Journal of Research in Personality 46 (2012) 147–156

Contents lists available at SciVerse ScienceDirect

Journal of Research in Personality

journal homepage: www.elsevier.com/locate/jrp

# Eyes as windows to the soul: Gazing behavior is related to personality

John F. Rauthmann [*,1], Christian T. Seubert [1], Pierre Sachse, Marco R. Furtner

Leopold-Franzens University of Innsbruck, Austria

ARTICLE INFO

Article history:
Available online 28 December 2011

Keywords:
Eye movements
Personality
Traits
Big Five
BIS/BAS
Eye-tracking

ABSTRACT

Gazing is a fundamental human behavior with important cognitive, affective, motivational, and social underpinnings that is likely to have produced individual differences linking it to major personality traits. If traits play a substantial role in gazing, they should predict eye movement parameters above and beyond stimuli without meaningful and topical information. The current eye-tracking study ($N = 242$) demonstrated with linear mixed models that personality (Big Five, Behavioral Inhibition System/Behavioral Activation System) predicts number of fixations, mean fixation duration, and dwelling time in two different abstract animations. Specifically, neuroticism, extraversion, openness, and the Behavioral Activation System were related to eye movement parameters. Prospective research in studying links between dispositions and gazing is discussed.



## 1. Introduction

According to a popular proverb, "eyes are the window of/to the soul."[2] And, indeed, people have long pondered whether there is something in our eyes indicative of character. For example, someone often socializing would naturally be called "extraverted," but could we also deduce extraversion from how someone gazes? Behaviors are core features of traits, personality manifests at different levels of behavior, and gazing is an essential human behavior. The current work examines associations among traits and eye movements to gain new insights on whether and how dispositional variables manifest in oculomotor behavior.

### 1.1. Links between personality and gazing

Gazing behavior can (and should) be linked to personality for several reasons. First, individual differences manifest on molar and molecular levels of behavior (Furr, 2009). Fleeson and Noftle (2008a) point out that there is only "very little knowledge about how personality is present in behavior and about what behaviors are relevant to personality," which is "partly because of the difficulty in specifying the level at which behavior should be studied" (pp. 1668/1679). This problem in identifying personality-relevant behaviors is also crucial for other psychological disciplines such as social and experimental psychology which tend to consider possibly important individual differences only to a minor degree. Attention should also be given to individual differences in micro-behaviors such as eye movements.

Second, gazing serves important social, motivational, cognitive, and regulatory functions. Eye contact is essential in our daily lives: it is related to personality (Libby & Yaklevich, 1973) and we make inferences about people based on their eye contact (Brooks, Church, & Fraser, 1986). Gazing is used to track others' behaviors (Matsumoto, Shibata, Seiji, Mori, & Shioe, 2010) and to communicate. It is also linked to motives and motivation (e.g., Furtner, Martini, & Sachse, 2011; Terburg, Hooiveld, Aarts, Kenemans, & van Honk, 2011), wishes, and preferences as it is directed toward goal-consistent and averted from goal-inconsistent stimuli to achieve and maintain good mood (Balcetis & Dunning, 2006; Isaacowitz, 2006). Eye movements can also be used for perceptual-cognitive performance tasks (e.g., Haley, 1971; Iacono & Lykken, 1979) because they are indicative of early visual attention processes guided by preconscious mechanisms (Terburg et al., 2011; Wilkowski, Robinson, Gordon, & Troop-Gordon, 2007). Moreover, precise eye-hand coordination is an important feat in humans (Furtner & Sachse, 2008).

Third, stimulus material substantially influences eye movement parameters such as fixation rates (Land, 2007), but participants nonetheless tend to show stable eye movement patterns (across different stimuli/occasions) *and* differ in those from others (Etaugh, 1972; Etaugh & Rose, 1973; Furtner, 2006). This implies an underlying neurobiological system influencing oculomotor (re-)activity, which is linked to personality (Canli, 2006).

Fourth, eye movements have already been linked to personality. Kaspar and König (2011) found that interindividual differences in personality and motivation influence attention processes in gazing, and personality psychopathology has also been related to eye

* Corresponding author. Address: Department of Psychology, Leopold-Franzens University of Innsbruck, Innrain 52, A-6020 Innsbruck, Austria.

*E-mail address:* jfrauthmann@gmail.com (J.F. Rauthmann).

[1] These authors have equally contributed to this work and thus share the first authorship.

[2] It can be traced back to the Latin proverbial phrase "oculus animi index" (engl. the eye is the soul's window/mirror).

0092-6566/$ - see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.jrp.2011.12.010

movements (Ceballos & Bauer, 2004; Iacono & Lykken, 1979; Siever, 1982; Siever et al., 1990; Thaker, Cassady, Adami, Moran, & Ross, 1996). Also, lateral eye movements (averting the gaze while thinking; Day, 1970; Etaugh, 1972; Etaugh & Rose, 1973) and attentional preferences in selective attention during early visual processing have been linked to circumscribed personality dimensions (optimism: Isaacowitz, 2005; trait anger: Wilkowski et al., 2007).

In summary, previous research suggests that personality influences visual information processing, social gazing, and where we gaze when making sense of (ambiguous) pictures. However, there are limitations to this research. First, not all studies were able to use sophisticated eye-tracking methodology, which provides objective and quantifiable behavioral data. Second, rather small sample sizes were used which present difficulties in detecting small effects. Effect sizes in trait – eye movement relations ought to be in the range of $r = |.05 - .30|$, which can be deemed common and realistic when broad, self-rated traits are related to narrowly defined, objective behavioral data on a micro-level (Vazire & Carlson, 2010). To demonstrate such effects, usually larger sample sizes ($N > 150$) are needed. Third, many studies do not focus on sub-clinical traits, and if they do, only on very specific ones (cf. Isaacowitz, 2005; Terburg et al., 2011; Wilkowski et al., 2007) which does not allow a bigger picture on trait – eye movement relations. Lastly and most importantly, it remains unexplored whether dispositional variables are also related to the "*how*" of gazing (e.g., more fixations), not just the "*where*" (e.g., fixating a car). Personality effects in the absence of meaningful stimuli with semantic or topical information would provide compelling evidence that traits are linked to gazing. The current study is a first endeavor in demonstrating such effects.

### 1.2. The Big Five and gazing

The broad Big Five traits (neuroticism, extraversion/surgency, openness/intellect/fantasy/culture, agreeableness, conscientiousness) were used for several reasons. First, the structural and descriptive five factor model of personality is a widely acknowledged, integrative taxonomy of most human individual differences categories that are important, meaningful, and consequential (Costa & McCrae, 1992; John & Srivastava, 1999).

