A RIGHT VISUAL FIELD ADVANTAGE FOR TOOL – RECOGNITION IN THE VISUAL HALF-FIELD PARADIGM

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Abstract

Neuropsychological and brain imaging studies have shown that the identification and use of tools mainly involve areas of the left hemisphere. We investigate whether this dominance can be observed in a behavioral visual half-field (VHF) task as well. To make sure that the VHF-effect was due to laterality and not due to attentional bias, we made use of two tasks: Tool recognition and object recognition. On the basis of the existing literature, we predicted a right visual field (RVF) advantage for tool recognition, but not for object recognition. Twenty right-handed participants made judgments about whether one of two bilaterally presented stimuli was an object/non-object or a tool/non-tool. No VHF/hemisphere advantage was found for object recognition, whereas a significant RVF/ left hemisphere advantage was observed for tool recognition. These findings show that VHF-tasks can be used as a valid laterality measure of tool recognition.

A Right Visual Field Advantage for Tool Recognition in the Visual Half-field Paradigm

The use and manufacturing of tools are typical human skills, going back to pre-historic times (Ambrose, 2001), although primates can also be taught to manipulate existing objects in order to achieve goals. Neuropsychological and brain imaging research have indicated that tool knowledge in humans not only involves dedicated brain regions but also that these areas are lateralized to the language-dominant (usually the left) hemisphere (Lewis, 2006).

Tool knowledge involves two types of information: (i) Knowledge about tools and their functions, and (ii) the motor skills needed to manipulate tools. Evidence from patients with brain damage suggests that these two types of information are controlled by different brain areas, as there is a double dissociation between both functions (Buxbaum, Schwartz and Carew, 1997; Buxbaum, Vermonti and Schwartz, 2000). Patients suffering from ideational apraxia have problems with the knowledge of tools and their use, whereas patients with ideomotor apraxia are particularly deficient in the effective manipulation of tools.

Randerath, Goldenberg, Spijkers, Li, and Hermsdorfer (2010) examined 42 patients and 18 healthy controls on tool grasping and typical use of tools. They found that patients with impaired tool use had a large area of overlap in the left supramarginal gyrus, whereas patients with erroneous grasping had lesion overlap in the left inferior frontal gyrus and the left angular gyrus. Goldenberg and Spatt (2009) examined 38 patients with brain damage and compared appropriate tool use (both for common tools and new tools) and functional associations to tools (i.e., knowing which recipients are appropriate for a tool and which other tool could be used for the same purpose). These authors too observed that parietal lesions involving the left supramarginal gyrus impaired tool use (both common and novel), whereas left frontal lesions affected tool use and tool knowledge (as assessed by the test for functional associations). Osiurak, Jarry, Allain, Aubin, Etcharry-Bouyx, Richard, Bernard, and Le Gall (2009) compared 21 left brain damaged, 11 right brain damaged and 41 healthy controls on experimental tests assessing the conventional use of objects, conceptual knowledge about object function, pantomime of object use, recognition of object utilization gestures, and unusual use of objects. They found that left brain damage patients had more difficulties on the unusual use of objects than controls or right brain damaged patients.

Brain imaging has also been used to investigate and localize the various components of tool use. The most frequently used task involves asking participants to pantomime specific tool operations and to compare these movements to repetitive limb movements (Choi, 2001), to other meaningful hand gestures (Fridman et al., 2006), or to meaningless hand movements (Fridman et al., 2006; Grezes and Decety, 2002; Johnson-Frey, 2005; Moll, de Oliveira-Sousa, Passman, Cunha, Souza-Lima, and Andreiuolo., 2000). Technological limitations often prevent the investigation of real tool use. Therefore, researchers usually work with imagined operations, asking participants to engage in mental simulations of tool use; the assumption being that the brain activity during simulation corresponds to that of the actual operation.

Another frequently used paradigm in the functional neuroimaging literature involves showing participants pictures of tools vs. pictures of humans, animals, houses, faces, or even scrambled images, and measuring the differences in brain activity (Beauchamp, Haxby and Martin, 2002; Chao, Haxby and Martin 1999; Chao, 2000; Creem Regher, 2005). Kallenbach, Brett and Patterson (2003) argued that the best comparison is tools vs. other man-made objects, such as houses, because otherwise it is difficult to determine whether the observed differences in brain activity are tool-specific or caused by processing differences between man-made things and naturally-occurring organisms (humans, animals). Other neuroimaging studies have involved naming tools vs. animals (Chao, 1999), or naming tools vs. actions (Rumiati et al., 2004).

