Impact of Wet Macular Degeneration on the Execution of Natural Actions

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Purpose. To use eye movements to investigate how people with a central scotoma might be impaired in the execution of natural actions and whether task familiarity affects performance.

Methods. Sixteen participants with AMD and 16 age-matched controls performed two natural actions: (1) a familiar sandwich-making task and (2) a less familiar model-building task. In each action, task-relevant and task-irrelevant objects were placed on a table, covering 90°. The participants were asked to execute the actions without a time constraint. Eye movements were recorded.

Results. The people with AMD were significantly slower than the controls, both in the exploration phase (before the first reaching movement) and in the working phase (execution of action), especially in the unfamiliar task. Gaze duration was longer on relevant than irrelevant objects in both groups and tasks, as might be expected. However, for the participants with AMD, gaze durations were longer on all of the objects, whether relevant or irrelevant, except in the more familiar task. This suggests that participants with AMD take longer to extract the information they need but that this can be counteracted when the task items are familiar. The number of saccades/min of the task was significantly greater for the people with AMD than for the controls.

Conclusions. The present results show that people with AMD can accomplish natural actions efficiently, but need longer gaze durations and more eye movements than normally sighted people. This effect can be reduced when executing a familiar task.

Keywords: macular degeneration, natural actions, eye movements, scotoma

Age-related macular degeneration (AMD) is a chronic retinal disease that leads to the loss of central vision. The end stage of AMD is the development of a central scotoma, which has a detrimental impact on many functions. Although reading and face perception are the most common clinical complaints of people with AMD, quality-of-life questionnaires indicate that central vision loss hinders the performance of many other activities of daily living, including driving, mobility, cooking, shopping, using public transportation, and watching TV.[1,2] Whereas substantial research effort has been directed toward understanding the behavioral aspects of the impairment experienced by people with AMD in vision-related tasks such as reading,[3,4] face perception,[5,6] and visual search,[7–9] little is known about the difficulties encountered by people with AMD in other tasks, such as natural actions. Timberlake et al.[10] examined the effect of central vision loss in reach-to-grasp movement dynamics in 10 subjects with bilateral scotomas. The task was to grasp blocks of three widths at two distances under binocular and monocular viewing conditions. They found that people with bilateral macular scotomas from AMD exhibited reach-to-grasp movements with longer trajectories and lower velocities, longer visual reaction times, and altered maximum grip aperture-block width scaling. More recently, Pardhan et al.[11,12] assessed the effect of contrast and flanking objects on reaching and grasping in people with various macular disorders. They reported that compared with controls, people with macular disorders generally took longer to initiate a hand movement and to complete the movement, but crowding (the presence of flankers) affected the performance of both healthy observers and those with macular disorders. When contrast was manipulated, the people with macular disorders took longer to initiate and complete the movement, but maximum velocity and grip aperture did not differ between the groups, suggesting that once the target was perceived by people with impaired central vision, their performance was similar to that of normally sighted people. These studies indicate that some parameters of action are impaired by central vision loss. Although reaching and grasping a solitary block or a cylindrical target flanked by another cylinder resembles some daily life actions, the characterization of visual impairment needs to include an assessment of the patient's ability to execute more complex natural actions that are more representative of the everyday situations faced by people with AMD. Indeed, actions in real-world environments differ in several ways from laboratory situations. In natural environments, occluding items or obstacles may have to be moved to see or access a target object; eye, head, and sometimes whole-body movements must be made to locate the object; and targets and background are often complex and defined in terms of a whole range of features and occlusions.