Second, the Big Five have a biological basis (Angleitner & Ostendorf, 1994; Buss & Plomin, 1975; DeYoung & Gray, 2009). Indeed, each of Cloninger's temperament and character factors[3] (Cloninger, Svrakic, & Przybeck, 1993) is substantially covered by the Big Five traits due to considerable construct overlap (de Fruyt, van de Wiele, & van Heeringen, 2000). Extraversion (linked to positive affect and activation) and Neuroticism (linked to negative affect and affective intensity) are considered strongly biologically determined (MacDonald, 1995; Rothbart & Derryberry, 1981; Yik & Russell, 2001). Agreeableness and conscientiousness may be traced back to effortful control, a super-ordinate regulatory system (Jensen-Campbell et al., 2002). The biological basis and associations with affect and activation may link the Big Five traits to eye movements.

Third, there is already empirical evidence that some of the Big Five can be linked to gazing. Openness has been linked to eye fixation points (Matsumoto et al., 2010), and extraversion to performance on anti-saccade tasks (Nguyen, Mattingley, & Abel, 2008) and spontaneous eye movements such as blinking rates (Franks, 1963). However, no study so far has linked the entire Big Five traits at once to eye movements.

### 1.3. BIS/BAS and gazing

The Behavioral Inhibition System (BIS), regulating sensitivity to punishment and avoidance behavior, and the Behavioral Approach/Activation System (BAS), regulating sensitivity to reward and approach behavior (Carver & White, 1994; Corr, 2008; Gray, 1987, 1990, 1991), can also be tied to eye movements. The BIS/BAS is rooted in Grays's Reward Sensitivity Theory (1982, 1991), which has been revised in the meanwhile. The BIS can be seen as a basis for anxiety (Gray & McNaughton, 2000) and the BAS for reward sensitivity/approach and impulsivity (Gray, 1991). First, BIS/BAS are considered neurobiological underpinnings of affective and motivational systems (Cloninger et al., 1993; Gray, 1991). Second, BIS/BAS can be linked to psychopathology (Scholten, van Honk, Aleman, & Kahn, 2006), which is known to influence oculomotor behavior (e.g., Iacono & Lykken, 1979). Third, BIS and BAS can be linked to the Big Five: consistent findings for relationships with neuroticism (for BIS) and extraversion (for BAS) are found (Keiser & Ross, 2011; Smits & Boeck, 2006). If the Big Five are associated with eye movements, then BIS and BAS should also be associated given their conceptualization in literature and empirical relations with the Big Five.

### 1.4. Eye-tracking methodology

Because not all readers may be familiar with eye-tracking methodology, we provide brief information on eye movement analyses. For more detailed introductions, see, for example, Duchowsky (2007). Visual perception relies on sequences of information input via complex patterns of eye, head, and body movements (Furtner & Sachse, 2008). High-resolution visual information input occurs only at so-called fixation points which are fixated with the fovea (the central point of highest visual resolution in the retina) (Posner, 1980, 1995). Saccades lie between fixations and entail a passive suppression of visual information processing during which visual perception is strongly reduced for about 50–80 ms. Eye movements can be recorded and analyzed with two basic types of eye-trackers: remote or table-mounted and head-mounted systems. Remote systems are usually affixed to a table with video cameras and infrared lights (Furtner, Rauthmann, & Sachse, 2009; Goldberg & Wichansky, 2003; Jacob & Karn, 2003), whereas head-mounted systems are worn on the head (Duchowsky, 2007). Data recording is usually carried out with the pupil center corneal reflection method (Ohno, Mukawa, & Yoshikawa, 2002) where the eyes' position and direction of movement is related to a vector (visual axis) spanning from the corneal reflection (Purkinje reflection), captured with infrared light, to the center of the pupil. There are many different eye movement parameters (e.g., saccade duration, saccadic velocity, saccadic acceleration, saccadic amplitude, smooth pursuits, fixation duration, number of fixations, gaze duration, dwelling time; see Joos, Rötting, & Velichkovsky, 2003), but a meta-analysis has shown that the three most widely used eye movement parameters are number of fixations, mean fixation duration, and dwelling time (Jacob & Karn, 2003; see also Joos et al., 2003), which all refer to fixations and can be sampled with the pupil center corneal reflection method (Ohno & Mukawa, 2004). In the current study, we also utilize a table-mounted eye-tracker with pupil center corneal reflection method to capture eye movement parameters.

## 2. The current study

The current work aims at showing that dispositional variables are linked – even in the absence of any semantic or topical

[3] It should be noted that most so-called "temperamental" factors are now also referred to as "personality." In this study, we do not delve into discussion about (possible) distinctions between terms of "personality", "temperament", and "character." Rather, we refer to any dispositional variable that describes moderately stable, enduring characteristics of a person with considerably broad bandwidth in the perceptual-cognitive, affective, motivational, behavioral, and social domain as "personality."

stimulus information – to three most commonly used indices of gazing behavior (number of fixations, mean fixation duration, dwelling time; see Duchowsky, 2007; Jacob & Karn, 2003) across two very different non-meaningful, abstract stimuli to control for possible co-effects of topical and semantic sense, content and context saliency, memory, lifestyle, preferences, and interests. First, we investigated main effects of personality on gazing, distinct from any matching to the type of stimulus involved. This provides a very rigorous examination of whether dispositional variables are manifest in gazing behavior. It was hypothesized that the Big Five and BIS/BAS would predict eye movement parameters above and beyond variation of stimulus material which would make a strong case for the influence of traits on gazing behavior. Second, we also explored interaction effects of condition by personality traits.

Effects can be specified in presence, magnitude, and direction. Given empirical literature, presence of effects was expected at least for extraversion (e.g., Franks, 1963; Nguyen et al., 2008) and openness (e.g., Matsumoto et al., 2010), but also for neuroticism and BIS/BAS given their strong affective-motivational conceptualizations. Nonetheless, we explore presence of effects for the entire Big Five. Magnitude of effects was expected to be no higher than |.35|, which is a typical finding when relating broad trait domains to narrowly defined, unaggregated behavioral criteria (e.g., Back, Schmukle, & Egloff, 2009; Vazire & Carlson, 2010). Specific directions of effects were not a priori hypothesized and are thus explored here for the first time as it could not be extrapolated from existing literature which traits should be positively and which negatively associated with which eye movement parameters. The current study thus expands existing literature in establishing novel findings on the presence, magnitude, and direction of trait effects on commonly used eye movement parameters.