In line with the neuropsychological evidence, two sets of left-hemisphere brain areas have been identified in functional neuroimaging: Those related to the identification of tools, and those related to the motor skills required for tool manipulation. As far as the identification of tools is concerned, three cortical areas have been identified. They are: the left ventral pre-central gyrus in the frontal lobe (ventral Premotor Cortex, VPMCx), the left Intraparietal Sulcus (IPS) in the posterior parietal cortex, and the posterior middle temporal gyrus (PMTG) either on the left or bilaterally (Beauchamp, Lee, Haxby and Martin, 2002; Chao and Martin, 2000; Martin, Wiggs, Ungerleider and Haxby, 1996; Perani, Schnur, Tettamanti, Gorno Tempini, Cappa, and Fazio, 1999). PMTG was particularly involved in a study by Chao, Haxby and Martin (1999), who compared the perception of tools to that of houses, suggesting that the activity in this area could be associated with the manipulability of the object (tools vs. houses). Chao and Martin (2000) showed additional activation of the left VPMCx and the left IPS for the naming of manipulable tools vs. houses. The left VPMCx has also been shown active during the pantomiming of tool use, imagining motor actions, observation of movement; hence leading to the proposal that it stores movement representations and relevant motor information for tool use (Buccino et al., 2001; Decety et al., 1994; Grafton, Fagg, Woods and Arbib, 1996; Moll et al., 2000). The left IPS activity has been linked to the retrieval of tool specific grasping movements (Grezes and Decety, 2001a). Lesion data also suggest that this area is responsible for finger movement co-ordination associated with grasping and manipulating objects (Binkofski et al. 1998).

With respect to the motor skills required for tool manipulation, Frey (2008) combined the results from apraxia studies and neuroimaging studies, and concluded that retrieval and planning of these skills involves a network of cortical areas in the left hemisphere, situated in the parietal, prefrontal, and posterior temporal cortices. Surprisingly, the left hemisphere dominance was also observed when the actions were performed with the left hand (Moll, de Oliveira-Sousa, Passman, Cunha, Souza-Lima, and Andreiuolo., 2000). The involvement of parietal and frontal brain areas in tool-related motor responses can be understood in the light of a proposal made by Heilman, Rothi, and Valenstein., (1982). According to this proposal, parietal sites store representations of skills whereas the frontal sites take part in the retrieval of the skills during performance. Activation of the left PPC (posterior parietal cortex) during pantomiming and imagery corroborates the proposal.

In summary, it can be concluded that tool use, as a behavior that is especially advanced and sophisticated in humans compared to other species (see Boesch & Boesch (1990) for chimpanzees, and Hunt & Gray (2003) for crows), involves various components that are lateralized to the left hemisphere.

Interestingly, to our knowledge no one has yet investigated whether the left lateralization of tool knowledge can also be confirmed in a behavioral study. Neuroimaging techniques, such as fMRI, are good methods to establish the lateralization of cognitive functions. However, they also tend to be rather resource-intensive, meaning that they are less suited for research on large groups or for pilot testing. Before the introduction of functional neuroimaging, barely two decades ago, the common practice was to test the laterality of cognitive functions with behavioral methods, such as visual half field (VHF) experiments for visual stimuli and dichotic listening tasks for auditory stimuli (Bradshaw and Nettleton, 1983; Bryden, 1982). So, for tool identification researchers would have used a VHF-experiment and gauged the laterality of the function by comparing the performance of right-handers to stimuli presented in the left visual field (LVF) with stimuli presented in the right visual field (RVF).

The VHF technique rests on assumption that a visual stimulus can be processed more efficiently if it is projected directly to the specialized hemisphere than if it is initially sent to the non-specialized hemisphere. Due to the crossing of nasal fibers in the optic chiasm, stimuli in RVF are projected directly to the left hemisphere, whereas stimuli in LVF are projected to the right hemisphere. Therefore, the expectation is that tool identification would be better in RVF than in LVF, given the left hemisphere dominance for this function.