Table 1. Demographic and Clinical Data of Participants With AMD

Number/Sex/Age	Tested Eye	MMSE	Duration of AMD, y	LogMAR VA	CNV Type	Greatest Linear Diameter, mm	Surface Area, mm^2
1/M/82	L	29	3	0.8	Type 1	3.41	6.79
2/M/72	R	25	1	0.4	Type 1	3.63	9.54
3/F/98	L	26	0.5	0.3	Type 1	3.4	4.23
4/F/88	R	26	1	0.3	Type 1	2.37	4.5
5/F/84	L	28	2	1	Type 2	6	24.6
6/M/78	R	25	0.5	0.7	Type 1	2.4	4.12
7/M/87	L	27	3	1	Type 1	4.98	15.2
8/F/76	L	28	1	1	Type 1	4.08	10.1
9/M/89	R	28	1.5	0.8	Type 2	3.93	7.8
10/M/82	R	29	1.5	1	Type 2	3.7	8.18
11/F/84	L	29	2	0.7	Type 1	3.4	8.35
12/F/82	L	27	3	0.8	Type 2	3.9	6.1
13/F/72	L	30	2	0.5	Type 1	4.1	10.6
14/F/70	R	30	3	0.5	Type 1	2.6	4.3
15/M/71	R	28	1	0.7	Type 1	3.4	5.41
16/F/70	R	29	5	1	Type 2	3.4	7.17

The CNV type and the size of the lesion (greatest linear diameter and surface area) were evaluated with the Heidelberg retinal angiograph. CNV, choroidal neovascularization; F, female; L, left; M, male; R, right; VA, visual acuity.

The aim of the current study was to examine the oculomotor behavior of people with AMD while they accomplished natural actions. To this end, participants with AMD and normally sighted age-matched controls were asked to perform two tasks while their eye movements were recorded: a daily life sandwich-making task that we will call "familiar" because it is likely accomplished every day, and a less familiar task of model building. In both tasks, the scene contained relevant and irrelevant objects.

Studies of natural actions in normally sighted observers have examined a range of activities, including making tea or a sandwich, playing cricket, building models, and navigation.[13–17] The central findings of these studies include the following: fixations are tightly linked to the performance of the task; gaze is directed to locations that are not the most salient but that are relevant for the immediate task demands; participants exhibit regular, quite stereotyped fixation sequences as they accomplish the task; and very few irrelevant areas or objects are fixated, regardless of their saliency (see Ref. 18 for a review).

As most tasks are normally accomplished with central vision, the presence of a central scotoma should be detrimental in both tasks. However, we expected that the difficulties experienced by participants with low vision would be amplified in the less familiar task (model building) as building a model with nuts and bolts is less automatic than putting butter and jelly on a loaf of bread and because the model-building task is more demanding in terms of discriminability, as it involves the selection of small items within structurally similar objects.

Methods

Participants

Patients. Sixteen participants with neovascular AMD (9 women; mean age: 80.2 years; SD: 8.1 years) and 16 age-matched normally sighted controls (11 women; mean age: 67.8 years; SD: 7 years) were included in the study. Both the participants with AMD and the elderly controls were recruited from the Department of Ophthalmology of Saint Vincent de Paul Hospital (Lille, France).

Participants with neovascular AMD, with subfoveal involvement confirmed by fluorescein angiography, and with best-corrected visual acuity (BCVA) between 20/40 and 20/400 were included. They were followed and treated with ranibizumab (4 mg/0.05 mL) on a pro renata regimen and were included after the loading phase. Best-corrected visual acuity was measured at a distance of 4 m using the Early Treatment Diabetic Retinopathy Study chart, and the corresponding logMAR visual acuity was used for statistical purposes. The area of the lesion (mm^2) and the greatest linear diameter of the lesion were measured from digital angiograms by outlining the lesion using image analysis software (Eye Explorer; Heidelberg Engineering, Heidelberg, Germany).[19,20] As the pathology was asymmetrical, the participants performed the tasks monocularly. In cases of bilateral AMD, we considered the eye with the BCVA. If both eyes had equal acuity, one eye was randomly selected. Detailed clinical data (duration of AMD, type of choroidal neovascularization, and size of the lesion) are provided in Table 1.

