compared the speed rating of motion lines in different positions (suppletion, backfix, motion lines, and object only) and found that the appearance of motion lines significantly strengthened the speed rating of an object compared to the object without motion lines. Research also showed that the number of motion lines were positively correlated with the perceived speed of motion (Gillan & Sapp, 2005), and the thickness had no impact on the perceived speed (Gillan & Sapp, 2005). Hacımusaoğlu and Cohn (2025) also showed that more motion lines are associated with faster perceived speed. All these findings support the idea that motion lines function as cues for the understanding of motion in static pictures. In Olson and Filby's study (1972), schematic drawings of car collisions were used, in which a truck was shown bumping into a car. They used wavy lines to illustrate the bumping area for the Agent object and non-wavy lines to illustrate the bumping area of the Patient object. Further, they added parallel motion lines to the Agent and imitated the contours of the Patient with motion lines to further strengthen the bumping action. They found that participants were able to identify the Agent (the truck) significantly faster than the Patient (the car). However, this result might be influenced by the task, which required participants to answer questions such as "What hit?" or "What was hit?". Moreover, because visual features such as motion lines and impact contours were not systematically manipulated, it remains unclear to which extent these additional visual cues (motion lines, contours of bumping area) might draw participants' attention and thereby impact the Agent advantage effect. Building on this, Segalowitz (1982) argued that motion lines might influence the Agentness of objects and thereby artificially alter the Agent advantage effect, which is the reason why he excluded the use of motion lines in his stimuli. However, this claim was never systematically tested. Recent work in visual language research has suggested that motion lines are not merely perceptual cues but can serve as cognitive markers that emphasize unexpected movement, especially for inanimate entities, which reflects a broader "mark the unexpected" principle (Krajinović et al., 2025). While their study focused on differences in motion line use between animate and inanimate entities, our study investigates whether motion lines also influence the identification of event roles when both entities are animate. In particular, we examine whether motion lines behind either the Agent or Patient impact the Agent advantage effect in pictures depicting social interaction. Our present research fills this gap by investigating the influence of the presence of motion lines on the Agent advantage effect within two experiments, which contributes to a deeper understanding of the cognitive mechanisms underlying event role processing in pictures.

We manipulated the presence/absence of motion lines behind the agent and patient in two experiments (Experiment 1: parallel to motion direction, Experiment 2: orthogonal to motion direction). We

asked participants to search for either the Agent or the Patient in pictures depicting line drawings of two fish, with one fish biting the other. For both experiments, we expected to replicate the Agent advantage effect (Segalowitz, 1982) in pictures without motion lines by observing faster reaction times for Agent search than Patient search. In addition, we investigated whether the presence of motion lines behind the Agent and/or Patient influence the size of the Agent advantage effect. If motion lines influence event role processing, we would expect an interaction with the Agent advantage effect. Conversely, if no such interaction occurs, this could indicate that the perception of motion lines and the identification of event roles are processed by distinct, possibly independent mechanisms.

Experiment 1: The impact of parallel motion lines

Methods

This experiment was preregistered: https://osf.io/tgn4r.

Participants

Our final sample size following exclusions consisted of 74 participants recruited from the University of Tübingen (16 males and 55 females; 3 did not state their gender) with a mean age of 24.76 years ($SD = 4.60$; two participants did not state their age). Participants reported normal or corrected-to-normal vision and signed an informed consent form.

We determined that 72 participants were required to achieve 80% power for the predicted two-way interactions investigated (alpha 5%, minimum relevant effect: increase or decrease of Agent advantage effect by half of its size, e.g., increase from 150 ms to 225 ms or decrease from 150 ms to 75 ms, for details see power analysis script available at https://osf.io/7tayn). To account for potential exclusions, we initially aimed to recruit 80 participants. However, after recruiting 80 participants, there were only 69 valid datasets. Therefore, we decided to continue data collection until we achieved 72 available data sets after exclusion. Because two additional participants had participated in the experiment before we stopped data collection, our final sample consisted of 74 participants after exclusion. In total, 86 participants were tested, and 12 were excluded due to a correct response rate below 80%, leading to the final sample of 74 participants.

Apparatus

The experiment was programmed in *PsychoPy Experiment Builder (v2023.1.2)* (Peirce, 2007, 2009). We used a 60 Hz monitor (1920 × 1200 pixels; 51.8 × 32.3 cm) for the presentation of the stimuli.

Stimuli material

The stimulus materials were based on 24 line-drawing pictures (12 pictures with the Agent on the left and 12 pictures with the Agent on the right) containing Agent-Patient relation, which successfully replicated the Agent advantage effect (Xu et al., 2024). Each picture consisted of two fish, one biting the other. The spatial configuration varied in two ways: (1) horizontally, with either the left fish biting the right fish or the right fish biting the left fish, and (2) vertically, with the Agent (the biting fish) appearing at the top, in the centre, or at the bottom of the image. To further counterbalance spatial positions, in the second block of the experiment the images were systematically flipped both horizontally and vertically, so that left/right and top/bottom orientations were reversed across trials.

For the present experiment, we added motion cues selectively to the Agent's tail, the Patient's tail, both tails, or neither (original picture), represented by three directional lines parallel to the fish's orientation (see Figure 1). This resulted in a total of 96 images: 24 without motion lines (Figure 1(a)), 24 with motion lines behind the Agent's tail (Figure 1(b)), 24 behind the Patient's tail (Figure 1(c)), and 24 behind both tails (Figure 1(d)). To maintain consistency in perceived speed across event roles, we standardized motion cues using three waving lines per tail, aligned with the fish's movement. Additionally, we varied the orientation and length of the fish bodies and tails in all images to ensure participants focused on the biting action. All stimuli were presented at a size of 640 × 360 pixels (17.3 × 9.7 cm) in the centre of the screen.

Procedure and design

Participants were instructed about the search task. Participants were instructed to locate the side (left

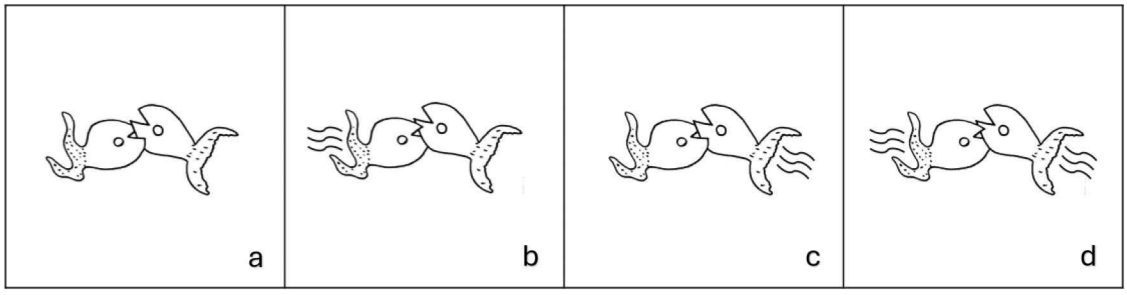

Figure 1. Sample stimuli for Experiment 1. Note. (a) both Agent fish and Patient fish without parallel motion lines, (b) parallel motion lines behind the Agent's tail, (c) parallel motion lines behind the Patient's tail, and (d) parallel motion lines behind both tails of the Agent and Patient.

or right) of the biting fish (Agent search) or bitten fish (Patient search). Half of the participants performed an Agent search first, followed by a Patient search, and the other half of the participants performed a Patient search first, followed by an Agent search. Each search comprised 32 practice trials and 96 experimental trials.

Participants initially completed practice trials to better understand the tasks required in the experimental trials. After they had finished the practice trials, they were informed of the start of the experimental trials. Participants responded using the keyboard, pressing "1" if the search target appeared on the left side and pressing "9" if the search target appeared on the right side. A 500 ms blank screen appeared before each picture was displayed in the centre of the screen. Following each response, a mask was displayed for 500 ms. Then, the next trial started.

Both search tasks present the same pictures, with the pictures being horizontally and vertically flipped for the second search task. The order of pictures was randomized for each task and participant. Please note that for each biting action, there were two possible versions of how it could appear: either with the upper part of the Agent's mouth on top of the Patient fish or with the lower part of the Agent's mouth on top of the Patient fish. We presented half the pictures with one version and the other half with the alternative version, then counterbalanced the picture versions across participants.

After the participants finished both search tasks, the experiment ended. The experiment lasted around 20 min.

The experiment followed a 2 (search-task: Agent search, Patient search) x 2 (Agent parallel motion lines: with, without) x 2 (Patient parallel motion lines: with, without) within-participants design.

Results

Preregistered analysis

For all analyses, we analyzed the reaction times for correct responses (proportion correct rates: Agent search: $M = .96$, $SD = .19$; Patient search: $M = .95$, $SD = .21$).