The reason why researchers in tool use may not have thought of the VHF task is that it has been criticized as a good measure of laterality in the past decades. For instance, Voyer (1998) showed that the laterality index on the basis of a VHF task has a low reliability ($r = 0.56$ for verbal tasks and $r = 0.28$ for non-verbal tasks). Another problem is that VHF-tasks usually reveal some 30% LVF advantage for verbal stimuli in right-handers, although it is well established that right hemisphere dominance in these people is below 5% (Knecht, Drager, Deppe, Bobe, Lohmann, Floel, Ringelstein, and Heningsten, 2000.). Furthermore, there is a low correlation between the laterality estimates of the same participants based on a VHF-task and those based on a dichotic listening task (Kim, 1997). All these findings have questioned the usefulness of the VHF-task and suggested that task-related variables may be more important in the outcome than the fact that the two VHFs have direct access to different hemispheres.

Hunter and Brysbaert (2008) recently reviewed the task variables that may play a role in VHF-asymmetries and made eight recommendations for the proper implementation of a VHF-experiment. First, because of the low reliability of the VHF-asymmetries, experimenters must present a reasonably large number of trials to the participants. How many depends on the conclusions one wants to draw from the study. If the goal is to make an individual assessment of the participants, then more trials will be required than when the goal is to draw conclusions on the basis of the grouped data. Second, the stimuli in LVF and RVF must be matched. Otherwise, the VHF-asymmetry may be influenced by the stimuli presented in both VHFs. Third; bilateral presentation is to be preferred. In this technique, two stimuli are presented simultaneously in LVF and RVF and a central arrow indicates to which stimulus the participant must respond. This procedure creates competition between the left and the right hemisphere and also seems to be better to counteract attentional biases to LVF or RVF (e.g., as a result of the reading direction). Fourth, the stimuli must be clearly visible, despite the fact that stimulus presentation is limited in the VHF paradigm (because the participants must not be able to make eye movements to the stimulus). Fifth, some fixation control must be exerted, to make sure that the stimulus is presented in the intended hemisphere. If fixation control entirely depends on instructions, there is no way to exclude participants who fail to follow the instructions. Sixth, the task must be a valid measure of the function one wants to assess (e.g., a naming task must be used if the experimenter wants to measure the laterality of speech). Seventh, the stimuli must be optimized to exclude confounds (i.e. the stimuli should be carefully selected to minimize irrelevant effects due to factors such as stimulus clarity, stimulus roundedness, stimulus orientation, and so on). And finally, low correlations are to be expected if the range of participants is limited. The main outcome of a VHF-task (or any other laterality task) is to determine whether a person is left or right dominant, not whether there are consistent differences in the degree of left dominance. So, if only left hemisphere dominant participants are tested (who all show the expected RVF advantage), one is bound to find low reliability data and low correlations with other tasks (because the differences in RVF advantage between the participants are largely due to noise). If one wants to test the validity of a VHF-task, one must compare left dominant with right dominant participants and check whether the VHF-asymmetries of both groups are indeed reversed.

Using these criteria, Hunter and Brysbaert (2008) were able to show that a word naming VHF task with short word stimuli is a valid measure of speech dominance, as assessed with fMRI and functional transcranial Doppler sonography. In the present study, we investigate whether a good VHF task is also able to reveal the left hemisphere dominance for tool recognition. To further make sure that the VHF-asymmetry for tool recognition is related to the task and not to a general attention bias towards RVF (e.g., because of the left-right reading direction of the participants), we additionally presented a task, object recognition, for which no RVF-advantage is expected. According to some authors no consistent VHF-asymmetries are expected for object recognition (for a review, see Biederman and Cooper, 1991). Others have reported a tendency towards a LVF-advantage, in particular when the objects are presented in a non-canonical view (McAuliffe and Knowlton, 2001).

Method

Participants: The participants were 20 students from Ghent University. There were 14 females and 6 males; all participants were right-handed with a mean laterality index of 73.9 on the Edinburgh Handedness Inventory. The experiment took 1.5 hrs in total. Participants were paid 12€.

Stimuli: For the object recognition task, we took line-drawings of 40 objects and 40 non-objects from the Line Drawing Library developed at the Laboratory of Experimental Psychology, University of Leuven, Belgium (van Diepen and De Graef, 1994). The objects included in the list were those encountered in daily life, such as ball, clock, cup, etc. The non-objects were unnamable, made-up images that matched the objects in general shape. The upper panel of

Figure 1 shows three examples of objects used and the lower panel shows three examples of non-objects used in the object-recognition task.