Controls. Sixteen healthy controls took part in the experiment. The controls were either relatives of the participants with AMD or people who had successful cataract surgery, with corrected visual acuity. The controls were tested monocularly on their preferred eye. The group characteristics are summarized in Table 2. Both the controls and the participants with AMD had an eye patched (the eye with the lower acuity for patients).

A Mini Mental State Examination (MMSE) was administered to check for cognitive impairments in both of the groups. Participants with a history of neurologic disease, psychiatric disease, cognitive impairment (MMSE $<$ 25), or other significant ocular diseases that might compromise oculomotor function were excluded. A physical therapist tested the participants for normal motion of the right arm and hand. All of the participants were right-handed. The study was approved by the ethics committee of Lille. In accordance with the tenets of the Declaration of Helsinki, written informed consent was obtained from all of the participants.

Stimuli

Different scene layouts were built, which included task-relevant objects required to make a butter and jelly sandwich

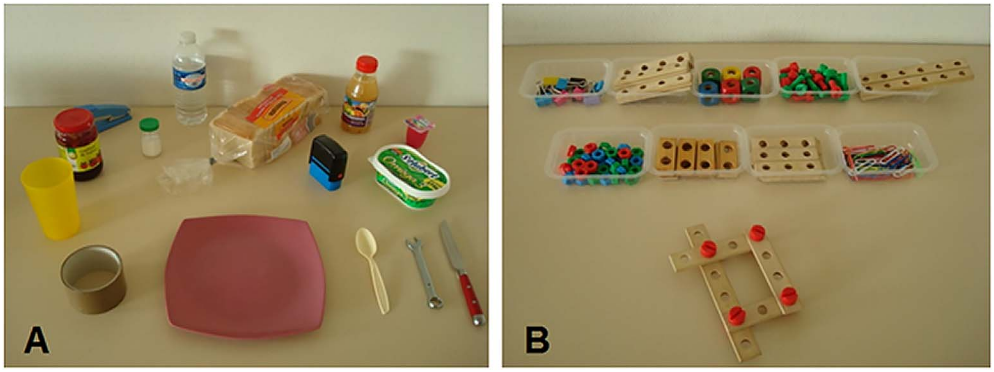

Figure 1. Examples of the two scene layouts used. (**A**) The "familiar sandwich scene" contained both task-relevant objects: bread, butter, jelly, knife, plate, glass, and water bottle; and irrelevant objects: spoon, tool, yogurt, Scotch tape, stapler, fruit juice, salt, and inkpad. (**B**) The "unfamiliar construction set scene" contained both task-ROs: model pieces, screws, and nuts; and IOs: two other pieces from the construction set that were not part of the model, and two different types of paperclips.

and to pour a glass of water as well as task-irrelevant objects. All of the objects were laid out on a table (Fig. 1A). When the participant was seated at the table, with all of the objects within reach, the plate close to the observer subtended approximately 20° of visual angle, and the butter and jelly subtended approximately 7°. All of the objects were located within a region covering 90° of visual angle. A display model and several pieces from a child's construction set were located in containers situated on another table (Fig. 1B). A total of nine plastic containers were put on the table in front of the participant. Three containers held the model pieces that had to be manipulated, one contained screws, one contained nuts, and four contained distractor pieces. All of the containers were within reach of the participant.