In the first step, we examined whether the Agent advantage effect was replicated in stimuli without motion lines. Thus, we analyzed participants' reaction times for correct responses with a paired *t*-test, showing a reaction time benefit of 128 ms: the participants' reaction time in the Agent search condition ($M = 623$ ms, $SD = 111$) was significantly shorter than in the Patient search condition search ($M = 750$ ms, $SD = 188$), $t(73) = -9.33$, $p < .001$, $d_z = -1.08$. Therefore, we could replicate the Agent advantage effect in the stimuli without motion lines (Segalowitz, 1982; Xu et al., 2024).

In the second step, we investigated the effect of parallel motion lines on the Agent advantage effect by investigating the interaction between the search task (Agent search vs. Patient search) and the presence or absence of parallel motion lines. We performed a 2 (search task: Agent search, Patient search) x 2 (Agent parallel motion lines: with, without) x 2 (Patient parallel motion lines: with, without) repeated measures ANOVA with the dependent measure mean reaction time. This revealed significant main effects of search, $F(1, 73) = 96.69$, $p < .001$, $\eta_p^2 = .57$, of Patient parallel motion lines, $F(1, 73) = 4.10$, $p = .047$, $\eta_p^2 = .05$, and a significant two-way interaction of Agent parallel motion lines and

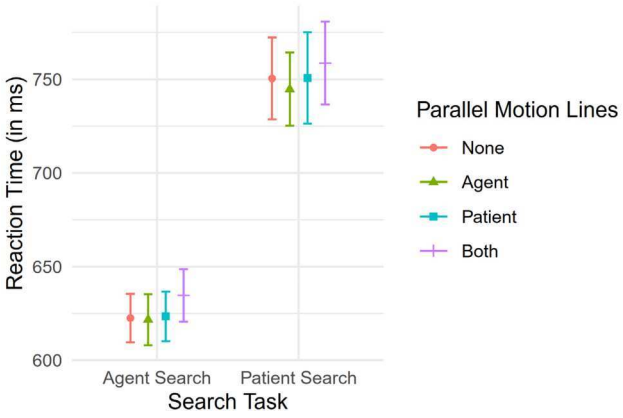

Figure 2. Mean reaction time in seconds on search task and parallel motion line conditions. Note. Error bars show the standard error of the mean.

Patient parallel motion lines, $F(1, 73) = 5.53$, $p = .021$, $\eta_p^2 = .07$. In contrast, the main effect of Agent parallel motion lines, $F(1, 73) = 0.48$, $p = .490$, $\eta_p^2 = .01$, as well as the two way interactions of search and Agent parallel motion line, $F(1, 73) = 0.36$, $p = .550$, $\eta_p^2 = .00$, search and Patient parallel motion lines, $F(1, 73) = 0.00$, $p = .986$, $\eta_p^2 = .00$, and three-way interaction of search, Agent parallel motion lines and Patient parallel motion lines, $F(1, 73) = 0.02$, $p = .881$, $\eta_p^2 = .00$, were all non-significant. Thus, while we observed an overall strong effect of the search task on reaction times with a faster search for Agent information than Patient information, all interactions including search and parallel motion lines were not statistically significant, suggesting that the Agent advantage was not reliably modulated by motion lines (see Figure 2).

Despite the interactions including search and parallel motion lines being non-significant, we still observed a significant main effect of Patient parallel motion lines and a significant interaction between Agent parallel motion lines and Patient parallel motion lines. We further investigated this interaction of the presence of Agent parallel motion lines and Patient parallel motion lines (see Table 1) with pairwise comparisons using paired *t*-tests. This revealed that adding parallel Patient motion lines increased reaction times only when Agent motion lines were already present (Agent vs. Both), but not when no motion lines were present (None vs. Patient). That is, compared with pictures that had no motion lines, only adding parallel motion lines behind both the Agent fish and the Patient fish significantly increased reaction times (None vs. Both). In contrast, adding parallel motion lines only behind the Agent fish (None vs. Agent) or only behind the Patient fish (None vs. Patient) did not significantly affect reaction times.

Discussion

In Experiment 1, we investigated the Agent advantage effect in pictures. The aim of the study was twofold: first, we tried to replicate the Agent advantage effect in reaction times (Segalowitz, 1982), and second, we tried to investigate the impact of the presence of parallel motions of the Agent advantage effect. As predicted, we observed faster reaction times when participants searched for the Agent than when participants searched for the Patient when there were no parallel motion lines within the stimuli, thus replicating the results reported by Segalowitz (1982) and Xu et al. (2024). Regarding the presence of parallel motion lines, we observed that the interactions including search and motion lines were not statistically significant, suggesting that the cognitive process underlying the Agent advantage effect may not be reliably modulated by motion lines. One possible explanation for why the presence of parallel motion lines did not impact the Agent advantage effect could be that participants' attention was likely focused more on the overlapping mouth area. This area distinctly presents the strong Agent-Patient

Table 1. Pairwise comparisons to investigate the agent parallel motion lines by patient parallel motion lines interaction in Experiment 1.

	Difference				*Cohens's* d_z		
Pairwise comparison of parallel motion line conditions	*M*	*SE*	*t*(73)	*p*	d_z	*95% CI*	p_{adj}
None vs. Agent	−3.26	5.24	−0.62	.536	−0.07	[−0.30, 0.16]	1.000
None vs. Patient	0.63	3.80	0.16	.870	0.02	[−0.21, 0.25]	1.000
None vs. Both	10.14	3.97	2.56	.013	0.30	[0.06, 0.53]	.063
Agent vs. Patient	3.88	7.00	0.55	.581	0.06	[−0.16, 0.29]	1.000
Agent vs. Both	13.40	4.93	2.72	.008	0.32	[0.08, 0.55]	.049
Patient vs. Both	9.52	5.30	1.80	.077	0.21	[−0.02, 0.44]	.307

Note. Difference scores are calculated as the second condition minus the first condition. p_{adj} shows Bonferroni-Holm corrected *p* values.

relation, which is sufficient for participants to localize the positions of the Agent and the Patient. Consequently, the areas where the motion lines were located, specifically behind the tails of the event roles (both the Agent and the Patient), might not receive much attention, rendering the motion lines relatively unnoticed.

However, the motion lines did impact the processing of the picture, supported by the significant interaction between the Agent parallel motion lines and the Patient parallel motion lines. When we added parallel motion lines for both the Agent and the Patient at the same time, we observed the tendency of reaction times to increase as compared to the other conditions. Interestingly, this increase in reaction times (as compared to no motion lines) was not observed for the conditions where we added the parallel motion lines only behind one of the fish, no matter whether it was the Agent fish or Patient fish. Based on our experiment, we cannot explain why it is only the combination of both parallel motion lines and not the addition of parallel motion lines behind a single fish that influence reaction times. However, what is most important for our research questions is the observation that the processing of motion lines was independent of the processing of event roles, supported by the finding that the described parallel motion line effects did not interact with the search task.

To further explore the role of motion lines related to the Agent advantage effect, we conducted a subsequent experiment using orthogonal motion lines of the same quantity and length. The aim of this follow-up experiment was two-fold. First, we aimed to investigate the stability of the finding of Experiment 1 by examining whether the manipulation of orthogonal motion lines would again lead to a strong Agent advantage effect unaffected by motion lines. Second, we aimed to better understand the influence of the presence of motion lines on overall reaction times observed in Experiment 1. The orthogonal motion lines added a comparable amount of additional visual information to the stimuli as the parallel motion lines, while the orthogonal motion lines were designed to neither enhance nor weaken the action of the event roles. If it was the mere amount of visual information that caused the effect of motion lines on reaction times in Experiment 1, we should replicate this finding with orthogonal motion lines in Experiment 2. If the effect was specific to parallel motion lines and altering the perceived intensity of the actions depicted, however, the overall effect of orthogonal motion lines on reaction times might not be observed in Experiment 2.

Experiment 2: The impact of orthogonal motion lines

Methods

This experiment was preregistered: https://osf.io/ydhn8.

Participants

Our final sample size following exclusions consisted of 72 participants recruited from the University of Tübingen (18 males and 53 females; 1 did not state their gender) with a mean age of 21.39 years ($SD = 2.90$; one participant did not state their age). Participants reported normal or corrected-to-normal vision and signed an informed consent form. The sample size was determined to achieve 80% power based on the power analysis described in Experiment 1. All the recruited participants for Experiment 2 didn't take part in the Experiment 1. In total, 95 participants were tested, 21 were excluded due to a correct response rate below 80% and 2 were excluded due to less than 12 correct responses left in at least one condition after the removal of responses slower than 5 s, leading to the final sample of 72 participants.