## 3. Method

### 3.1. Participants

Two hundred and forty-two students, 172 women and 70 men, with a median age of 22 years (range: 18–46 years) and normal or corrected-to-normal vision (glasses and contact lenses) were examined and earned credit points for participating. They were not required to fill out written consent forms, but we obtained verbal consent after explaining the steps of the study and what would be expected.

### 3.2. Procedure

Participants were welcomed to our lab and told that they would participate in a study examining ''personality and information processing.'' After informing participants by explaining the procedures of the study (eye-tracking and filling out questionnaires), we obtained verbal consent of the participants. Then, participants were seated in front of the table-mounted eye-tracking system which was calibrated to be approximately 23 in. away from participants' faces. After successful calibration of the eye-tracking system to participants' eye movement patterns, participants were instructed to watch the PC screen and try not move (to avoid decalibration of the table-mounted eye-tracker), and stimulus presentation began. The two animations were shown in randomized order and with a filler task[4] screen in between (Fig. 1): each trial commenced with a centrally presented fixation cross (10 s), followed by either Animation Red or Blue (60 s), another fixation cross (10 s), and then either Animation Blue or Red (60 s). Illumination was kept constant in the laboratory setting across all participants. Participants were subsequently administered the personality questionnaires. Time to first fixation,[5] number of fixations, mean fixation duration, dwelling time, and the Big Five were sampled; for a sub-sample of $n = 89$ BIS/BAS scales were additionally sampled.

### 3.3. Apparatus: table-mounted eye-tracker

A Pentium IV computer with a graphics card NVIDIA GeForce 4 MX 4000 was used, displaying animations on a 17-in. computer monitor (View Sonic VG700b) with a display refresh rate of 75 Hz in Windows Media Player (fullscreen). Eye movements were recorded with a frequency of $2 \times 60$ Hz by two binocular cameras positioned beneath the computer display and with 0.4° accuracy. NYAN 2.0 software from Interactive Minds Dresden (IMD) was used for the table-mounted Eyegaze Analysis System from LC Technologies Inc., which allowed registering, recording, and analyzing participants' fixations (minimum duration: 100 ms). The four eye movement parameters time to first fixation[5], absolute number of fixations, mean fixation duration (in ms), and dwelling time (total time of all fixation durations in ms) can be directly sampled (the software did not allow for the direct sampling of any saccadic variables, though) with the pupil center corneal reflection method. Two observation monitors allowed watching both eyes separately through input from the two binocular cameras beneath the monitor while in the process of eye-tracking in order to correct the sitting posture of participants to recalibrate during recording if necessary (Fig. 2). Calibrations regarding fixations were accepted if fixation accuracy showed an average drifting error of maximally 0.25 in. or smaller. The average drifting error was 0.12 in.

### 3.4. Stimulus material: Animation Red versus Animation Blue

Two different animations were selected to be in maximum contrast to each other on several dimensions (e.g., color, forms, movements, velocity; cf. Furtner, 2006). Their specific characteristics are summarized in Table 1. The animations were programmed by programers of the University of Zurich in C++ without external software. They rely on cellular automata comprised of a number of different species (cells) that change their state over time according to their current state and the state of neighboring species. The species were assigned different colors, and cellular automata were programmed to run some thousand steps.

*Animation Red* had fast and jerky movements across the whole screen, a mix of different colors (red: 0x7D2926; yellow: 0xE2D468; blue: 0x4B88C9; black: 0x12110F),[6] and edgy forms (Fig. 3, first row). It had several sections that differed in position, velocity, movements, and color of object patterns (01–08 s: patterns edging towards the observer; 08–16 s: blinking patterns edging fast towards the observer; 16–34 s: fast vertical movements of patterns from left to right; 34–45.4 s: patterns edging towards the observer with changes in yellow and red of objects; 45.4–60 s: vertically positioned objects steadily increasing in size). It was to provoke more fixations with shorter fixation durations and dwelling time. *Animation Blue* had slow and smooth movements of white dots swirling around in the middle of the screen on a blue background (dark blue:

[4] According to Sundar et al. (2001), fast movements (such as in Animation Red) induce higher levels of physiological activation in perceivers. This, again, may entail a higher number of fixations even in subsequent, slower animations. Thus, it is necessary to implement filler tasks (for example, a fixation cross for about 10 s).

[5] Time to first fixation was also sampled (for $n = 104$ participants), but apart from finding no effects of traits on this eye movement parameter, this parameter makes no sense in stimuli with non-topical information. If used at all, it should be used in pictures with topical information. However, it has also been proposed to eliminate the first 1–3 fixations even within pictures (e.g., Joos et al., 2003), thus rendering time to first fixation almost completely irrelevant. As a consequence, we therefore do not report any findings on time to first fixation.

[6] Color codes are reported in the hexadecimal (base 16) number system widely used in programming languages. It can also be easily converted into the RGB metric.