Equipment

Monocular (right or left) eye position was monitored using the iViewXTM HED (SensoMotoric Instruments (SMI), Teltow, Germany) eye tracker with a scene camera. This video-based eye tracker is head-mounted, using infrared reflection to provide an eye-in-head signal at a sampling rate of 50 Hz. The SMI eye tracker has a reported spatial accuracy of greater than 1°. Calibration, drift correction, and validation were performed using the algorithms provided by the instrument. The scene camera mounted on the head was positioned so that its field of view was approximately centered with the observer's line of sight. Calibration was performed using a 5-point grid. Despite the central acuity loss of the participants, they were able to reliably direct their gaze to the large, high-contrast black disks used for the calibration, and after calibration, they were able to closely follow the experimenter's finger as she pointed to each disk, thus confirming the accuracy of the calibration. Following calibration, the eye tracker creates a cursor, indicating eye-in-head position, that is merged with the video from the scene camera. The scene camera moves with the head, so the eye-in-head signal indicates the direction of gaze with respect to the world. The eye tracker thus provides a video record of eye position from the participant's perspective on the scene. The video records were analyzed on a frame-by-frame basis. The analysis considered the fixation locations of the participants in regions of interest within the scenes. Key features (i.e., the objects useful to accomplish the task) were manually marked out on each image trial using the software BeGaze (SMI, Teltow, Germany). For example, the key features for the sandwich task were the knife, bread, butter, jelly, glass, plate and bottle of water. The time of initiation and termination of each eye and hand movement, the locations of fixation, and saccades were recorded.

Procedure

The participants performed two active-viewing tasks: making a butter and jelly sandwich and pouring a glass of water (called the familiar task); and taking four wooden slats from a child's construction set and then joining them together using screws and nuts according to a display model (called the unfamiliar task). The order of the tasks was randomized. Before each task, the layout was occluded by a white board showing the five calibration points, enabling the participants to be calibrated on the plane of the working surface. The participant had to fixate the targets (colored dots) while his or her eye positions were recorded by the system. Once the calibration was completed, the white board was removed, and the participant immediately started the task. A recalibration procedure was performed after each task. The entire session lasted approximately 30 minutes. The participants were instructed to ignore other (distractor) pieces and containers. The entire task was self-paced. Natural movement was encouraged.

Data Analysis

Two experimental conditions were tested: the familiar versus the unfamiliar task. We measured the total duration to accomplish each task, the duration of the pretask (i.e., exploration before the first action) and of the working phase, the duration of individual fixations, and the total gaze duration on specific objects or areas requiring more manipulation or longer observation (e.g., the loaf of bread in the sandwich task; the model to be reproduced and the building area in the model-building task). We also recorded the number of saccades per second, the amplitude and the duration of saccades, and the number of errors (grasping an irrelevant object). Videos of dynamic scanpaths are available in the public domain at: https://sites.google.com/site/videoslnfp/Videoshttps://sites.google.com/site/videoslnfp/Videos.

In these videos, the red cross indicates the point of fixation of the participant. The data were subjected to ANOVAs using the software STATISTICA 7.1 (Stat Soft, Inc., Tulsa, OK, USA).

Results

The controls were significantly younger than the patients ($t[15] = 4.17$, $P < 0.001$).

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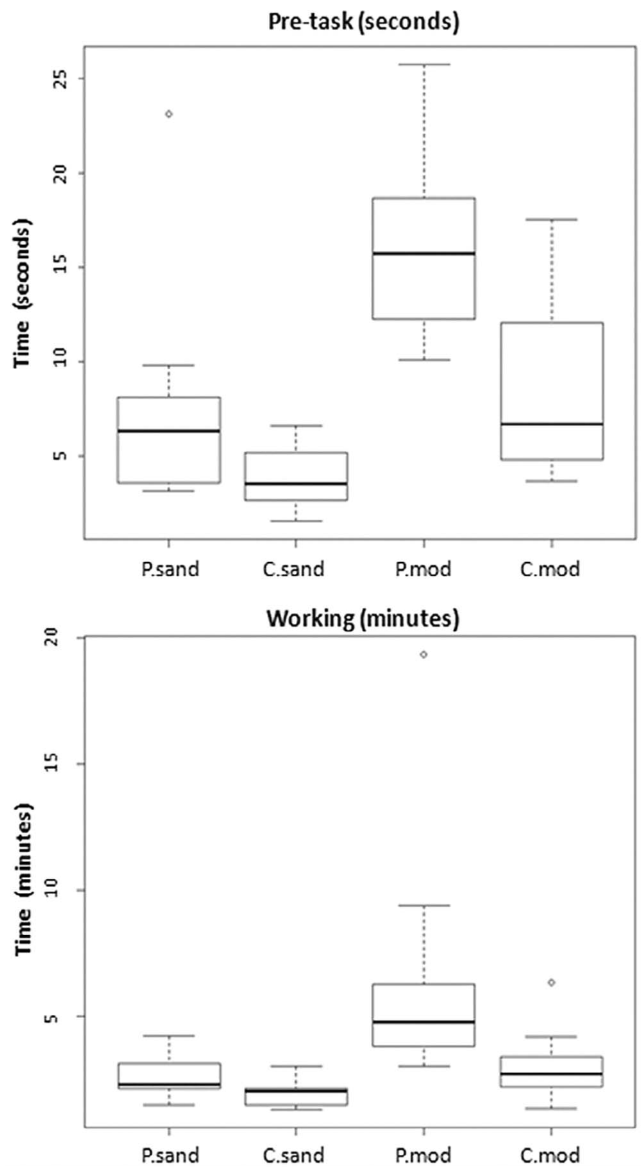