Apparatus and stimuli

We used the same apparatus and stimuli as in Experiment 1, with the only difference being the direction of motion lines being orthogonal instead of parallel (see Figure 3).

Procedure and design

The experiment was a 2 (search-task: Agent search, Patient search) x 2 (Agent orthogonal motion lines: with, without) x 2 (Patient orthogonal motion lines: with, without) within-participants design. The procedure was the same as in Experiment 1.

Results and discussion

Preregistered analysis

For all analyses, we again analyzed the reaction times for correct responses (proportion correct rates: Agent

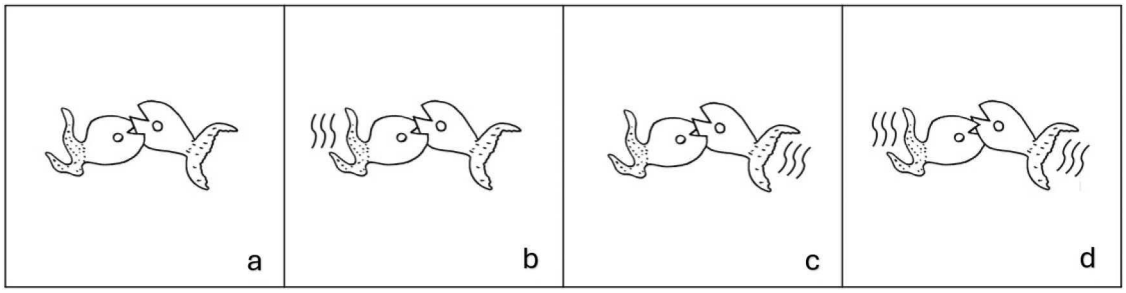

Figure 3. Sample stimuli for the Experiment 2. Note. (a) both Agent fish and Patient fish without orthogonal motion lines, (b) orthogonal motion lines behind the Agent's tail, (c) orthogonal motion lines behind the Patient's tail, and (d) orthogonal motion lines behind both tails of the Agent and Patient.

search: $M = .96$, $SD = .19$; Patient search: $M = .96$, $SD = .21$) and followed the same analytic strategy as for Experiment 1.

In the first step, we examined whether the Agent advantage effect was replicated in stimuli without motion lines. Thus, we analyzed participants' reaction times for correct responses with a paired *t*-test, showing a reaction time benefit of 90 ms: the participants' reaction time in the Agent search condition ($M = 665$ ms, $SD = 139$) was significantly shorter than in the Patient search condition search ($M = 755$ ms, $SD = 199$), $t(71) = -4.71$, $p < .001$, $d_z = -0.55$. Therefore, we could also replicate the Agent advantage effect in the stimuli without motion lines in Experiment 2.

In the second step, we investigated the effect of orthogonal motion lines on the Agent advantage effect by investigating the interaction between search task (Agent search vs. Patient search) and the presence or absence of orthogonal motion lines. We performed a 2 (search task: Agent search, Patient search) x 2 (Agent orthogonal motion lines: with, without) x 2 (Patient orthogonal motion lines: with, without) repeated measures ANOVA with the dependent measure mean reaction time. This revealed significant main effects of search, $F(1, 71) = 31.24$, $p < .001$, $\eta_p^2 = .31$. In contrast, the main effects of Agent orthogonal motion lines, $F(1, 71) = 0.00$, $p = .955$, $\eta_p^2 = .00$, and Patient orthogonal motion lines, $F(1, 71) = 0.00$, $p = .992$, $\eta_p^2 = .00$ were non-significant. Likewise, the two-way interaction of search and Agent orthogonal motion line, $F(1, 71) = 0.25$, $p = .617$, $\eta_p^2 = .00$, of search and Patient orthogonal motion lines, $F(1, 71) = 1.30$, $p = .257$, $\eta_p^2 = .02$, and of Agent orthogonal motion lines and Patient orthogonal motion lines, $F(1, 71) = 0.90$, $p = .345$, $\eta_p^2 = .01$, as well as the three-way interaction of search, Agent orthogonal motion lines and Patient orthogonal motion lines, $F(1, 71) = 2.52$, $p = .117$, $\eta_p^2 = .03$, were all non-significant. As evident from the data and Figure 4, while we observed a strong overall Agent advantage effect with faster responses for Agents than Patients, all interactions including search and orthogonal motion lines were not statistically significant, suggesting that the Agent advantage was not reliably modulated by orthogonal motion lines. While we observed significant effects of Patient parallel motion lines (main effect and interaction with Agent parallel motion lines) on reaction times in Experiment 1, Patient orthogonal motion lines had no significant effects on reaction times in Experiment 2.

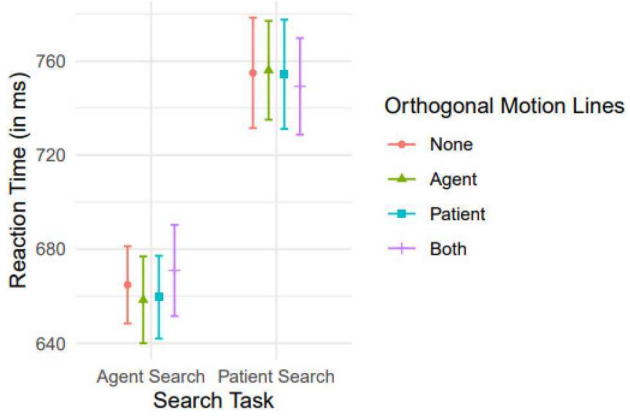

Figure 4. Mean reaction time in seconds on search task and orthogonal motion line conditions. Note. Error bars show the standard error of the mean.

Discussion

In Experiment 2, we investigated the impact of orthogonal motion lines on the Agent advantage effect in pictures. We observed faster reaction times

when participants searched for the Agent than when participants searched for the Patient when there were no orthogonal motion lines within the stimuli, thus replicating the results of Experiment 1 as well as the results reported by Segalowitz (1982) and Xu et al. (2024). Importantly, the interactions including search and parallel motion lines were not statistically significant, suggesting that the cognitive process underlying the Agent advantage may not be reliably modulated by motion lines. That is, the size of the Agent advantage effect was altered neither by parallel motion lines (Experiment 1) nor orthogonal motion lines (Experiment 2).

With Experiment 2, we also aimed to further understand the influence of the presence of motion lines on overall reaction times independent of the Agent advantage effect and thereby further investigate the motion line effects observed in Experiment 1. We replaced the parallel motion lines with orthogonal motion lines, which added a comparable amount of additional visual information to the stimuli as the parallel motion lines. With these orthogonal motion lines, we found no significant influence on reaction times, which was different from the findings in Experiment 1. Therefore, the effects observed in Experiment 1 might be specific to parallel motion lines, potentially because the parallel motion lines alter the perceived intensity of the depicted actions.

General discussion

Across two experiments, we investigated whether the presence of motion lines behind the Agent or Patient impacts the Agent advantage effect. The aim of the study was twofold: first, we replicated the Agent advantage effect in reaction times (Segalowitz, 1982; Xu et al., 2024), and second, we investigated whether the presence of motion lines behind the event roles impacted the Agent advantage effect. As predicted, we observed faster reaction times when participants searched for the Agent than when participants searched for the Patient when there were no motion lines within the pictures, which is consistent with previous studies (Segalowitz, 1982; Xu et al., 2024). Critically, and most importantly, all interactions including search and motion lines were not statistically significant, suggesting that motion lines did not reliably modulate the size of the Agent advantage effect.

Nonetheless, our results also revealed that participants did process the motion lines to some degree. Although motion lines did not interact with the search task, we observed an interaction of parallel Agent motion lines and parallel Patient motion lines in Experiment 1. When both the Agent and the Patient were accompanied by parallel motion lines, overall reaction times increased relative to stimuli without any motion lines. In contrast, orthogonal motion lines in Experiment 2 had no such impact on overall reaction times. This pattern suggests an important distinction in how motion lines may be processed. While parallel lines can accentuate or clarify the direction and intensity of an action (Cohn & Maher, 2015; Hacımusaoğlu & Cohn, 2023, 2025; Kim & Francis, 1998), orthogonal lines might function more as purely additional visual information, neither augmenting nor diminishing the action's perceived speed or force. However, this interpretation remains speculative, given that we did not collect additional ratings of perceived intensity of the depicted action to corroborate this interpretation (Hacımusaoğlu & Cohn, 2025). Crucially, however, neither form of motion lines showed statistically significant modulation of the Agent advantage effect, suggesting that the mechanisms responsible for prioritizing Agents (Hafri et al., 2013, 2018; Isasi-Isasmendi et al., 2023; Xu et al., 2024) may operate independently of these cues.