Insert Figure 1 here

For the tool recognition task, we used line-drawings of 30 tools and 30 non-tools from the IPNP Pictures database (Snodgrass and Vanderwart, 1980). The tools were familiar in daily life, such as hammer, saw, screwdriver etc. The objects included familiar objects, such as bottle, candle, shoe, etc. Care was taken to ensure that the tool and non-tool pictures were perceptually similar (which imposed a strong limitation on the number of pictures that could be used), so that the tools on average did not have a different shape from the other objects (tools in general tend to be elongated and are often drawn with the right slant typical for right-hand use). The upper panel of Figure 2 shows three examples of tools used and the lower panel shows three examples of non tools used as control objects.

Insert Figure 2 here

It was not possible to use the same pictures for object/non-object and tool/non-tool tasks, because the Leuven database did not contain enough pictures of tools, whereas the IPNP database did not include pictures of non-objects. This was a limitation, but not a real problem because both tasks were run in separate blocks, and we did not expect carry-over effects from one type of drawing to the other. All pictures were sized to 150x150 pixels.

Procedure: Participants started by completing the Edinburgh Handedness Inventory. They were then seated in front of a 17" computer screen at a distance of 80 cm. Before the start of each experiment the participants were familiarized with the pictures that would be presented, by giving a tachistoscopic presentation of the stimuli (with the same presentation duration as in the real experiment).

The sequence of presentations was as follows. First there was a blank screen for 1000ms. This was followed by a fixation cross (sized 1 degree of visual angle) in the center of the screen for 300ms. The fixation cross was then replaced by a slide which included an ARROW of 1 degree of visual angle in the center pointing to the left or to the right, together with a picture in LVF and a picture in RVF (extending from 3° to 7°). The duration of the slide was 200ms. Research by Walker and McSorley (2006) indicated that participants are not able to initiate an eye movement within 200 ms when they first have to pay attention to a stimulus at the fixation location. The pictures in LVF and RVF could depict an object or a non-object in the object recognition task, and a tool or a non-tool in the tool recognition task. The participants were instructed to direct their attention to the picture to which the arrow pointed, and to ignore the other picture. If the picture was an object (or a tool) they had to press with their left and right index fingers simultaneously; if the picture represented a non-object (or non-tool) they had to press with their left and right middle fingers. Responses were registered with an external four-button box, connected to the USB port of the computer. We used bi-manual responses to avoid the stimulus-response compatibility effect (i.e., the fact that responses with the right hand are faster to stimuli in RVF than LVF, whereas the reverse is true for responses with the left hand). Reaction times were calculated based on the first key press registered.

Eight types of trials were defined, depending on the VHF the participant had to attend to (LVF or RVF), whether this VHF contained a picture of an object/tool or non-object/non-tool, and whether the opposite VHF contained a picture of the same category (e.g., tool – tool) or of the other category (e.g., tool – non-tool). This ensured that over trials the same information was presented in LVF and RVF.

Each task (object decision, tool decision) started with a practice session of 48 trials, before the main experimental block was administered. The experimental block was divided into 2 parts having 240 trials each. There was a break of 2-3 minutes between the two parts. The object recognition task always preceded the tool recognition task, to avoid participants from recoding stimuli of the object recognition task as tools. Reaction times of the correct responses and accuracies were the dependent variables.

Results

Insert Table 1 here

First, we compared the two tasks with a 2x2x2x2 omnibus ANOVA, containing Task (object/tool), VHF (LVF/RVF), Response (yes/no), and Compatibility of the distracter picture (compatible/incompatible) as independent variables. Distracter Compatibility refers to the arrangement of the pictures in the two visual half fields: A compatible condition is a condition in which the pictures of both visual half fields belong to the same category (tool, non-tool, object, non-object), whereas an incompatible condition refers to a situation in which the pictures of the visual half fields belong to opposite categories. For the RT data, this resulted in a significant main effect of Task type (object recognition = 451 ms, tool recognition = 474 ms; F (1, 19) = 5.117, $p < .05$), Response type (yes = 444 ms, no = 481 ms; F (1, 19) = 17.589, $p < .001$), and distracter Compatibility (compatible = 455 ms, incompatible = 470 ms; F (1, 19) = 43.303, $p < .001$). The main effect of VHF was not significant (LVF = 465 ms, RVF = 459 ms; F (1, 19) = 5.117, $p = .22$).