FIGURE 2. *Top*: Duration of the pretask (before the first reaching movement, in seconds). *Bottom*: Total task duration of the working phase (in minutes) for people with AMD (P) and controls (C) as a function of task. sand, sandwich-making; mod, model-building.

Total Task Duration (Pretask and Working Phase)

A 2 (group: Participants with AMD/Controls) × 2 (task: Familiar/Unfamiliar) ANOVA showed significant main effects of group (F[1,30] = 12.4, $P < 0.002$) and task (F[1,30] = 19.8, $P < 0.001$) on total task duration. There was a significant interaction between group and task (F[1,30] = 5.8, $P < 0.03$). To accomplish the familiar sandwich-making task, the participants with AMD took an average of 30 seconds (F[1,30] = 9.7, $P < 0.01$) longer than the participants of the control group (controls: 2.31 minutes [ranging from 1.34–3.02 minutes] versus participants with AMD: 3.01 minutes [ranging from 2.01–4.22 minutes]). The participants with AMD took an average of 3.28 minutes (F[1,30] = 9.3, $P < 0.01$) longer than the controls on the unfamiliar model-building task (participants with AMD: 6.35 minutes [ranging from 3.04–19.33 minutes] versus controls: 3.07 minutes [ranging from 1.36–6.34 minutes]). The participants with AMD took significantly longer on the unfamiliar task compared with the familiar task (F[1,30] = 23.4, $P < 0.001$), whereas there was no significant difference between the two tasks in the control group (F[1,30] = 2.1, P = 0.2, nonsignificant).

Pretask Duration

We also examined visual scanning after the scene was initially exposed by removing the calibration display and before the first reaching movement, which indicated that the participants had begun the task. This time period was called "pretask."

A 2 (group) × 2 (task) ANOVA showed a significant main effect of group (F[1,30] = 24.3, $P < 0.001$), a main effect of task (F[1,30] = 53.8, $P < 0.001$) and a significant interaction between group and task (F[1,30] = 6.5, $P < 0.02$). In the familiar task, the participants with AMD needed an average of 6.8 seconds, compared with 3.9 seconds in the control group (F[1,30] = 5.9, $P < 0.03$), to explore the scene before making their first move. In the unfamiliar task, the exploration time was 15.7 seconds for the participants with AMD and 8.2 seconds for the controls (F[1,30] = 48.8, $P < 0.001$). The results are presented in Figure 3.

Accuracy

Errors were recorded post hoc on the videos. We considered an error the grasping of an irrelevant object in the sandwich-making task and both the use of an irrelevant piece and a mistake when building the display model in the model-building task.