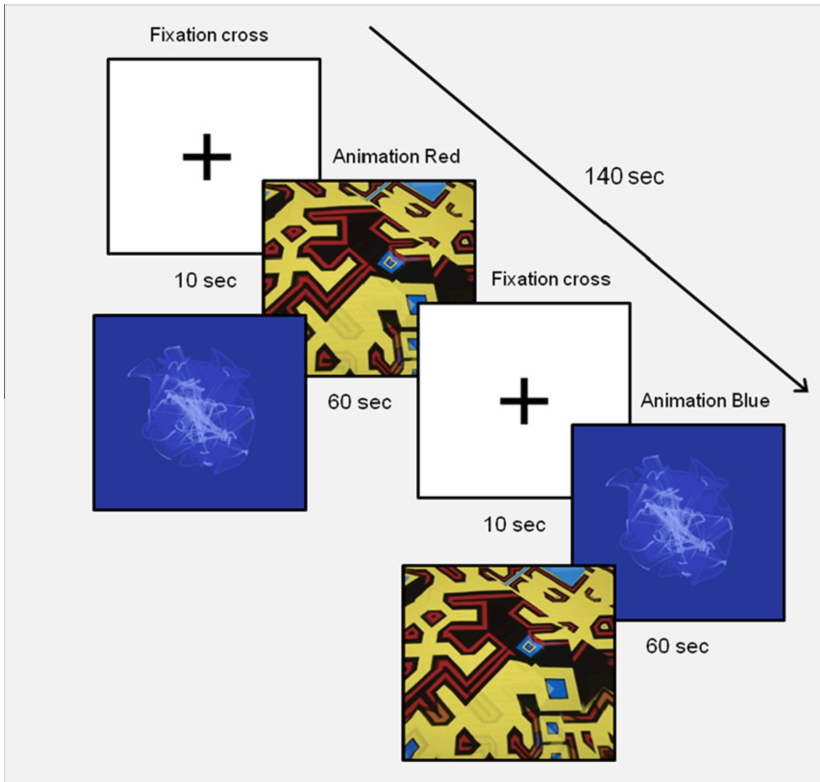


**Fig. 1.** Illustration of the sequential presentation of stimuli within the study.

**Fig. 2.** Table-mounted eye-tracking system.

0x2E3A90; blue: 0x3A46AC; light blue: 0x9FABF2)[6] (Fig. 3, second row). It was to provoke fewer fixations with longer fixation durations and dwelling time. Quick movements of objects, as in Animation Red, are known to elicit activation (Mikunda, 2002), whereas slow and small movements, as in Animation Blue, tend to elicit deactivation (Schwender, 2001). This allowed us to devise two animations with diametric effects on observers (Sundar, Kalyanaraman, Martin, & Wagner, 2001).

### 3.5. Measures

#### 3.5.1. Big Five

The Big Five traits (neuroticism, extraversion, openness, agreeableness, conscientiousness) were assessed with the NEO-FFI (original: Costa & McCrae, 1992; German version: Borkenau & Ostendorf, 1993) with 60 items (12 items per scale) on a five-point Likert-type scale (0 *strongly disagree* – 4 *strongly agree*) and means across items were computed. Item language was German.

#### 3.5.2. BIS/BAS

BIS (sensitivity and reactions to the anticipation of punishment: e.g., "If I think something unpleasant is going to happen, I usually get pretty 'worked up'"), BAS Drive (persistent pursuit of desired

**Table 1**
Synopsis of characteristics of Animation Red and Blue.

| Dimension | Animation Red | Animation Blue |
|---|---|---|
| Colors | Red, yellow, blue, orange, black | Blue, white |
| Brightness, intensity | Bright and intense color | Darker and "soft" colors |
| Saturation | Different saturation levels | Monochromic planes with consistent saturation |
| Objects, forms | Polygons and complex patterns that constantly changed | Circles and dots that did not change |
| Texture | Abrasive surface | Soft, smooth surface |
| Perspective, penetration | Differences in size and perspectives of moving objects | Almost no differences in size between objects |
| Position of objects | Vertical movements from right to left | Horizontal, centered positions |
| Movements | Quick, erratic, jerky | Slow, orbital, smooth |

Animations Red and Blue can be seen in Figs. 1 and 2.

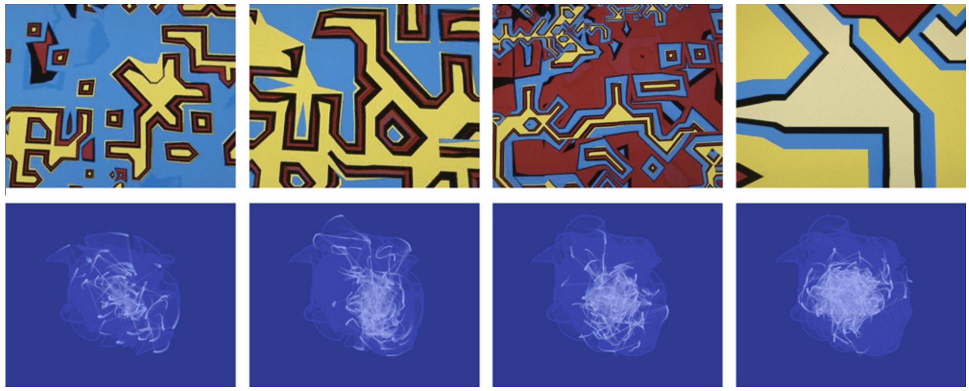

**Fig. 3.** Stimulus material: Animation Red (upper row) and Animation Blue (lower row). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

goals: e.g., ‘‘I go out of my way to get things I want’’), BAS Reward Responsiveness (positive responses to and anticipation of rewards: e.g., ‘‘When I get something I want, I feel excited and energized’’), and BAS Fun-Seeking (desire for novel rewards and their approaching in the spur of the moment: e.g., ‘‘I crave excitement and new sensations’’) were assessed with the BIS/BAS Scale (original: Carver & White, 1994; German version: Strobel, Beauducel, Debener, & Brocke, 2001), comprising 20 items to be rated on a four-point Likert-type scale (0 *strongly disagree* – 3 *strongly agree*). Means across items were computed to form the scales. Item language was German.

### 3.6. Statistical analyses

To estimate what dispositional variables predict above and beyond condition variation (Animation Red vs. Blue), linear mixed modeling (LMM) was employed. LMM allows modeling of hierarchical data, such as measurements (conditions) nested within persons. When data is collected at different levels, this case can be addressed with classical regression techniques by either treating the data as unrelated to within-group processes (effectively ignoring this information: complete pooling) or by computing separate models for each group (restoring group-specific information, but lacking an aggregate model: no pooling). LMM, in contrast, incorporates data collected at different levels into one comprehensive model, while also yielding reasonable estimates for each level. This is accomplished by balancing the information obtained from processes within *and* between levels (partial pooling; Snijders & Bosker, 1999). In the baseline model, eye movement parameters (number of fixations, mean fixation duration, dwelling time) were predicted from effect-coded condition. The comparison model, then, included dispositional variables (Big Five; BIS/BAS scales) at level 2 (individual level) while controlling for condition (Animation Red vs. Blue) at level 1 (measurements level). Thus, the ‘‘pure’’ effect of personality traits on eye movement parameters, controlling for stimulus variation as well as cross-level personality × stimulus interactions, can be obtained. Intercepts and/or slopes were allowed to vary randomly across individuals. Equations for the models can be found in Table 2. Model comparisons by means of Log-Likelihood (*LR*) indicate whether dispositional variables can significantly reduce prediction error (measured in $R^2$; Luke, 2004; Snijders & Bosker, 1999) over and above condition. All LMM analyses were computed in GNU R (R Development Core Team, 2011) with the nlme package (Pinheiro & Bates, 2000).[7]

[7] The pattern of LMM findings was additionally compared to the pattern of findings obtained from generalized linear models and ordinary least squares regressions. Effects were robust and very similar across these methods.