Insert Figure 3 here

Most importantly, as predicted, there was a significant interaction between Task and VHF [F (1, 19) = 10.231, $p < .001$], which is shown in Figure 3. VHF was also involved in a significant three-way interaction with Task and distracter Compatibility (F (1, 19) = 7.685, p < .05). The interpretation of both effects will be clearer when we have a look at the individual tasks.

Finally, there was a significant interaction between Response type and distracter Compatibility [*F* (1, 19) = 24.415, *p* < .001]. The Compatibility effect was only observed for the no-responses [*t* (19) =56.35, *p* <.001]. There was no difference between compatible and incompatible trials in the yes-trials [*t* (19) = .576, *p* =.97].

The same omnibus 2x2x2x2 ANOVA on the percentages of error only revealed significant main effects of Response type [Yes = 18.2 , no = 12.4; F (1,19)= 8.622, p<0.01] and distracter Compatibility [compatible = 14.1 , incompatible = 16.6; F(1,19)= 12.528, p<0.01).

We ran separate 2x2x2 ANOVAs for the two different tasks, to separately understand the effects of the three variables (Visual Half Field, Response Type, and Distracter Compatibility). For the RTs in the object recognition task, there was no significant effect of Visual Field [F(1, 19)= 0.616, n.s.], but there were significant effects of Response type [F(1,19) = 33.700, p<0.01] and distracter Compatibility [F (1,19)= 8.998, p<0.01]. In addition, there were significant interactions between VHF and Response type [F (1, 19) = 4.510, p<0.05] and between Response type and Distracter Compatibility, F (1, 19) = 36.172, p<0.01. The latter has been discussed in the omnibus analysis; the former is new and is due to the fact that no-responses were 13 ms faster in LVF than RVF (t(19) =3.379, p>0.05) , whereas RTs were 3 ms faster in RVF than LVF for yes-responses (t(19)=0.868, p>0.05). The 2x2x2 ANOVA on the percentages of errors only revealed significant main effects of Response type [F (1, 19) = 15.338, p < 0.01] and distracter

Compatibility [F (1, 19) = 4.916, p<0.05]. The three-way interaction was not significant (F (1, 19) = 0.262, p>0.05).

The 2x2x2 ANOVA of the RTs in the tool recognition task returned the predicted effect of VHF [F (1, 19)= 8.477, p<0.01] with faster responses in RVF (465 ms) than in LVF (483 ms). There was no significant difference between Response types [F(1,19)= 1.88, p>0.05], but participants were faster in distracter compatible trials than in distracter incompatible trials [F(1,19)= 30.448, p<0.01]. VHF was further involved in a significant interaction with distracter Compatibility (F (1, 19) = 4.848, p<.05), because the RVF advantage was smaller with compatible distracters (10 ms) than with incompatible distracters (25 ms). Finally, as in all the previous analyses there was a significant interaction between Response type and distracter Compatibility (F (1, 19) = 7.478, p<.05). The three-way interaction was not significant (F(1, 19) = 0.019, p>0.05). The same ANOVA on the percentages of error only revealed a significant main effect of Compatibility [F (1, 19) = 12.564, p<0.05]. The effects of VHF and Response type failed to reach significance in this analysis [VHF: F (1, 19) = 2.445, p>0.05; Response type: F (1, 19) = 3.534, p>0.05].

As the participants were significantly faster on the object/non-object decision task than on the tool/non-tool decision task (object recognition = 451 ms, tool recognition = 474 ms; $F(1, 19) = 5.117$, $p < .05$); we further checked whether task difficulty played a role in the LVF advantage obtained in the tool/non-tool decision task. The reaction times of each participant in the tool/non-tool decision task were split into a faster and a slower half and were analyzed with the same 2x2x2 ANOVA having VHF, Response (Yes/No) and Compatibility as factors. The analyses revealed that the VHF advantage was the same in the fast half of the trials (RVF = 365 ms, LVF = 382 ms; F (1, 19) = 18.910, $p < 0.01$) as in the slow half (RVF = 563 ms, LVF = 581 ms; F (1, 19) = 5.114, $p < 0.05$). The same analysis for the object recognition task revealed that the VHF asymmetry was absent both in the fast trials (LVF = 352 ms, RVF = 356 ms) and in the slow trials (LVF = 543 ms, RVF = 548 ms). Given this pattern of results, it is unlikely that task difficulty was involved in the LVF advantage for tool recognition.