A 2 (group) × 2 (task) ANOVA showed significant main effects of group (F[1,30] = 28.5, $P < 0.001$) and task (F[1,30] = 13.2, $P < 0.002$) on the number of errors. There was a significant interaction between group and task (F[1,30] = 7.6, $P < 0.01$). The participants with AMD made significantly more mistakes than the controls in the unfamiliar task (patient mean = 4.0 errors; control mean = 0.6 errors; F[1,30] = 17.6, $P < 0.001$) but not in the familiar task [patient mean = 0.8 errors; control mean = 0.2 errors; F[1,30] = 3.0, P = 0.1, nonsignificant).

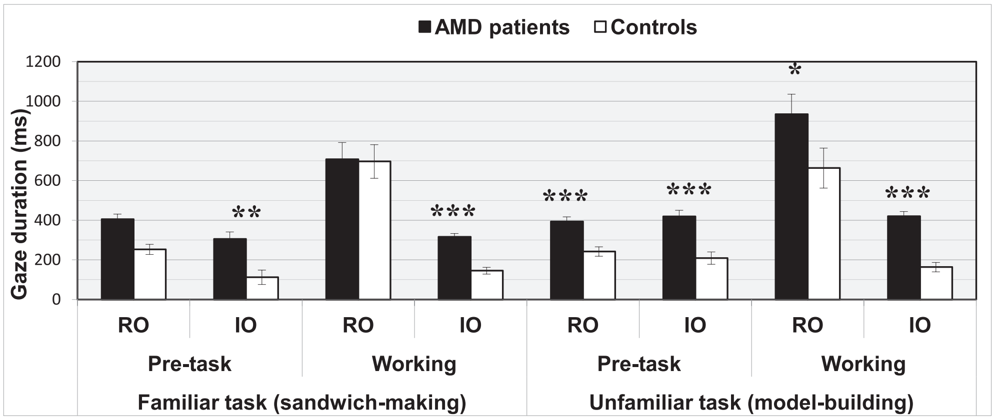
Gaze Duration on Relevant Objects (ROs) and Irrelevant Objects (IOs)

To examine visual exploration of the objects, two time periods were defined for the two tasks: the pretask (i.e. the period before the first reaching movement); and the "working" period (i.e. when the participants accomplished the task).

A 2 (group: Participants with AMD/Controls) × 2 (task: Familiar/Unfamiliar) × 2 (period: Pretask/Working phase) × 2 (objects: Relevant/Irrelevant) ANOVA, conducted on the average gaze durations, showed significant main effects of group (F[1,30] = 30.9, $P < 0.001$), task (F[1,30] = 13.4, $P < 0.001$), period (F[1,30] = 41.6, $P < 0.001$)], and objects (F[1,30] = 68.1, $P < 0.001$) on gaze duration. There was significant interaction among group, task, and period (F[1,30] = 5.6, $P < 0.03$) (Fig. 2).

Familiar Task (Sandwich Making)

In the pretask period, the gaze durations of the participants with AMD were longer than those of the controls on both relevant (405 vs. 253 ms, F[1,30] = 17.6, $P < 0.001$] and IOs (305 vs. 112 ms, F[1,30] = 14.1, $P < 0.001$). In the working phase, the participants with AMD exhibited longer gaze durations than the controls only on IOs (315 vs. 145 ms, F[1,30] = 48.3, $P < 0.001$). No difference was observed for ROs



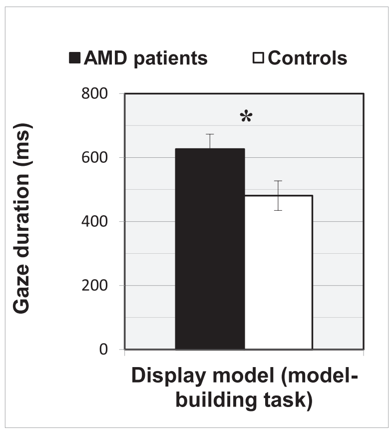


FIGURE 3. *Top*: Gaze durations for participants with AMD and controls as a function of task, period, and objects. ROs, relevant objects; IOs, irrelevant objects. *Bottom*: Gaze duration (ms) on the display model in the model-building task. *Error bars* represent SEs. *Asterisks* represent the level of significance: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

(participants with AMD: 708 versus controls: 697 ms, $F[1,30] = 0.1$, $P = 0.9$, nonsignificant].