**Table 2**
Prototypical equations used in linear mixed model analyses.

| | |
|---|---|
| *Random intercept-only model* | |
| Level 1 | $Y_{ij} = \beta_{0j} + \beta_{1j}\,(\text{condition})_{ij} + r_{ij}$ |
| Level 2 | $\beta_{0j} = \gamma_{00} + \gamma_{01}\,(N)_j + \gamma_{02}\,(E)_j + \gamma_{03}\,(O)_j + \gamma_{04}\,(A)_j + \gamma_{05}\,(C)_j + u_{0j}$ |
| | $\beta_{1j} = \gamma_{10} + \gamma_{11}\,(N)_j + \gamma_{12}\,(E)_j + \gamma_{13}\,(O)_j + \gamma_{14}\,(A)_j + \gamma_{15}\,(C)_j$ |
| *Random slopes and intercept model* | |
| Level 1 | $Y_{ij} = \beta_{0j} + \beta_{1j}\,(\text{condition})_{ij} + r_{ij}$ |
| Level 2 | $\beta_{0j} = \gamma_{00} + \gamma_{01}\,(N)_j + \gamma_{02}\,(E)_j + \gamma_{03}\,(O)_j + \gamma_{04}\,(A)_j + \gamma_{05}\,(C)_j + u_{0j}$ |
| | $\beta_{1j} = \gamma_{10} + \gamma_{11}\,(N)_j + \gamma_{12}\,(E)_j + \gamma_{13}\,(O)_j + \gamma_{14}\,(A)_j + \gamma_{15}\,(C)_j + u_{1j}$ |

*Y* = dependent variable (number of fixations, mean fixation duration, dwelling time).
*N* = neuroticism, *E* = extraversion, *O* = openness, *A* = agreeableness, *C* = conscientiousness.
Subscripts denominate measurement occasions *i* and individuals *j*.
Main effects are obtained by modeling level 1 intercept ($\beta_{0j}$) as a function of level 2 dispositional variables, whereas cross-level interactions are obtained by modeling slope ($\beta_{1j}$) of condition as a function of level 2 dispositional variables.
Models for BIS/BAS variables are constructed accordingly by substituting Big Five measures for BIS/BAS measures.

## 4. Results

### 4.1. Descriptive statistics

Descriptive statistics for eye movement parameters (*M*, *SD*) and traits (*M*, *SD*, $\alpha$) can be found in Table 3. Intercorrelations (bivariate zero-order Pearson correlations) among all variables can be found in Table 4. Findings on the bivariate correlation level may still contain spurious effects, likely enhancing type I errors. Thus, LMM was used to further analyze the data because a multi-level approach is conceptually superior regarding our data structure.

Compared to random intercept-only models, random slopes and intercept models provided superior fit for number of fixations [Big Five models: $LR(2) = 80.11$, $p < .001$; BIS/BAS models: $LR(2) = 6.20$, $p = .045$] and mean fixation duration [Big Five models: $LR(2) = 214.91$, $p < .001$; BIS/BAS models: $LR(2) = 22.06$, $p < .001$], but they did not for dwelling time [Big Five models: $LR(2) = 1.29$, $p = .526$; BIS/BAS models: $LR(2) = 0.16$, $p = .921$]. Consequently, the more parsimonious random intercept-only model was deemed more appropriate for dwelling time. As there is no a priori theory to guide us whether random intercept-only or random slopes and intercept models are conceptually superior for trait – eye movements links, we opted to use the method that fit the data better in each case.

### 4.2. Condition main effects

As expected and frequently found in eye-tracking studies, we found main effects for condition on eye movement parameters

**Table 3**
Descriptive statistics for eye movement parameters and trait scales.

| Variables | *M* | *SD* | α |
|---|---|---|---|
| *Eye movements over both animations* | | | |
| Number of fixations | 155.31 | 56.93 | |
| Mean fixation duration | 241.92 | 137.35 | |
| Dwelling time | 35,714.63 | 17,088.15 | |
| *Eye movements in Animation Red* | | | |
| Number of fixations | 177.01 | 64.19 | |
| Mean fixation duration | 187.37 | 76.82 | |
| Dwelling time | 33678.12 | 16786.75 | |
| *Eye movements in Animation Blue* | | | |
| Number of fixations | 133.61 | 37.82 | |
| Mean fixation duration | 296.48 | 161.03 | |
| Dwelling time | 37751.15 | 17178.39 | |
| *Personality (Big Five)* | | | |
| Neuroticism | 1.72 | 0.65 | .83 |
| Extraversion | 2.55 | 0.60 | .81 |
| Openness | 2.82 | 0.50 | .78 |
| Agreeableness | 2.73 | 0.46 | .77 |
| Conscientiousness | 2.66 | 0.61 | .79 |
| *Temperament (BIS/BAS)*[a] | | | |
| BIS | 1.76 | 0.51 | .81 |
| BAS Drive | 1.95 | 0.56 | .75 |
| BAS Reward Responsiveness | 2.17 | 0.46 | .76 |
| BAS Fun-Seeking | 2.04 | 0.58 | .75 |

*N* = 242.
Eye movement parameters mean fixation duration and dwelling time are given in ms. Number of fixations reflect absolute numbers of fixations.
[a] *n* = 89.

(Big Five models: $\gamma = -.38$, $p < .001$ for number of fixations; $\gamma = .40$, $p < .001$ for mean fixation duration; $\gamma = -.12$, $p = .058$; BIS/BAS models: $\gamma = -.33$, $p < .005$ for number of fixations; $\gamma = .23$, $p < .06$ for mean fixation duration; $\gamma = -.02$, $p = .811$). Differences between Animation Red and Blue were in line with the gazing behavior the animations should evoke (see descriptive statistics of eye movement parameters broken down for animation in Table 3): Animation Red produced more fixations, smaller fixation durations, and less dwelling time than Animation Blue. Further, the relatively high correlations between eye movement parameters in different conditions (see Table 4) indicate consistency in gazing behavior.