Discussion

In this paper we examined whether we could find evidence for left-hemisphere lateralization of tool recognition with the use of a behavioral VHF experiment. As reviewed in the Introduction, left-hemisphere lateralization of tool knowledge has been well-established on the basis of neuropsychological and brain imaging data (Frey, 2008; Frey, Funnel, Gerry and Gazzaniga, 2005; Goldenberg & Spatt, 2009; Johnson-Frey, 2004; Kallenbach, Brett and Patterson, 2003; Lewis, 2006; Osiurak et al., 2009; Randerath, Goldenberg, Spijkers, Li, and Hermsdorfer, 2010). Showing a similar effect in a VHF-task would not only make a new lateralized function available for behavioral research with healthy participants; it would also provide a further validation of the VHF task, which has been questioned.

Our results showed that the expected RVF advantage for tool recognition is observed, if a basic protocol is used to make sure that participants perform the task under optimal conditions. In addition, the same advantage was not observed in a very similar task (object recognition) for which no VHF-asymmetry was expected (Biederman and Cooper, 1991). These findings support Hunter and Brysbaert's (2008) conclusion that the VHF paradigm is a valid paradigm when used properly and that researchers can make use of the VHF task to examine the laterality of cognitive visual functions.

The finding of no VHF-asymmetry in the object recognition task is further interesting, because it deviates from the object naming task, which induces a RVF/left-hemisphere advantage similar to word naming (Hunter and Brysbaert, 2008). In object naming, however, a small set of 5 pictures is shown repeatedly and participants have to name the picture as fast as possible. In this task, the bottleneck is not to identify the picture but to pronounce the correct name (which is a left-hemisphere function). The difference between the object naming task and the object-recognition task clearly shows the importance of carefully selecting the proper VHF-task for the function one wants to study.

The finding of no VHF-difference in the object naming task is in line with the existing literature (Biederman and Cooper, 1991). In one of the more recent studies, McAuliffe and Knowlton (2001) reported a small (8ms) LVF/RH advantage by manipulating SOA and object orientation. As we did not change object orientation or manipulate SOA, we did not expect to trigger differences in perceptual processing between the hemispheres. At the same time, we saw some evidence for a LVF advantage on the no-responses, against no VHF-difference for the yes-responses, leading to a significant interaction between VHF and Response type in the object recognition task. It is not clear whether much attention should be given to this finding until we know more about its robustness. Possible reasons why right-handed participants may find it easier to give no-responses to stimuli in LVF could be related to right hemisphere superiority at processing non-familiar shapes or to the fact that participants spontaneously tend to associate no-responses with "left" and yes-responses with "right" (Nuerk, Iversen, & Willmes, 2004).

The fact that we found different results for tool/non-tool decisions and object-non-object decision further confirms that tools form a special category of objects strongly related to specific movements (Grafton, Fadiga, Arbib, and Rizzolatti, 1997). Most of the tools in our stimuli pool (razor, axe, hammer) belonged to the class of manipulable objects, which are associated with discrete activations in left posterior parietal cortex. Tools (as a class of manipulable objects) encourage automatic engagement of mechanisms involved in the planning of grasping and reaching movements, activating the left premotor cortex during naming/observation (Frey, 2008). It has been proposed that tools when viewed can be processed not only for identity but also for how they can be used as opposed to other classes of objects (Creem-Regher and Lee, 2005). This proposal hints to the fact that viewing pictures of tools in comparison to objects is more likely to trigger activations in the brain regions responsible for simulating motor actions closely associated with them even when the actions are not overtly performed (Tucker and Ellis, 1998). As these regions largely lie in the left hemisphere (Frey 2008) a clear left hemisphere/right visual field advantage is a logical expectation, which was confirmed by our results.

A slight complication is that the tool-recognition VHF-task contains 8 types of trials, rather than the two conditions of neuroimaging studies. The participants not only respond to tools in LVF and RVF, but in addition they have to respond to stimuli that evoke a no-response, and they are confronted with compatible or incompatible distracters. Both variables have significant effects: Participants are faster on yes-trials than on no-trials, and they are faster on trials with compatible distracters than on trials with incompatible distracters. Luckily, these variables do not interact with the RVF-advantage to such an extent that they wipe out the main effect of VHF. In addition, later experiments can zoom in on the effects due to the distracter, to get a clearer image of the interhemispheric dynamics in the tool recognition task. Given that the distractors influence the processing of the targets, there is cross-talk involved, the origin of which will be interesting to flesh out (see, e.g., Ratinckx and Brysbaert, 2002, for a similar study in number processing).