Our results suggest that two independent processes might occur when comprehending pictures containing motion lines. On the one hand, there may be a process responsible for extracting Agent-Patient relations and event roles (e.g., Hafri et al., 2013, 2018; Isasi-Isasmendi et al., 2023; Segalowitz, 1982; Xu et al., 2024). On the other hand, a second process might specifically handle additional visual cues such as motion lines (e.g., Cohn & Maher, 2015; Hacımusaoğlu & Cohn, 2023, 2025). In our experiments, we used a paradigm that was originally designed to measure the first process (Segalowitz, 1982; Xu et al., 2024), and found no influence from the second process. Importantly, the functional role of motion lines in our paradigm may differ from previous studies. Unlike Cohn and Maher (2015), where motion lines were integral to the narrative interpretation of the scene (e.g., indicating the trajectory of a ball), the event roles in our stimuli could be identified based on the Agent-Patient relation (the biting action

between two fish), without relying only on the motion lines. In this context, motion lines may have functioned as supplementary visual elements rather than as integral to role identification. This finding could imply several possibilities. First, both processes might operate in parallel, but draw from independent cognitive resources. Second, the two processes might unfold at different time frames; for instance, the event role process could be completed before motion lines become fully relevant. Alternatively, these processes might not operate simultaneously but instead be selectively activated depending on the task, explaining their independence. However, our experiments tested only a limited subset of motion lines (parallel and orthogonal motion lines) and did not include more conflicting or semantically incongruent conditions, such as reversed motion lines. As such, we refrain from making strong claims about the general independence of these processes. Rather, our findings provide an initial indication that, under specific task requirements, event role assignment may proceed independently of motion lines. Future work is needed to explore a broader range of motion lines and task contexts (e.g., in situations where motion lines play a central role in interpreting the visual narrative of the scene) to better understand the potential interactions between these processes.

To better understand why there was no significant influence of motion lines on the Agent advantage effect in our study, we evaluated our findings in light of three proposed interpretations of motion lines. First, these results challenge the perceptual account, which posits that motion lines simulate low-level perceptual phenomena such as motion streaks in the primary visual cortex (Geisler, 1999; Hacımusaoğlu & Cohn, 2023). If motion lines operated as automatic visual cues rooted in perceptual encoding, we would expect them to enhance the salience of the Agent and thereby strengthen role recognition. However, our data showed no such interaction, suggesting that motion lines are not automatically processed as directional percepts in this context. The metaphorical account proposes that motion lines act as visual analogies to physical traces left by motion in the real world, such as tyre tracks in mud or water waves, thereby conveying motion by analogy (Hacımusaoğlu & Cohn, 2023). However, in our experiments, motion lines did not strengthen the perception of agency, even when their position and orientation were consistent with the implied action. This suggests that the metaphorical function cannot extend to the search task of identifying the event roles within static pictures. The lexical account (Hacımusaoğlu & Cohn, 2023) argues that motion lines are learned graphical conventions whose interpretation depends on prior exposure to specific visual languages, such as comics or animated media. According to this view, motion lines are not universal cues but culturally acquired visual vocabulary items. In our study, we did not collect data on participants' nationality or familiarity with motion lines in comics, making it difficult to directly evaluate this account. Future studies could assess visual language proficiency or cultural background to directly test this hypothesis.

Another possibility is that motion lines may play a more prominent role in scenes with structurally ambiguous event roles, where Agent – Patient relations are less visually defined. In such cases, motion lines may act as disambiguating cues, and their influence might be more pronounced. Our current study tested stimuli in which Agent-Patient relations were clearly defined through spatial and semantic relations. In such contexts, motion lines may simply be redundant. However, in situations where the visual structure is less defined and the interpretation of the scene depends on the direction of motion lines, motion lines might become more functionally relevant. For example, in a study by Cohn and Maher (2015), participants viewed comic panels depicting a baseball player hitting a ball, with the panels varying in motion line type (normal, absent, or anomalous). Viewing times differed significantly across these conditions: panels with normal motion lines were viewed for less time than those with no motion lines, which in turn were viewed faster than those with anomalous motion lines. This suggests that motion lines can serve not only as supplementary information but as key perceptual cues that actively guide scene interpretation. Investigating how motion lines function in visual scenes with ambiguous event roles may further reveal whether motion lines can be capable of directly inducing Agent-Patient relations. For example, in a simplified scene with two identical objects and no clear action direction, the addition of motion lines behind one object could induce the perception that this object is the Agent initiating the action. Future work using

stimuli with ambiguous role configurations and varying motion line cues could help determine whether motion lines can meaningfully influence event role processing.

Our experiments were carefully designed to control for visual features that are known to influence event role processing. For example, both the Agent and the Patient were visually similar fish, with similar size and posture and shared the same level of animacy. By doing so, we minimized possible confounds – such as differences in shape posture and animacy (Hafri et al., 2018; Scholl & Tremoulet, 2000; Schultz & Frith, 2022; Van Buren et al., 2016) – that might otherwise direct attention disproportionately to one event role. Observers thus needed to rely on the Agent-Patient relation itself to identify the roles. This design choice allowed us to capture a "pure" measure of the Agent advantage effect, free from the influence of extraneous perceptual cues beyond the effect of motion lines that we explicitly studied with the present experiments.

Based on our present findings, we believe that further investigating the following three aspects could contribute to our understanding of the relationship between the processing of motion lines and event roles. First, measuring the influence of the presence or absence of the motion lines with our stimuli on participants' ratings regarding the perceived motion and action (e.g., speed, direction, or intensity) could contribute to understanding whether motion lines influence these ratings (Hacımusaoğlu & Cohn, 2025), thus supporting the idea that the processing of event role identification and motion lines might be two independent processes. Second, it would be beneficial to measure participants' comic-reading habits, as familiarity with comics may influence their processing of visual narratives (Hacımusaoğlu & Cohn, 2025). Finally, additional research could extend the perceptual diversity of the images presented, ranging from simple, line-drawn stimuli to more complex, naturalistic scenes, to investigate whether the same independence between motion lines and the Agent advantage effect holds in richer contexts.

In summary, the current experiments provide robust evidence that the Agent advantage effect – faster identification of Agents than Patients – persists even when motion lines, parallel or orthogonal, are added to static images. Although parallel motion lines can increase the overall complexity of a display when both the Agent and the Patient are emphasized, they do not significantly alter the fundamental priority that Agents hold in event role processing under the present task conditions. These findings offer new insights into how visual cues like motion lines function and underscore the strength of the Agent advantage effect as a core feature of event cognition.

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Disclosure statement

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Data availability statement

Data and analysis scripts (for the statistical programming language R) have been made publicly available via the Open Science Framework (OSF) and can be accessed via the following project links: Experiment 1: https://osf.io/v5kwb and Experiment 2: https://osf.io/c6492.

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Appendix C: Manuscript 3

The following is a preprint of a manuscript that is currently under review.

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The Agent Advantage Effect Is Not Invariant: Evidence From Fighting and Chasing Scenes

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Abstract

This research investigated whether the Agent advantage effect remains stable across two depicted action contexts in still pictures. The Agent advantage effect refers to human observers responding faster to someone performing an action (called an Agent) compared to the person or thing acted upon (called a Patient). Using schematic stimuli in which the Agent and Patient were visually indistinguishable, we compared role processing across the two canonical dyadic interactions, fighting and chasing. We presented the participants with pictures showing two fish, with one fish biting the other. Participants searched for the Agent or the Patient and pressed the corresponding button, and their reaction time was recorded. Experiment 1 used fighting action (i.e., two fish facing each other) and replicated the Agent advantage effect. Experiment 2 replaced the fighting action with the chasing action (i.e., two fish facing in the same direction), resulting in the disappearance of the effect. Experiment 3 tested both actions in a single experiment and replicated the Agent advantage effect only for the fighting action, not for the chasing action. This pattern suggested that the two action contexts place different demands on visual event role processing: fighting may require finer local verification of the overlapping mouth region, whereas chasing may support a faster global parse of the interaction.

Keywords: Agent advantage effect, Agent, Patient, action, chasing, fighting

The Agent Advantage Effect Is Not Invariant:

Evidence From Fighting and Chasing Scenes

To understand events, humans rapidly extract event role information while perceiving actions, which is central to event understanding (Zacks, 2020). Event roles include Agents, which are the performers of the action, and Patients, which are the person or thing acted upon (Cohn & Paczynski, 2013; Hafri et al., 2018; Verfaillie & Daems, 1996; Xu et al., 2024, 2025). Previous work with pictures suggested that Agent information is often more accessible than Patient information during visual event processing, which is called the Agent advantage effect (Hafri et al., 2018; Segalowitz, 1982; Verfaillie & Daems, 1996; Xu et al., 2024, 2025). Olson and Filby (1972) , for example, found faster identification of the acting entity in collision scenes, and Segalowitz (1982) reported the same asymmetry in schematic fish-biting displays. Related work with visual narratives further suggested that Agent information played a privileged role in building event structure and supporting predictions about upcoming events (Cohn & Paczynski, 2013).