### 4.3. Personality main effects

LMM findings for Big Five traits in level 2 can be found in Table 5. Big Five variables were able to significantly reduce prediction error above and beyond condition for number of fixations [$R^2 = .004$, $LR(10) = 32.18$, $p < .001$], for mean fixation duration [$R^2 = .04$, $LR(10) = 37.12$, $p < .001$], and dwelling time [$R^2 = .03$, $LR(10) = 43.07$, $p < .001$]. Level 2 main effects were only found for neuroticism, extraversion, and openness. Specifically, neuroticism manifested marginally significantly longer mean fixation durations ($\gamma = .11$, $p = .051$) and dwelling time ($\gamma = .12$, $p = .071$), extraversion a marginally significantly shorter dwelling time ($\gamma = -.12$, $p = .10$), and openness significantly longer mean fixation durations ($\gamma = .11$, $p = .047$) and dwelling time ($\gamma = .13$, $p = .046$). From all Big Five traits, openness emerged as the only trait with significant ($p < .05$) effects on eye movement parameters.

LMM findings for BIS/BAS traits in level 2 can be found in Table 6. BIS/BAS variables were able to significantly reduce prediction error above and beyond condition for number of fixations [$R^2 = .07$, $LR(8) = 16.24$, $p = .039$], but not for dwelling time [$R^2 = .05$, $LR(8) = 11.31$, $p = .185$] and mean fixation duration [$R^2 = .04$, $LR(8) = 11.93$, $p = .154$]. Level 2 main effects were only found for all BAS scales. Specifically, BAS Drive manifested significantly less number of fixations ($\gamma = -.31$, $p = .001$) and shorter dwelling time ($\gamma = -.29$, $p = .01$), BAS Reward Responsiveness a marginally significantly longer mean fixation duration ($\gamma = .20$, $p = .081$), and BAS Fun-Seeking a marginally significantly shorter mean fixation duration ($\gamma = -.18$, $p = .075$). From all BIS/BAS traits, BAS Drive emerged as the only trait with significant ($p < .05$) effects on eye movement parameters.

### 4.4. Condition × personality interaction effects

As can be seen in Table 5 under "cross-level interactions," only neuroticism and extraversion from the Big Five manifested significant interactions with condition. Specifically, neuroticism manifested under Condition Red significantly less number of fixations ($\gamma = -.12$, $p = .001$) and shorter dwelling time ($\gamma = -.08$, $p < .001$), and extraversion a significantly higher number of fixations ($\gamma = .08$, $p = .030$) and shorter dwelling time ($\gamma = -.05$, $p = .008$).

As can be seen in Table 6 under "cross-level interactions," only BAS Fun-Seeking manifested significant interactions with condition. Specifically, it manifested under Condition Red a significantly shorter mean fixation duration ($\gamma = -.10$, $p = .024$).

## 5. Discussion

### 5.1. Interpretation of findings

Differences in eye movement parameters between Animation Red and Blue were observed (which is line with the gazing behavior they should evoke, as outlined by Furtner, 2006), but with high correlations between the animations. This may suggest relatively stable eye movement patterns despite variability caused by stimulus variation and is in line with behavioral rank-order consistency (Fleeson & Noftle, 2008a, 2008b): people can exhibit substantial variation in behavior across different occasions (intraindividual perspective), but still remain "consistent" when compared to others (interindividual perspective). For example, Person 1 generally exhibits more fixations than Person 2 – regardless the animation – and thus the rank order (Person 1 > Person 2 in fixations) remains consistent although both persons may vary intraindividually in fixations between animations. This may imply the influence of personality (i.e., an underlying system generating observed consistency).

Neuroticism manifested a tendency towards longer fixation duration and dwelling time and, specifically, less fixations and shorter dwelling time in Animation Red. As a domain of affective intensity (MacDonald, 1995), affect regulation (McAdams, 1992; van Lieshout, 2000), pondering and rumination (Costa & McCrae, 1992), and negative affect (John & Srivastava, 1999; Yik & Russell, 2001) it might be tied to longer processing of stimuli to determine their (potentially negative or aversive) value. Interestingly, BIS did not show any relations to eye movement parameters despite its convergence with neuroticism. Although BIS and neuroticism are linked, BIS may represent a somewhat rotated version of neuroticism and capture distinct aspects that seem not related to eye movement parameters. In any case, this dissociation between BIS and neuroticism in associations with eye movement parameters should be replicated in further studies.

Extraversion manifested shorter dwelling time and, specifically, in Animation Red higher number of fixations and less dwelling time. As a domain of external orientation and outgoingness (Costa & McCrae, 1992); liveliness, energy, and activation (Buss & Plomin, 1975; MacDonald, 1995); stimulation, sensation, excitement, or activity seeking (Costa & McCrae, 1992; McCrae & John, 1992) it is linked to more frequent or rapid behaviors (Brebner, 1985) and higher interest in external stimuli which could manifest in more fixations (with less fixation durations and overall dwelling time).

Openness to new experiences manifested longer mean fixation durations and dwelling time. Individuals scoring more highly on

