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# Solving the paradox between same-object advantage and different-object advantage

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ABSTRACT

The same-object advantage (SOA) effect is usually cited as evidence for object-based attention. However, the different-object advantage (DOA) effect, which appears to be the opposite of the SOA effect, has also been reported by some researchers. The present study was designed to resolve this apparent inconsistency. As the SOA effect has been well documented, here we focus on exploring when and why the DOA effect occurs. With a series of four experiments, we manipulated the identicality between two targets and found the SOA effect when the targets were different but the DOA effect when they were identical. These results demonstrate that the presence of SOA vs. DOA effects can be critically determined by the identicality between targets. Moreover, Experiment 4 provides direct evidence for our hypothesis that the DOA effect arises from the benefit of placing two identical targets in distinct objects (e.g., rectangles) that can help the differentiation between targets.



## 1. Introduction

Visual processing is limited in its capacity; therefore, selective attention plays an important role in its functioning. Many previous studies have focused on the units on which attentional selection operates. Early studies suggested that attentional selection operates in a space-based manner (Eriksen & Hoffman, 1973; Eriksen & Yeh, 1985; Posner, Snyder, & Davidson, 1980). These studies characterized attention as a "spotlight" or "zoom lens" which can move across the visual field, and only the information that falls within that spatial region can be selected for further processing. In contrast, subsequent researchers have suggested that attention is directed toward discrete objects or perceptual groups according to gestalt principles (see Scholl, 2001, for a review). The evidence favoring the object-based attention view comes from the same-object advantage (SOA) effect in various types of paradigms, such as the divided-attention paradigm (e.g., Duncan, 1984) and the spatial-cuing paradigm (Egly, Driver, & Rafal, 1994). The SOA effect typically shows that participants respond faster and/or more accurately regarding two stimuli or features from the same object than those from different objects (divided-attention paradigm), or regarding a probe appearing in the same object as a preceding cue relative to that appearing in a different object (spatial-cueing paradigm). In the past 30 years, these two types of SOA effect have been repeatedly demonstrated under various circumstances in numerous studies (Chen, 2012; Scholl, 2001).

On the other hand, the different-object advantage (DOA) effect shows a pattern that is exactly opposite to that of the SOA effect (Cepeda & Kramer, 1999; Chou & Yeh, 2011; Davis, 2001; Davis & Holmes, 2005; Davis, Welch, Holmes, & Shepherd, 2001; Harrison & Feldman, 2009). That is, participants' performance was even worse when judging two stimuli or features within the same object than those in different objects. The illustrations of SOA and DOA effects were shown in Fig. 1. This apparent inconsistency raises several important questions, which, to the best of our knowledge, remain to be answered. Why does the DOA effect sometimes happen if SOA is a general phenomenon? Is DOA a genuine effect or just an artifact of certain methods? What determines the presence of the SOA vs. DOA effect? In the present study, we attempt to address these issues and solve the apparent paradox between the SOA and DOA effects.

### 1.1. Previous studies on the SOA effect

In a pioneering study on the SOA effect using the divided-attention paradigm, Duncan (1984) adopted the approach of using an "outline box + crossing line" pattern which was briefly presented and then rapidly masked. Both the box and the line had two attributes, and observers were tested on either (a) two attributes from the same object (e.g., the height of the box and the side

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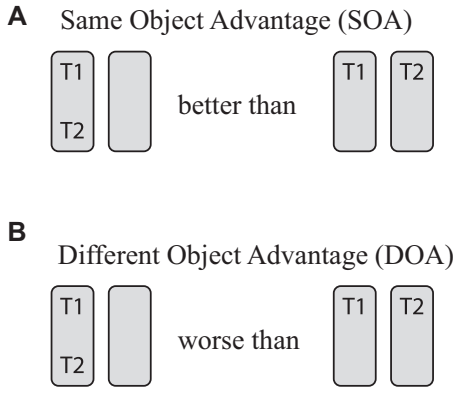


**Fig. 1.** The illustrations of the SOA and DOA effects. (A): SOA effect: participants' performance of judging two targets is better (faster and/or more accurately) when they are from the same object than when they are from different objects. (B): DOA effect: this effect shows an exactly opposite pattern as that of SOA effect. That is, participants are worse in responding two targets within the same object relative to those in different objects.

of the gap on the box) or (b) two attributes, one from each of the two objects (e.g., the height of the box and the texture of the line). The results showed a SOA effect: observers' performance was substantially better when the attributes were from the same object compared to when they were from different objects.

This SOA has not only been replicated in similar paradigms (Duncan, 1993a, 1993b) but has also been extended in various ways. For example, Baylis and Driver (1993) adopted an ambiguous stimulus display (analogs to Rubin's faces–vase figure) which could either be perceived as one central white object against black background or as two black objects against the central white background, and manipulated participants' perceptual interpretation (one or two objects) by using color instruction. They found that participants' performance of edges judgment was better when these edges were perceived to be from one single object than when they were perceived to be from two different objects, despite the physical stimuli were the same between the one-object and two-object conditions. In another case, Lavie and Driver (1996) used stimuli across a wide spatial extent (e.g., two overlapping straight lines subtending about 12° of visual angle) and still confirmed the SOA effect.