A key open question is what drives Agent prioritization in pictures. Research indicates that event roles can be extracted rapidly, sometimes with exposures as brief as 37-73 ms, consistent with fast and partly automatic visual processes (Hafri et al., 2013, 2018). Such rapid role assignment can be supported by low-level perceptual cues, including shape and posture information (e.g., outstretched arms) that reliably indicate who is acting on whom (Hafri et al., 2013, 2018). Role assignment is not determined by perceptual cues alone: the assignment of Agent and Patient roles can be guided by higher-level interpretations of social interaction, including perceived animacy and intentionality (Gao et al., 2009; Gao & Scholl, 2011; Hafri et al., 2018; Schultz & Frith, 2022). In chasing scenes, for instance, event role assignment depends

strongly on relational cues such as facing relations and pursuit direction, which allow observers to derive who is pursuing whom from the scene structure (Gao et al., 2009; Gao & Scholl, 2011). Thus, the Agent advantage effect may depend not only on the presence of perceptual cues of the event roles, but also on how the interaction itself is structured.

One important prerequisite of the Agent advantage effect in pictures is the presence of an Agent-Patient relation between two entities (Segalowitz, 1982). To test whether the effect might instead be driven by purely physical or spatial characteristics, Segalowitz (1982) replaced the mouth outlines of the biting fish with the letter "W" and asked participants to search for "Agent-like" or "Patient-like" Ws. These "W" displays preserved the overall spatial configuration of the original scenes, except for the Agent-Patient relation, compared to the fish pictures. Under these conditions, the Agent advantage effect disappeared. This suggests that merely having two shapes in a particular arrangement is not sufficient; rather, an interpretable Agent-Patient relation appears to be a necessary precondition of Agent advantage effect in pictures (Segalowitz, 1982).

The two-fish paradigm was originally introduced by Segalowitz (1982), who demonstrated the Agent advantage effect in schematic biting scenes. Subsequent work using this paradigm has further examined the processes underlying this effect (Xu et al., 2024, 2025). For example, an eye-tracking study combining the same visual search task with gaze measures showed that the behavioral asymmetry between Agent and Patient detection was linked to fixation dynamics across processing stages (Xu et al., 2024). In addition, a later study manipulated motion lines in the same task to test whether low-level perceptual cues modulated the Agent advantage effect, but found no evidence that motion lines altered the effect, suggesting that this type of perceptual cue was not sufficient to impact the Agent advantage effect (Xu et al., 2025). Crucially, however, research using the two-fish paradigm has almost exclusively relied on

the same local contact relation (biting action, see Figure 1a) both in Segalowitz's original work and follow-up work (Segalowitz, 1982; Xu et al., 2024, 2025). Although visual features such as eyes, tail shape, or surface patterns were varied across studies, the depicted action itself remained unchanged (Segalowitz, 1982; Xu et al., 2024, 2025). This raises an open question: Is the Agent advantage effect a general property of event role processing, or has it so far been observed only within one particular kind of action (biting action)?

Put differently, research on Agent advantage effect with the two-fish paradigm has investigated whether perceptual cues modulate event role identification while holding the Agent-Patient relation fixed, whereas Hafri and colleagues (Hafri et al., 2013, 2018) examined multiple actions without measuring differences in Agent-Patient asymmetry across them. The present study reversed this logic: instead of varying what the characters look like, we held visual appearance constant, making the event roles visually indistinguishable, and varied their action. By manipulating action rather than perceptual features, we investigated whether the Agent advantage effect remained the same across actions.

To examine why action context may matter even under perceptual control, we focus on two canonical dyadic interactions, chasing and fighting, that differ in the relational structure they provide while keeping featural information constant. Importantly, both actions were implemented with the same Agent-Patient relation, such that one fish bites the other. This comparison allowed us to test whether the Agent advantage effect varied across action contexts while holding local contact and featural differences constant. Prior work on chasing suggested that observers could derive event role information efficiently from directionality and pursuit structure. This made chasing and fighting a useful contrast for testing whether the Agent advantage effect remained stable across different depicted interactions under perceptual control.

Chasing is a prototypical animate interaction tightly associated with goal-directed pursuit and intentionality (Gao et al., 2009; Gao & Scholl, 2011; Heider & Simmel, 1944; Scholl & Tremoulet, 2000). Even in minimal displays, observers readily interpret one entity as an intentional pursuer and the other as a target, and this role assignment is constrained by structural cues in the visual input - especially directionality and facing relations (Gao et al., 2009; Gao & Scholl, 2011; Van Buren et al., 2016, 2017). Although chasing is typically studied with dynamic stimuli (Gao et al., 2009; Gao & Scholl, 2011; Van Buren et al., 2017), these structural constraints can be captured in static scenes. Accordingly, we operationalised chasing action in static schematic scenes: one fish was positioned behind and bit the tail of the other fish (face-to-tail), while the two event roles were visually indistinguishable; only by processing the biting action could the event roles be recognised. This design allowed us to investigate whether the Agent advantage effect was sensitive to the action interpretation afforded by the scene, even when featural differences were controlled.

In contrast to chasing, we introduced the fighting condition as our baseline. Crucially, both action types contained the same Agent-Patient relation (biting). In our stimuli, the two fish were linked by either face-to-face (fighting action) or face-to-tail (chasing action) contact in both conditions, such that the biting action was held constant and continued to unambiguously specify the two event roles (Agent as the biting fish; Patient as the bitten fish). What differed was the higher-level action interpretation afforded by the surrounding relational context: the same biting contact could be construed as part of a chasing episode (e.g., pursuit culminating in a bite) or as aggressive conflict, which we labelled here as fighting.

We therefore referred to the face-to-face biting configuration as the fighting action in the present study. This terminological shift didn’t change the local action information; rather, it

allowed us to (1) retain direct methodological continuity with the established biting-based Agent advantage effect literature (Segalowitz, 1982; Xu et al., 2024, 2025) and, at the same time, (2) compare it to a chasing action that preserved the same biting cue. In this way, the two conditions could be contrasted while holding the local biting relation and obvious featural differences constant, allowing us to test whether event role processing remained stable across these two action contexts.

Taken together, the existing literature shows that the Agent advantage effect is robust and presence of an interpretable Agent-Patient relation, yet it remains unclear whether the Agent advantage effect might be influenced by different depicted actions. The present study addressed this gap by holding the Agent-Patient relation constant while varying the action between fighting and chasing with controlled stimuli in which the Agent and Patient were visually indistinguishable, so that any difference in event role processing cannot be attributed to differences between the Agent and the Patient. In Experiment 1[1], we used fighting actions to investigate whether the Agent advantage effect can be replicated with controlled stimuli. In Experiment 2, we used a chasing action to investigate whether the Agent advantage effect can be replicated with a different action while preserving the same Agent-Patient relation. In Experiment 3, we intermixed fighting and chasing within participants to investigate whether the results of Experiments 1 and 2, namely that the magnitude of the Agent advantage effect is modulated by action type, can be replicated within one set of participants.

Hypotheses

[1] To improve readability, we report the fighting action (Experiment 1) before the chasing action (Experiment 2), although the two studies were conducted in the opposite order.

H1 (Experiment 1: Fighting action). We predicted replicating the Agent advantage effect in fighting action with abstract fish, thus participants would respond faster during Agent search compared to Patient search.

H2 (Experiment 2: Chasing action). We predicted replicating the Agent advantage effect in chasing action with abstract fish, thus participants would respond faster during Agent search compared to Patient search.

H3 (Experiment 3: The impact of action). If the action impacted the Agent advantage effect, we would see an interaction between the action (fighting, chasing) and the search task (Agent search, Patient search) regarding reaction time. We predicted that the difference in reaction times between the Agent search and Patient search would be larger for the fighting stimuli than for the chasing stimuli. Thus, participants would respond with faster reaction times when locating the Agent compared to locating the Patient in the fighting condition, and this difference was expected to be larger than the difference observed in the chasing condition.

Experiment 1: Fighting Action

This experiment tested Hypothesis 1 (H1): We predicted replicating the Agent advantage effect in fighting action with abstract fish, thus participants would respond faster during Agent search compared to Patient search.