**Table 4**
Intercorrelations among all variables.

| Variables | Eye movement parameters | | | Big Five | | | | | BIS/BAS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NF | MFD | DT | N | E | O | A | C | BIS | BAS-D | BAS-RR | BAS-FS |
| Across both animations | | | | | | | | | | | | |
| *Eye movement parameters*[a] | | | | | | | | | | | | |
| NF | – | | | | | | | | | | | |
| MFD | −.24*** | – | | | | | | | | | | |
| DT | .42*** | .74*** | – | | | | | | | | | |
| *Big Five*[a] | | | | | | | | | | | | |
| N | .05 | .14** | .15** | – | | | | | | | | |
| E | −.04 | −.16*** | −.17*** | −.32*** | – | | | | | | | |
| O | .00 | .08† | .11* | −.07 | .06 | – | | | | | | |
| A | .04 | −.13** | −.11* | −.12† | .42*** | .10 | – | | | | | |
| C | −.04 | −.06 | −.09† | −.19** | .20** | −.28*** | .11 | – | | | | |
| *BIS/BAS*[b] | | | | | | | | | | | | |
| BIS | −.08 | .02 | −.03 | .52*** | .01 | −.07 | .15 | −.04 | – | | | |
| BAS-D | −.28*** | −.15† | −.27*** | −.05 | .11 | −.05 | −.07 | .34** | .12 | – | | |
| BAS-RR | −.01 | .09 | .06 | .13 | .15 | .28** | .07 | −.00 | .46*** | .27* | – | |
| BAS-FS | −.01 | −.18* | −.12 | −.05 | .31** | .24* | .10 | −.07 | −.14 | .29** | .19† | – |
| Animation Blue | | | | | | | | | | | | |
| *Eye movement parameters*[c] | | | | | | | | | | | | |
| NF | – | | | | | | | | | | | |
| MFD | −.31*** | – | | | | | | | | | | |
| DT | .23*** | .82*** | – | | | | | | | | | |
| *Big Five*[c] | | | | | | | | | | | | |
| N | −.15* | .17** | .09 | | | | | | | | | |
| E | .17 | −.24*** | −.18** | | | | | | | | | |
| O | .03 | .08 | .13* | | | | | | | | | |
| A | .11† | −.15* | −.09 | | | | | | | | | |
| C | .04 | −.09 | −.08 | | | | | | | | | |
| *BIS/BAS*[d] | | | | | | | | | | | | |
| BIS | −.13 | .06 | −.03 | | | | | | | | | |
| BAS-D | −.27** | −.14 | −.26* | | | | | | | | | |
| BAS-RR | −.05 | .12 | .06 | | | | | | | | | |
| BAS-FS | .07 | −.23* | −.13 | | | | | | | | | |
| Animation Red | | | | | | | | | | | | |
| *Eye movement parameters*[c] | | | | | | | | | | | | |
| NF | – | | | | | | | | | | | |
| MFD | .11† | – | | | | | | | | | | |
| DT | .70*** | .76*** | – | | | | | | | | | |
| *Big Five*[c] | | | | | | | | | | | | |
| N | .17** | .13* | .22** | | | | | | | | | |
| E | −.14* | −.07 | −.16* | | | | | | | | | |
| O | −.01 | .12† | .08 | | | | | | | | | |
| A | .01 | −.16* | −.13† | | | | | | | | | |
| C | −.09 | −.05 | −.09 | | | | | | | | | |
| *BIS/BAS*[d] | | | | | | | | | | | | |
| BIS | −.06 | −.02 | −.03 | | | | | | | | | |
| BAS-D | −.31** | −.17 | −.29** | | | | | | | | | |
| BAS-RR | .03 | .06 | .06 | | | | | | | | | |
| BAS-FS | −.07 | −.12 | −.11 | | | | | | | | | |

Correlations are bivariate zero-order Pearson product-moment correlation coefficients.
NF = number of fixations, MFD = mean fixation duration (in ms), DW = dwelling time (in ms);
N = neuroticism, E = extraversion, O = openness (to new experiences), A = agreeableness, C = conscientiousness;
BIS = Behavioral Inhibition System, BAS-D = Behavioral Activation System – Drive, BAS-RR = Behavioral Activation System – Reward Responsiveness, BAS-FS = Behavioral Activation System – Fun-Seeking.
[a] $N = 484$.
[b] $n = 178$.
[c] $N = 242$.
[d] $n = 89$.
*** $p < .001$.
** $p < .01$.
* $p < .05$.
† $p < .10$.

openness may actively seek information by processing also non-meaningful stimuli longer and more deeply. Longer fixations could be indicative of early perceptional "deep processing" mechanisms that underlie openness as open individuals have been found to be "deep," thoughtful, intellectual, culturally interested, and creative (Buss, 1996; John & Srivastava, 1999; van Lieshout, 2000). This is in line with Matsumoto et al.'s (2010) findings that individuals high in openness increased eye fixation points when watching gestures of other people, possibly to obtain more information. Indeed, longer mean fixation durations are associated with more attention, personal relevance (of stimuli), higher motivation, and deeper processing (Furtner et al., 2011).

Agreeableness and conscientiousness were the only two traits from the Big Five not to show effects on eye movement parameters. Agreeableness is a genuinely social-interpersonal domain (Costa & McCrae, 1992), and our animations contained

**Table 5**
Prediction of eye movement parameters from Big Five variables in linear mixed models.

| Dispositional variables | Number of fixations[a] | | | | Mean fixation duration[a] | | | | Dwelling time[b] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\gamma$ | *SE* | *t* | *p* | $\gamma$ | *SE* | *t* | *p* | $\gamma$ | *SE* | *t* | *p* |
| *Level 2 main effects* | | | | | | | | | | | | |
| Neuroticism | 0.03 | 0.05 | 0.59 | .557 | **0.11** | **0.05** | **1.96** | **.051** | **0.12** | **0.06** | **1.81** | **.071** |
| Extraversion | −0.06 | 0.06 | −1.04 | .299 | −0.10 | 0.06 | −1.62 | .107 | **−0.12** | **0.07** | **−1.65** | **.100** |
| Openness | −0.01 | 0.05 | −0.15 | .882 | **0.11** | **0.05** | **2.00** | **.047** | **0.13** | **0.06** | **2.01** | **.046** |
| Agreeableness | 0.08 | 0.06 | 1.38 | .169 | −0.09 | 0.06 | −1.59 | .114 | −0.06 | 0.07 | −0.84 | .399 |
| Conscientiousness | −0.03 | 0.05 | −0.53 | .593 | 0.02 | 0.06 | 0.28 | .778 | 0.00 | 0.07 | 0.01 | .992 |
| *Cross-level interactions* | | | | | | | | | | | | |
| Condition Red ∗ neuroticism | **−0.12** | **0.03** | **−3.44** | **.001** | 0.03 | 0.03 | 1.12 | .264 | **−0.08** | **0.02** | **−4.71** | **.000** |
| Condition Red ∗ extraversion | **0.08** | **0.04** | **2.19** | **.030** | **−0.12** | **0.03** | **−3.79** | **.000** | **−0.05** | **0.02** | **−2.66** | **.008** |
| Condition Red ∗ openness | 0.01 | 0.03 | 0.40 | .689 | 0.02 | 0.03 | 0.82 | .414 | 0.02 | 0.02 | 1.31 | .191 |
| Condition Red ∗ agreeableness | −0.02 | 0.03 | −0.66 | .513 | 0.01 | 0.03 | 0.26 | .797 | 0.02 | 0.02 | 1.43 | .154 |
| Condition Red ∗ conscientiousness | 0.03 | 0.03 | 1.00 | .320 | 0.00 | 0.03 | −0.08 | .935 | 0.00 | 0.02 | 0.20 | .839 |

$N = 242$.
Level 1 is condition (effect-coded) and Level 2 is Big Five factors. Cross-level interactions denote interactions among condition × personality trait.
Standardized regression coefficients are given.
Eye movement parameters mean fixation duration and dwelling time were sampled in ms.
Findings with $p < .10$ are indicated bold.
[a] Random slopes and intercept model.
[b] Random intercept-only model.

no social information. It is likely that agreeable persons show characteristic gazing patterns when confronted with social stimuli. Conscientiousness refers to perseverant impulse control despite hindrances (Denissen & Penke, 2008) which per se does not imply an association with any eye movement parameter. The non-effects of agreeableness and conscientiousness need to be replicated, though, in order to estimate whether or not they are also manifest in oculomotorics.