In addition to the above-mentioned studies with the divided-attention paradigm, Egly et al. (1994) also reported the SOA effect in a spatial-cuing paradigm. In their study, two rectangles were presented and the observers were asked to detect a target that could appear in one of the four ends of the two rectangles. One of the four ends was cued before the target onset. In 75% of the trials, the target appeared at the cued location (i.e., valid trials); in the other 25% of the trials, the target appeared either at the opposite end of the cued rectangle (i.e., invalid-same-object trials) or at the end of another rectangle but at an equal distance from the cued location (i.e., invalid-different-object trials). The results indicated that the observers responded faster in the invalid-same-object trials than in the invalid-different-object trials despite the targets in these two conditions were equally distant from the cued location. The SOA effect in the spatial-cuing paradigm has subsequently been widely confirmed and extended (e.g., Abrams & Law, 2000; Goldsmith & Yeari, 2003; Lamy & Egeth, 2002; Marino & Scholl, 2005; Moore, Yantis, & Vaughan, 1998; Richard, Lee, & Vecera, 2008; Shomstein & Yantis, 2002). In addition to these behavioral findings, several ERP studies adopting the spatial-cuing paradigm have also revealed evidence of the SOA effect by showing larger P1 and N1 components triggered by a stimulus in the attended object than in the unattended object (e.g., He, Fan, Zhou, & Chen, 2004; Khoe, Mitchell, Reynolds, & Hillyard, 2005).

### 1.2. Previous studies on the DOA effect

Although, as discussed above, the SOA effect has been widely reported, the opposite pattern (i.e., DOA) was also reported sometimes. One notable result was found by Davis et al. (2001) (see also Davis & Holmes, 2005) using the typical divided-attention paradigm. Observers were shown, and later tested on, two target features (e.g., square and diagonal notches), which appeared either on one single object or on two separate objects. The observers responded more rapidly when the target features belong to two separate objects than when they belong to a single object. In addition to Davis et al. (2001), Davis and Holmes (2005), other researchers have also reported the DOA effect, although they have not always labeled it as such. For example, Cepeda and Kramer (1999) used two wrench-like stimuli and asked participants to judge whether two ends that either come from the same wrench or different wrenches were the same or different in shape. They obtained a DOA effect and interpreted it as being just a consequence of using the mental rotation strategy. Harrison and Feldman (2009) manipulated the object orientation and the strength of the object percept, and asked participants to compare two features either from the same or different objects. They found that the presence of the DOA effect depended on the object orientation, but it was not influenced by the strength of object percept. Chou and Yeh (2011) adopted Egly et al.'s (1994) spatial-cueing paradigm by using both suprathreshold and subliminal spatial cues. Interestingly, they not only replicated the SOA effect under the condition of a suprathreshold cue, but more importantly, they observed the DOA effect under the context of a subliminal cue.

### 1.3. The present study

As mentioned above, the primary purpose of the present study is to attempt to solve the apparent conflict between the findings of DOA and SOA effects in the literature. The SOA effect is more intuitive and naturally follows from the common notion that attention tends to select an object as a single unit (e.g., Scholl, Pylyshyn, & Feldman, 2001). Therefore, it is reasonable to regard SOA as a "default", and the mission that needs to be accomplished is to identify the critical condition *when DOA will occur* and to provide a theory as to *why it is so*.

After a thorough comparison of previous reports on these two effects, we came to realize that the DOA effect is usually observed when the two target features are highly similar or identical to each other, whereas the SOA effect is usually observed when the two target features are clearly different from each other (e.g., Behrmann, Zemel, & Mozer, 1998; Cepeda & Kramer, 1999; Davis, 2001; Lavie & Driver, 1996). For example, Cepeda and Kramer found a DOA effect when asking participants to judge whether two highly similar ends of wrench-like stimuli (rounded vs. rectangular wrench ends) were the same or different, whereas they found a SOA effect when asking participants to compare two clearly distinct wrench ends (open end vs. bent closed end) in another experiment. Note that their purpose of manipulating the similarity between targets is to investigate the influence of the perceptual difficulty of the task on their results, which is completely different with our hypothesis as follows. We suspect that this methodological aspect (i.e., the identicality of the two targets) is critical to the direction of the results. In other words, the critical condition for observing a DOA (rather than a SOA) effect is that the two targets are identical to each other.

But why is this? Perhaps, for perceiving the targets and performing the task, the essential process is *to assign distinct labels to the two targets so that they can be differentiated from each other*. This differentiation is trivially easy when the two targets are clearly different from each other but becomes more challenging