Methods

This experiment was preregistered: https://osf.io/ts3yw

Participants

Our final sample size following exclusions consisted of 24 participants recruited from the University of Tübingen and the participant pool of the Leibniz-Institut für Wissensmedien (7

males, 16 females, and 1 with non-binary) with a mean age of 27.04 years (*SD* = 6.15). Participants reported normal or corrected-to-normal vision and signed an informed consent form.

We used G*Power to conduct a power analysis and determined that 24 participants were required to achieve 80% power with a medium effect size of *dz* = 0.60 based on former findings (Xu et al., 2024) for the Agent advantage effect at the standard .05 alpha error level. To ensure direct comparability across the two single-action experiments (Experiment 1 with fighting action and Experiment 2 with chasing action), we aimed to achieve the same final sample size in Experiments 1 and 2. In total, 27 participants were tested, and 3 were excluded because their accuracy fell below the preregistered exclusion threshold of 80%, resulting in a final sample of 24 participants.

Apparatus

The experiment was programmed in *PsychoPy Experiment Builder (v2024.1.4)* (Peirce, 2007, 2009). We used a 60 Hz monitor (1920 x 1200 pixels; 51.8 x 32.3 cm) for the presentation of the stimuli.

Stimuli material

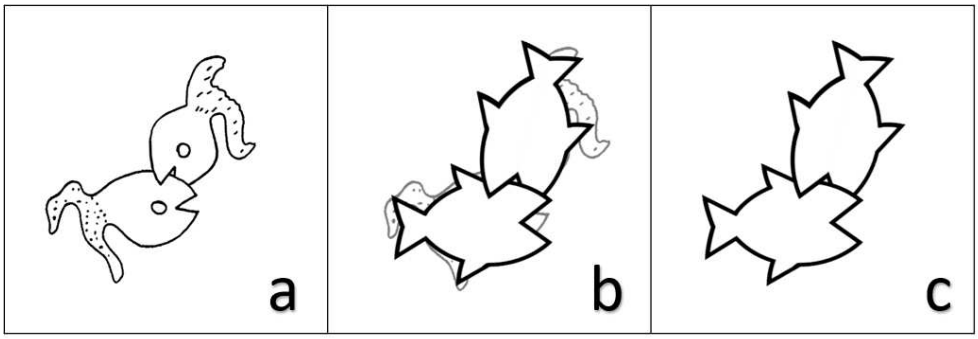
The stimulus materials (see Figure 1c) consisted of 24 line-drawing pictures of abstract fish outlines without internal details (e.g., no eyes or patterns, 12 pictures with the Agent on the left and 12 pictures with the Agent on the right), containing an Agent-Patient relation (biting action). Each picture showed two fish fighting in a face-to-face configuration (see Figure 1c).

We used the abstract fish to mimic the positions of the previous materials (see Figure 1a), which successfully replicated the Agent advantage effect and showed a fighting action (Xu et al., 2024, 2025). Thus, we created 12 pictures with the Agent on the left and 12 pictures with the

Agent on the right. All stimuli were presented at a size of 640 × 360 pixels (17.3 x 9.7 cm) in the center of the screen.

Figure 1

Sample Stimuli Creation for Experiment 1



Note. (a) stimuli as used from Xu et al., (2024, 2025) (b) abstract fish mimic the position of the previous stimuli, (c) the fighting stimuli were used in Experiment 1.

Procedure and Design

Participants were instructed to locate the side (left or right) of the biting fish (Agent search) or bitten fish (Patient search). Half of the participants performed an Agent search first, followed by a Patient search, and the other half of the participants performed a Patient search first, followed by an Agent search. Each search comprised 4 practice trials and 24 experimental trials.

Participants initially completed practice trials to better understand the tasks required in the experimental trials. During practice trials, they received feedback indicating whether their response was correct or incorrect. After they finished the practice trials, they were informed that the experimental trials would begin. Participants responded using the keyboard, pressing “1” if the search target appeared on the left and “9” if it appeared on the right. Following each response, a mask was displayed for 500 ms. Then, the next trial started.

After the participants finished both search tasks, the experiment ended. The experiment lasted around 15 minutes.

The experiment followed a one-factorial within-subjects design: we manipulated the search task (Agent search, Patient search).

Results

Preregistered Analysis

For all analyses, we analyzed the reaction times for correct responses (proportion correct rates: Agent search: $M = .96$, $SD = .05$; Patient search: $M = .96$, $SD = .04$).

We examined whether the Agent advantage effect was replicated. Thus, we analyzed participants' reaction times for correct responses with a paired *t*-test. The participants' reaction time in the Agent search condition ($M = 660$ ms, $SD = 102$) was significantly faster compared to the reaction time of the Patient search condition ($M = 787$ ms, $SD = 182$), $t(23) = -4.41$, $p < .001$, $d_z = -0.9$. Consistent with H1, the Agent advantage effect was replicated in the stimuli with fighting action.

Discussion

In Experiment 1, we investigated whether the Agent advantage effect can be replicated when participants viewed scenes depicting a fighting action using controlled and simplified stimuli in which the two event roles were visually indistinguishable. The results replicated the Agent advantage effect: participants identified the Agent significantly faster than the Patient. This finding established a baseline for the present stimulus set and demonstrated that even though the event roles were the same and with no distinguishable perceptual features, the Agent advantage effect could still emerge based on the Agent-Patient relation.

To explore the impact of actions on the Agent advantage effect, in Experiment 2, we used the same task and the same abstract stimuli for chasing actions to investigate whether the Agent advantage effect generalised across actions when the Agent-Patient relation was held constant.

Experiment 2: Chasing Action

This experiment tested Hypothesis 2 (H2): We predicted replicating the Agent advantage effect in chasing action with abstract fish, thus participants would respond faster during Agent search compared to Patient search.

Methods

This experiment was preregistered: https://osf.io/amf4k

Participants

Our final sample size following exclusions consisted of 24 participants recruited from the University of Tübingen and the participant pool of the Leibniz-Institut für Wissensmedien (6 males and 16 females; 2 did not state their gender) with a mean age of 27.70 years (*SD* = 10.78; one participant did not state the age). Participants reported normal or corrected-to-normal vision and signed an informed consent form.

Sample size was determined based on the same power analysis and sampling plan as Experiment 1. We targeted a final sample of 24 participants to enable direct comparison between the chasing and fighting conditions. In total, 27 participants were tested, and 3 were excluded because their accuracy fell below the preregistered exclusion threshold of 80%, resulting in a final sample of 24 participants.

Apparatus

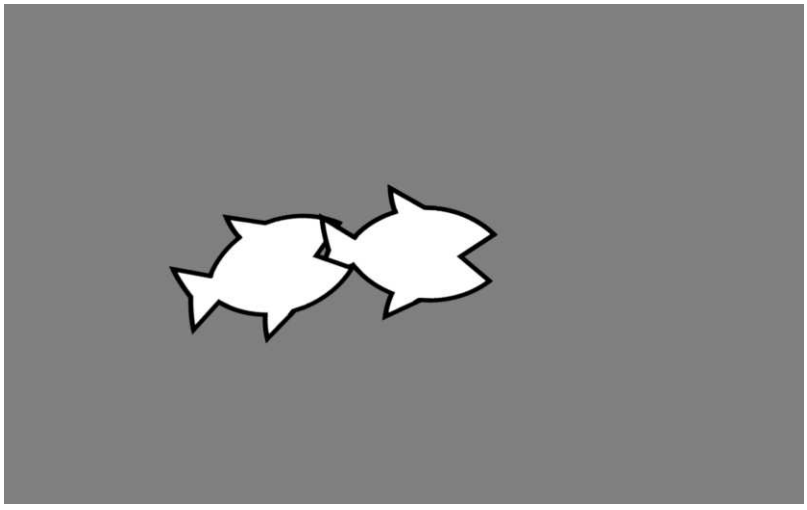
The experiment was programmed in *PsychoPy Experiment Builder (v2024.1.4)* (Peirce, 2007, 2009). We used a 60 Hz monitor (1920 x 1200 pixels; 51.8 x 32.3 cm) to present the stimuli.

Stimuli material

We continued using the abstract fish from Experiment 1. The first fish was always presented at the center of the screen. The second fish was positioned behind the first fish such that its mouth contacted the tail area of the first fish, creating a face-to-tail chasing configuration (see Figure 2). Stimuli were presented at a size of 863 × 863 pixels (23.3 × 23.3 cm) on the screen.

Figure 2

Sample Stimuli for Experiment 2



Note. The first fish was always in the center of the screen. The second fish appeared either within the mouth area or the tail area of the first fish to show a chasing action.

Procedure and Design

The experiment was a one-factorial within-subjects design with the manipulation the search task (Agent search, Patient search). The procedure was the same as in Experiment 1.