Unfamiliar Task (Model Building)

In the pretask period, the gaze durations of the participants with AMD were longer than those of the controls on both ROs (394 vs. 242 ms, $F[1,30] = 20.3$, $P < 0.001$) and IOs (419 vs. 209 ms, $F[1,30] = 22.7$, $P < 0.001$). The same pattern was observed in the working phase, with longer gaze durations for the participants with AMD than for the controls on both ROs and IOs (935 vs. 663 ms, $F[1,30] = 3.6$, $P < 0.05$) and IOs (420 vs. 163 ms, $F[1,30] = 59.6$, $P < 0.001$).

A separate ANOVA showed that the participants with AMD had to look more at the display model than the controls to correctly accomplish the task ($F[1,30] = 4.9$, $P < 0.04$) (Fig. 3).

Saccades

On average, the number of saccades per minute of task was greater for the participants with AMD than for the controls (198.5 vs. 152.3, $F[1,30] = 9.14$, $P < 0.005$), but the duration and amplitude of the saccades were equivalent in both groups (participants with AMD: 37 ms and 12.2° versus controls: 35 ms and 10.8°, $F[1,30] = 0.72$, $P = 0.40$ for duration and $F[1,30] = 0.46$, $P = 0.50$ for amplitude). There was no main effect of task (sandwich versus model building) and no interaction between group and task.

Correlations

Correlations (Pearson) were computed between the clinical data (surface area, acuity, and linear diameter) and the experimental variables (fixation duration, duration of exploration [pretask], working phase, amplitude, duration of saccades, and number of saccades/min). Significant correlations were found between the duration of the sandwich task (working phase) and the surface area ($r = 0.62$) and the greatest diameter of the lesion ($r = 0.50$). The larger the lesion, the longer it took to accomplish the sandwich task. No significant correlation was found for the model-building task. Saccade amplitude also correlated significantly ($r = -0.52$) with the working phase of the sandwich task. Saccade amplitude decreased with an increase in working phase duration.

DISCUSSION

We investigated whether the loss of foveal vision in AMD affects the efficiency of the execution of natural actions. To this end, we examined the performance of participants with AMD in two tasks, one which is likely to be accomplished every day

Table 2. Demographic and Clinical Data of Controls

Number/Sex/Age	Tested Eye	MMSE	LogMAR VA
1/F/64	R	26	0
2/F/79	R	26	0
3/M/61	L	26	0
4/M/62	R	29	0
5/M/64	L	29	0
6/F/73	L	28	0.1
7/F/84	R	30	0
8/F/62	R	28	0
9/F/60	R	30	0
10/F/75	R	28	0.1
11/M/65	R	28	0
12/F/65	R	30	0
13/F/66	L	30	0.1
14/M/73	R	30	0.1
15/F/68	R	29	0
16/F/64	L	30	0.1

for breakfast and a less-familiar task of model building. The central findings included the following: (1) The people with impaired central vision took, on average, longer than the age-matched controls to complete the tasks, particularly the unfamiliar model-building task. The increase in time, relative to controls, was lower in the daily life sandwich task. For the sandwich task, total task duration was on average 30 seconds longer in the people with AMD compared with the controls. This cannot be explained by a longer exploration to locate ROs before starting the action, as the participants with AMD took, on average, 7 seconds longer than the controls on the pretask when performing the sandwich task. Greater impairment appeared in the unfamiliar model-building task in some of the participants with AMD (numbers 5 and 10), who needed 9.4 and even 19 minutes to complete the task. Although the exploration phase (pretask) was, on average, 16 seconds longer for the participants with AMD than for the controls, the working phase itself was much longer in the participants with AMD than in the controls, with some of them using tactile information (i.e., trying to find the holes in the wood pieces with their fingers. (2) Even though the participants with AMD needed more time to perform the tasks, they were able to accomplish these natural tasks with few mistakes, although significantly more than the controls. Only one error was observed in the AMD group in the sandwich task (a patient misidentified Scotch tape for a glass to pour water), and on average, four mistakes were made by the participants of the AMD group in the more complex model-building task, which involved small, structurally similar objects.