All in all, the present study replicates earlier evidence for the left hemisphere lateralization of tool use by finding a clear RVF-advantage of 17 ms for tool recognition. This is an important step towards establishing valid behavioral estimates of cerebral asymmetry. The visual half field task as operationalized here is a viable means to assess the laterality of cognitive functions, the more so because participants only showed the RVF-advantage for the tool recognition task and not for the object recognition task, where no VHF-asymmetry was predicted. The ease with which VHF studies can be run means that this is a more versatile technique to examine the details of tool lateralization. Above, we discussed the possibility to investigate the interhemispheric dynamics. Other topics to address are the extent to which the effect depends on the type of tools (e.g., manipulable or not), and whether the VHF advantage is fundamental enough to be observed in a tool/non-object decision task, or whether in that case tools are processed like other objects. Further questions are how tool use is lateralized in left-handed individuals, how important the orientation of the tool is (e.g., typical for left or right hand use) and whether this interacts with the handedness of the participant. Finally, studies with atypically lateralized individuals can be expected to yield interesting results, as it would be fascinating to investigate whether tool representations follow language representations and shift to the right hemisphere in right-dominant individuals. The present study calls for a greater exchange between behavioral and neuroimaging research by providing a behavioral paradigm that can be used both as a precursor to brain research and in combination with brain research (e.g., to see to what extent brain activity differs when the stimulus is presented in LVF or RVF).

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Figure 1

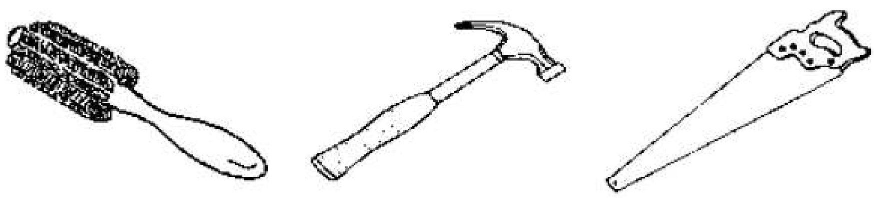
Examples of Stimuli Used in Object Recognition Experiment

Objects

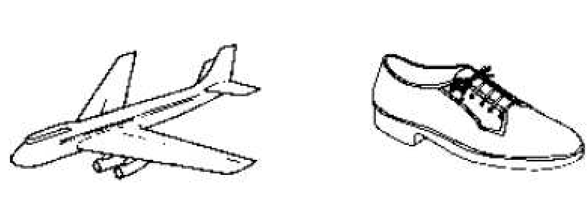
Non-Objects

Figure 2

Examples of Stimuli Used in the Tool Recognition Experiment



Tools



Non Tools

Figure 3

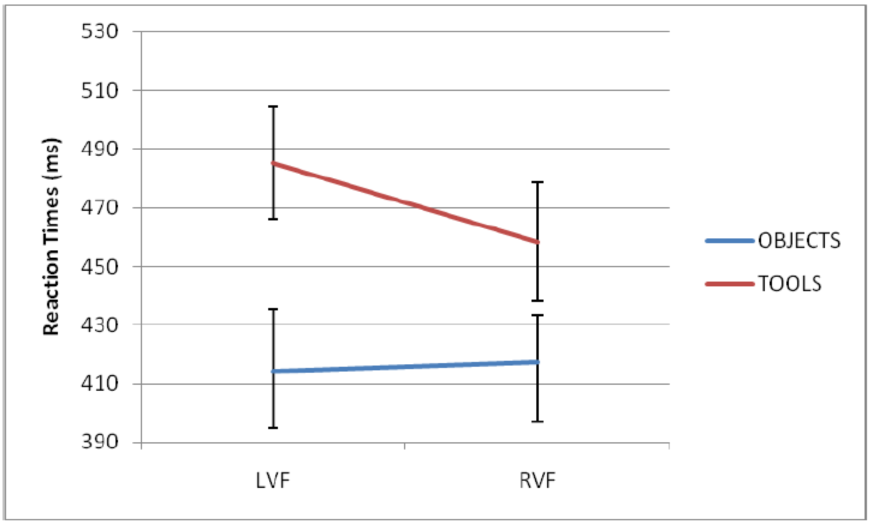


Figure 3: Showing significant RVF facilitation for tools, while no such facilitation is seen for objects.