Results

Preregistered Analysis

For all analyses, we analyzed the reaction times for correct responses (proportion correct rates: Agent search: M = .95, SD = .08; Patient search: M = .98, SD = .05).

We examined whether the Agent advantage effect was replicated. Thus, we analyzed participants' reaction times for correct responses with a paired t-test. The participants' reaction time in the Agent search condition (M = 657 ms, SD = 347) had no significant difference from the Patient search condition (M = 668 ms, SD = 377), $t(23) = -0.27$, $p = .788$, $d_z = -0.06$. Contrary to H2, the Agent advantage effect was not replicated in the stimuli with chasing action, reaction times did not differ reliably between Agent and Patient search.

Discussion

In Experiment 2, we investigated whether the Agent advantage effect could be replicated in chasing action with the same controlled stimuli. Contrary to the fighting action, the Agent advantage effect was not observed for chasing action. This dissociation suggested that the Agent advantage effect was not determined by the presence of an Agent-Patient relation alone, but may vary across action contexts that differed in how event role information was processed within the scene.

One possibility is that chasing provides a particularly strong, direction-based Agent-Patient relation: one entity is construed as pursuing another along a coherent trajectory (Gao et al., 2009; Gao & Scholl, 2011; Meyerhoff et al., 2013, 2014). Because this pursuit structure constrains "who does what to whom" in a systematic way, participants may be able to assign Agent and Patient roles more efficiently and with less need for late-stage role verification in the search task (Xu et al., 2024), thereby attenuating the usual Agent advantage effect. In addition,

the face-to-tail layout may encourage processing the relation as a whole (pursuer–target) rather than prioritizing one role over the other, which could further reduce the asymmetry between Agent and Patient (Gao et al., 2009; Gao & Scholl, 2011). More generally, embedding the same biting contact in a pursuit event rather than a conflict event may alter how strongly the Agent advantage effect is expressed in identification speed, even when the underlying Agent-Patient relation is held constant.

A more conservative alternative is that the simplified stimulus format reduced support for event role identification overall. However, because Experiment 1 produced a robust Agent advantage effect with the same abstract stimulus, reduced visual detail alone is unlikely to be sufficient to explain the absence of the effect in chasing. Experiment 3 therefore directly contrasted chasing and fighting within the same experimental context by intermixing both action contexts within participants, providing a more systematic test of whether the Agent advantage effect remained stable across the two displays and whether the patterns from Experiments 1 and 2 could be replicated.

Experiment 3: The Impact of Action

This experiment tested Hypothesis 3 (H3): If the action type (i.e., fighting vs. chasing) impacted the Agent advantage effect, we would see an interaction between the action (fighting, chasing) and the search task (Agent search, Patient search) regarding reaction time. We predicted that the difference in reaction times between the Agent search and Patient search would be larger for the fighting stimuli than for the chasing stimuli. Thus, participants would respond with faster reaction times when locating the Agent compared to locating the Patient in the fighting

condition, and this difference was expected to be larger than the difference observed in the chasing condition.

Methods

This experiment was preregistered: https://osf.io/nmdve

Participants

Our final sample size following exclusions consisted of 84 participants recruited from the University of Tübingen and the participant pool of the Leibniz-Institut für Wissensmedien (30 males, 53 females, 1 with non-binary and 4 did not state their gender) with a mean age of 24.66 years (*SD* = 6.30; one participant did not state their age). Participants reported normal or corrected-to-normal vision and signed an informed consent form.

We determined that 84 participants were required to achieve 95% power for detecting the predicted two-way interactions at an alpha level of 5%. We calculated the required sample size of 83 participants; to balance the four conditions, 84 participants were recruited. This calculation was based on effect sizes from previous Experiments 1 and 2. In Experiment 2 (chasing action), the mean reaction time was 662.5 ms, with an average standard deviation of 362 ms. In Experiment 1 (fighting action), mean reaction times were 660 ms (Agent search) and 787 ms (Patient search), with an average standard deviation of 140 ms. For the power analysis, a pooled standard deviation of 251 ms (the mean of 140 ms and 362 ms) was used.

None of the participants recruited for Experiments 1 and 2 participated in Experiment 3. In total, 93 participants were tested. As preregistered, we excluded participants with an overall accuracy below 80% (n = 2). We then removed trials with reaction times > 5 s and, as preregistered, excluded any participant (n = 7) with fewer than 12 correct responses (24 trials per

condition) remaining in at least one of the four conditions, resulting in a final sample of 84 participants.

Apparatus

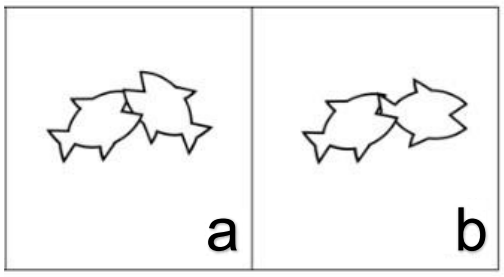
The experiment was also programmed in *PsychoPy Experiment Builder (v2024.1.4)* (Peirce, 2007, 2009). We used a 60 Hz monitor (1920 x 1200 pixels; 51.8 x 32.3 cm) for the presentation of the stimuli.

Stimuli material

Based on the fighting stimuli we used in Experiment 1, we created a new set of pictures for the chasing condition by changing the orientation of the biting fish so that one fish bit the tail of the other fish (see Figure 3b). For the pictures of the chasing condition, they included 12 pictures with the Agent on the left and 12 pictures with the Agent on the right. All stimuli were presented at a size of 640 × 360 pixels (17.3 x 9.7 cm) in the center of the screen.

Figure 3

Sample Stimuli Creation for Experiment 3



Note. (a) The fighting stimuli were used in Experiment 1 and 3, and (b) the chasing stimuli were used in Experiment 3.

Procedure and Design

Participants received the same instructions as Experiment 1 and 2 for the search task, which involved identifying the side (left or right) of the biting fish (Agent search) or the bitten fish (Patient search). Each search task included 4 practice trials and 24 experimental trials. Participants were divided based on the initial condition: half began with the fighting action condition, and the other half with the chasing action condition. The order of search tasks for each participant remained consistent across both action conditions, either Agent-first followed by Patient or Patient-first followed by Agent. All conditions were counterbalanced.

The experiment was a repeated-measures 2 (search task: Agent search, Patient search) x 2 (action: fighting, chasing) ANOVA with reaction time as the dependent measure, thus investigating the interaction between action and search task.

Results

Preregistered Analysis

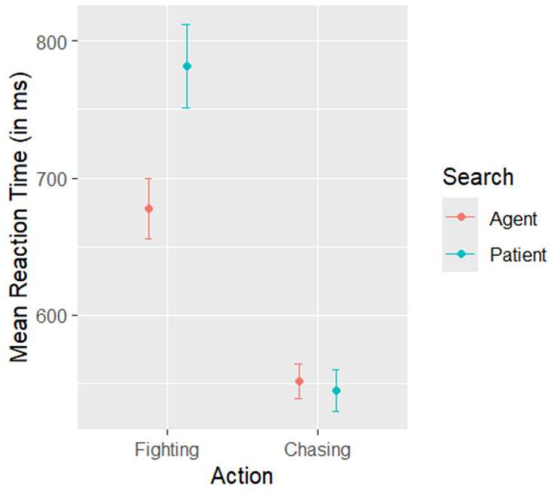
For all analyses, we analysed the reaction times for correct responses (proportion correct rates: Agent search: $M = .97$, $SD = .04$; Patient search: $M = .97$, $SD = .05$).

We investigated the effect of action on the Agent advantage effect by investigating the interaction between search task (Agent search vs. Patient search) and the action (fighting vs. chasing). We performed a 2 (search task: Agent search, Patient search) x 2 (action: fighting, chasing) repeated measures ANOVA with the dependent measure mean reaction time (see Figure 4). This revealed significant main effects of search, $F(1, 83) = 25.41$, $p < .001$, $\eta_p^2 = .23$ and of action, $F(1, 83) = 133.15$, $p < .001$, $\eta_p^2 = .62$, indicating overall faster reaction time in the chasing condition ($M = 548$ ms, $SD = 119$) than in the fighting condition ($M = 730$ ms, $SD = 233$), despite identical appearance of the two fish. The two-way interaction of search and action was also significant, $F(1, 83) = 44.52$, $p < .001$, $\eta_p^2 = .35$. To further examine the significant

interaction between search task and action, we conducted separate paired-samples *t*-tests for the chasing condition and fighting condition, as preregistered. For the fighting condition, participants responded significantly faster in the Agent search (M = 678 ms, SD = 203) than in the Patient search (M = 782 ms, SD = 278), $t(83) = -6.83$, $p < .001$, $d_z = -0.75$, thus, the Agent advantage effect was replicated in the fighting condition. For the chasing condition, in contrast, there was no significant difference between the Agent search (M = 552 ms, SD = 114) and the Patient search (M = 545 ms, SD = 140), $t(83) = 0.68$, $p = .497$, $d_z = 0.07$, thus the Agent advantage effect was not replicated in the chasing condition. These results replicated the pattern observed in Experiments 1 and 2: the Agent advantage effect was robust in fighting conditions but not in the chasing conditions (See Figure 4). Importantly, they supported H3 by showing that action modulated the Agent advantage effect: the Agent-Patient difference was larger for fighting action than for chasing action.