Like normally sighted young observers in previous studies of natural actions, both people with AMD and controls fixate ROs more than IOs.[17,18] The participants with AMD fixated both relevant and IOs longer than the controls, presumably due to their greater difficulty discriminating objects with their peripheral vision, especially when relevant and IOs were small and similar in shape, as in the model-building task. This result suggests that people with AMD take longer to extract useful information but that this can be counteracted when the task items are familiar.

The people with AMD made significantly more saccades than the controls, but the duration and amplitude of the saccades were equivalent to those of the controls. This is consistent with previous studies of visual search tasks. A greater number of saccades has been reported both in people with a central scotoma and when central scotomas are simulated in normal observers with gaze-contingent displays.[21–23] In people with central vision loss, the greater number of saccades reflects gaze instability due to the need for perception to rely on peripheral vision and, presumably, an adaptive mechanism to make the best use of preferred retinal locations (PRLs). We did not measure the PRLs of our participants, but large variation in the locations of PRLs has been reported depending on viewing conditions (e.g., a dim versus bright target), task complexity (e.g., fixate a dot versus reading versus navigation), the duration of the disease, and monocular versus binocular vision.[24–27] For instance, Sullivan et al.[28] compared the eye movement strategies of a single case with central visual field loss due to Stargardt disease with those of normally sighted observers while performing a set of natural tasks, including making a sandwich; building a model; and reaching, grasping, and catching a ball. They observed that the patient preferred to use PRLs in the lower-left visual field, but there was considerable variation in the location and extent of the PRLs used, suggesting that a well-defined PRL is not necessary to adequately perform natural tasks.

The characterization of visual impairment needs to include an assessment of the patient's ability to accomplish real-world tasks. Although limited in scope due to the relatively small group of participants, this study illustrates the feasibility of the completion of natural tasks by people with a central scotoma. Even when using a single eye, the people with AMD were able to accomplish the tasks with little impairment, only a slightly longer time (30 seconds) in the familiar task, suggesting that under unconstrained conditions, the peripheral retina may be adequate to perform a variety of tasks. Better performance may have been obtained under binocular conditions. Indeed, some studies have shown that binocular viewing improves fixation stability,[29] although performance remains lower than that of normally sighted controls even under binocular conditions.[9] In contrast to laboratory tasks in which people with central vision loss exhibit difficulties detecting a small target (e.g., Landolt rings with a gap or letters) within an array of structurally similar distracters[23] or objects or faces under limited presentation conditions,[6] this study shows that performance in active vision (i.e., when participants can make any eye and head movements) is less impacted by central vision loss.

The study has some limitations: The controls were, on average, 7 years younger than the participants with AMD. This might explain, in part, that the people with AMD were slower to perform the tasks. However, the older participants in the AMD group (numbers 3 and 9) were relatively fast even in the unfamiliar model-building task. Depth perception is an essential component of many natural activities. We did not measure depth perception in our participants. Cao and Markowitz[30] investigated the effect of residual stereopsis on vision-related abilities in people with AMD using the near Frisby stereotest. The Frisby test presents targets that are "in depth" because they are printed on the two sides of transparent plates of different thicknesses. They found that 59.3% (16/27) of the people with AMD were not able to see any stereoacuity plates, whereas 40.7% showed various levels of stereopsis. They also reported that those who retained stereopsis demonstrated Overall Functional Visual Abilities scores higher than those who did not and that stereopsis was correlated with higher ability scores for reading and visual motor skills.

In conclusion, our study shows that people with AMD are able to perform efficiently natural actions, particularly the tasks that are accomplished daily.

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