Figure 4

Mean Reaction Time in Milliseconds on Search Task and Action Conditions



Note. Error bars show the standard error of the mean.

Discussion

In Experiment 3, we combined the chasing and fighting actions into one experiment to investigate the impact of these two action contexts on the size of the Agent advantage effect. As predicted, reaction times showed a significant interaction between action (fighting, chasing) and search task (Agent search, Patient search): the Agent-Patient difference depended on the depicted action. Specifically, the difference in reaction times between Agent and Patient search was larger for fighting action than for chasing action. Thus, participants responded faster when locating the Agent than the Patient in the fighting condition, but not in chasing action, replicating the pattern observed in Experiments 1 and 2.

Notably, the experiment also revealed a significant main effect of action: overall reaction times were faster in the chasing condition than in the fighting condition. This difference suggested that the two actions placed different perceptual demands on event role identification. Fighting action involved a face-to-face biting configuration that may increase event role ambiguity or visual competition, thereby slowing the identification of event roles. In contrast, chasing action involved a directional face-to-tail configuration that conveyed a clearer sense of movement and causal structure, which may enhance faster recognition of who was acting on whom (Gao et al., 2009). The absence of an Agent advantage effect in the chasing condition might therefore reflect the reduced salience of the Agent role when the scene provides a strong directional cue that shifts attention toward the overall motion rather than the initiator of the action (Gao et al., 2009).

Taken together, the Agent advantage effect appeared in fighting but not in chasing conditions, and fighting was overall processed more slowly, demonstrating that the event role processing did not remain constant across the two action contexts, but varied with the structural cues and processing demands provided by the displays (at least in chasing and fighting contexts).

General Discussion

Across three experiments, we investigated whether the Agent advantage effect remained stable across fighting and chasing in static pictures under high perceptual control. Using the same abstract fish displays across experiments, we first established in Experiment 1 that the Agent advantage effect was replicated when the scene conveyed a fighting action and the Agent and Patient were perceptually indistinguishable. This result suggested that the appearance of the Agent advantage effect was related to the Agent-Patient relation within the picture and was independent of the perceptual features of the stimuli. In contrast, Experiment 2 showed that the Agent advantage effect disappeared with a chasing action, despite the presence of the same Agent-Patient relation (i.e., biting). Critically, Experiment 3 directly compared the two action types within participants and replicated the results pattern observed in Experiments 1 and 2: participants showed an Agent advantage effect in the fighting condition but not in the chasing condition, and reaction times were slower overall in the fighting condition. Together, these findings indicated that the Agent advantage effect was not an invariant consequence of depicting an Agent-Patient relation in static images, but differed across the two action contexts tested here.

These results also further challenge a common claim that the Agent-Patient relation is a prerequisite for the Agent advantage effect (Segalowitz, 1982; Xu et al., 2024, 2025). In the current experiments, the stimulus was the same and both action contexts contained a biting action that could, in principle, support an asymmetric “Agent-Patient” structure: in the chasing condition, one fish bit the other’s tail, whereas in the fighting condition, one fish bit the other's head. Despite this shared Agent-Patient relation (biting action, though the biting position was different), the Agent advantage effect was replicated only for fighting. Thus, the presence of an Agent-Patient relation may be necessary, but it was not sufficient: what seemed to matter was

how that Agent-Patient relation was embedded in the broader scene structure and what processing demands this structure places on event role identification.

A potential interpretation is that the different perceptual complexity of the two action contexts leads to the different cognitive resources required for the event role assignment. In the fighting condition, identifying the Agent hinges on resolving a fine-grained relation at the mouths (e.g., which mouth bites), a cue that plausibly requires careful local inspection. This provides a natural explanation for why fighting scenes were processed more slowly overall while still producing a robust Agent advantage effect: participants may need more time to verify the local spatial relation, yet the resolution of that relation yields a strong role asymmetry that manifests as faster Agent than Patient identification (Segalowitz, 1982; Xu et al., 2024, 2025). This local verification demand plausibly contributes to the slower overall response times in the fighting condition (relative to chasing), and the additional attentional resources focused on the mouth region may further strengthen role asymmetry, reinforcing the Agent advantage effect.

Chasing, by contrast, is a prototypical case of perceived animacy in which role assignment is strongly constrained by relational cues such as directionality and pursuit structure (Gao et al., 2009; Gao & Scholl, 2011; Scholl & Tremoulet, 2000). These findings demonstrate that observers can robustly derive “who is pursuing whom” from the configuration and implied dynamics of the interaction, even with minimalistic stimuli, however, this interaction construal does not necessarily entail an Agent advantage effect in a role-identification search task (Gao et al., 2009; Gao & Scholl, 2011; Scholl & Tremoulet, 2000). In contrast, the chasing configuration provides a strong global structure that may be easier to extract quickly, for example, the consistent face-to-tail arrangement and shared heading direction (Gao et al., 2009; Gao & Scholl, 2011). When the relevant structure is available at a coarse relational level, participants may

complete the task efficiently without engaging the role-specific selection or verification processes that generate an Agent advantage effect in this paradigm. Importantly, this result should not be taken to imply that chasing action elicits no Agent-related bias in general; rather, it suggests that in the present task, the global relational frame may be sufficient to support rapid responding without producing a differential advantage for Agent over Patient at the moment of selection. On this view, faster processing of chasing scenes does not imply stronger Agent prioritization; instead, it may reflect that the scene supports a rapid relational “parse” that does not differentially privilege the Agent over the Patient in our search-based measure.

Importantly, because participants were never provided with explicit labels such as "chasing" or "fighting," the differential effects were less plausibly attributable to word-driven framing and were more parsimoniously traced to the visual Agent-Patient relations extracted from the still images. Future work could examine the processing of chasing actions more directly, using measures sensitive to early attentional dynamics (e.g., eye movements, brief presentation durations), which would help clarify why an Agent advantage effect failed to emerge in the chasing condition despite rapid and accurate performance.

Our findings also connect to the early and late processes of the event role processing. Prior work suggests that event roles can be extracted rapidly and partly automatically, while still being sensitive to higher-level features (Hafri et al., 2013, 2018). In the eye-tracking work using the two-fish stimulus in the search task, researchers argued that Agent-Patient asymmetries may reflect distinct early and late processes, with more last fixations located on the Patient fish when participants were conducting the Patient search condition (Xu et al., 2024). The present pattern (fighting condition) is consistent with this finding: the fighting condition plausibly amplifies late-stage verification because correct event role assignment depends on resolving subtle overlap

information, which may increase the difficulty for the participants performing the search task, thus leading to the Agent advantage effect. A key next step is therefore to combine the current action manipulation with the eye-tracking method to test whether the chasing condition exhibits a different fixation dynamic - potentially no significant last fixation difference for both Agent search and Patient search - thus leading to the disappearance of the Agent advantage effect in the chasing condition (Xu et al., 2024).

In sum, across three experiments with perceptual control, we found that the Agent advantage effect was selectively expressed: it emerged in fighting scenes but not in chasing scenes, despite both contexts holding the same Agent-Patient relation. These findings indicated that Agent advantage effect in static pictures is not a universal consequence of representing an Agent-Patient relation but depends on the depicted action. At the same time, our evidence is based on a speeded role-identification search task, and it remains an open question how these action contexts shape event representations when observers are free to describe what they saw. To address this, an important next step is to complement the current behavioural measures with constructed responses, testing whether fighting versus chasing displays differentially biased linguistic encoding, for example, whether Agents are more likely to be mentioned first or more explicitly in fighting than in chasing (Magliano & Graesser, 2012). Such language-based measures would provide evidence about how action context guides event role processing and would help clarify whether the present results reflect a broader shift in event representation.

Data availability statement

Data and analysis scripts (for the statistical programming language R) have been made publicly available via the Open Science Framework (OSF) and can be accessed via the following project link: https://osf.io/8as6d/overview?view_only=7690e4819bb848e0aba163c6fd1852fc

Disclosure statement

The authors report there are no competing interests to declare.

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