BAS, which can be seen as a somewhat rotated version of extraversion in a factor space, also manifested significant relations with eye movement parameters. BAS Drive manifested less fixations and shorter dwelling time. This indicates that individuals high in BAS Drive show more and longer saccades in gazing and that they have their gaze "swirl" around more often and wider (without narrow fixations). It could be possible that the perseverant goal-pursuit of appetitive stimuli in BAS Drive is accompanied by a gazing style that resembles visual scanning or searching (which is manifested in fewer fixations and shorter dwelling time). BAS Reward Responsiveness manifested a tendency towards longer mean fixation duration. It is related to reward responsiveness and dependence (Carver & White, 1994), and this could manifest in oculomotor output if reward responsive individuals engage into longer gazing to extract more potentially positive and rewarding stimuli (even in abstract material with no topical information). On the other hand, BAS Fun-Seeking interestingly manifested a tendency towards a shorter mean fixation duration, and particularly so in interaction with Animation Red.

### 5.2. Merits and implications

The present findings link personality and individual differences to eye movements and have theoretical and practical significance. First, eye-tracking methodology has thus far rarely been applied to the study of personality and individual differences. Refining paradigms utilizing eye-tracking methodology seems worthwhile because selective attention and attentional deployment of environmental cues in different traits could be studied systematically. Hypotheses about trait sensitivities regarding circumscribed classes of environmental stimuli (Traits as Sensitivities Model: Marshall & Brown, 2006; see also Denissen & Penke, 2008) could be tested, for example, whether people scoring highly on neuroticism would fixate socially threatening stimuli more (or less) than other stimuli in a given situation or setting. Such research may also go a long way in ultimately highlighting person × environment transactions. Second, we demonstrated that personality also manifests in a micro-behavior neglected up to now in personality research: eye movements. Elaborating on trait – eye movement relationships could yield important findings on why, when, and how personality and individual differences are behaviorally manifest (and consistent). Thus, personality psychology can advance its knowledge on behavior (Fleeson & Noftle, 2008a; Furr, 2009). Second, we demonstrated that individual differences play a role in eye movement parameters – above and beyond stimulus variation and in non-meaningful stimuli. This is compelling evidence for personality influences on gazing. Particularly cognitive and social psychologists should seek to assess dispositional "covariates" in experimental settings to estimate (or control for) their effects. Moreover, we have also identified interaction effects, highlighting the necessity to carefully consider possible trait x stimulus interactions in cognitive-experimental paradigms. Third, it has always been an ambitious goal to construct objective measures of personality. The fact that personality is manifest also in abstract stimuli without topical information opens up the door for new and exciting avenues in objective personality assessment. Ultimately, personality and individual differences could also be objectively assessed with eye-tracking methodology because how and where we gaze may be related to personality and individual differences.

### 5.3. Limitations and prospects

There are some limitations that future in-depth research should attend to in order to replicate, corroborate, and extend the findings presented here. First, a coherent theory should be elaborated on *why* and *how exactly* traits manifest in oculomotorics. Findings on trait manifestations in gazing behavior in the sub-clinical domain remain scant thus far.

Second, a wider variety of stimuli (e.g., meaningful vs. non-meaningful, social vs. non-social, simple vs. complex, etc.), traits (e.g., needs, goals, interests, lifestyle, etc.), and eye movement parameters (e.g., saccades and anti-saccades; smooth pursuit eye movements; pupil dilation; time to first fixation; etc.) should be employed. Also, affective tonality of stimuli as well as participants' momentary mood should be sampled to gauge to what extent state affect plays a role in gazing. Thus, complex state × trait × stimulus interactions can be explored in future eye-tracking studies which will help further tease apart the unique influence that traits may

**Table 6**
Prediction of eye movement parameters from BIS/BAS variables in linear mixed models.

| Dispositional variables | Number of fixations[a] | | | | Mean fixation duration[a] | | | | Dwelling time[b] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *γ* | *SE* | *t* | *p* | *γ* | *SE* | *t* | *p* | *γ* | *SE* | *t* | *p* |
| *Level 2 main effects* | | | | | | | | | | | | |
| BIS | −0.09 | 0.10 | −0.86 | .394 | −0.08 | 0.11 | −0.70 | .486 | −0.10 | 0.12 | −0.85 | .395 |
| BAS Drive | **−0.31** | **0.09** | **−3.35** | **.001** | −0.14 | 0.10 | −1.34 | .182 | **−0.29** | **0.11** | **−2.65** | **.010** |
| BAS Reward Responsiveness | 0.10 | 0.10 | 1.00 | .318 | **0.20** | **0.11** | **1.76** | **.081** | 0.20 | 0.12 | 1.65 | .103 |
| BAS Fun-Seeking | 0.05 | 0.09 | 0.55 | .583 | **−0.18** | **0.10** | **−1.80** | **.075** | −0.09 | 0.11 | −0.78 | .439 |
| *Cross-level interactions* | | | | | | | | | | | | |
| Condition Red * BIS | 0.01 | 0.05 | 0.15 | .885 | 0.00 | 0.05 | −0.09 | .931 | 0.00 | 0.02 | −0.18 | .861 |
| Condition Red * BAS Drive | 0.04 | 0.05 | 0.86 | .390 | 0.00 | 0.04 | −0.07 | .943 | 0.02 | 0.02 | 0.98 | .332 |
| Condition Red * BAS Reward Responsiveness | −0.06 | 0.05 | −1.19 | .238 | 0.07 | 0.05 | 1.46 | .149 | 0.00 | 0.02 | 0.08 | .938 |
| Condition Red * BAS Fun-Seeking | 0.07 | 0.05 | 1.42 | .159 | **−0.10** | **0.04** | **−2.30** | **.024** | −0.01 | 0.02 | −0.61 | .540 |

*N* = 89.
Level 1 is condition (effect-coded) and Level 2 is Big Five factors. Cross-level interactions denote interactions among condition × personality trait.
Standardized regression coefficients are given.
Eye movement parameters mean fixation duration and dwelling time were sampled in ms.
Findings with $p < .10$ are indicated bold.
[a] Random slopes and intercept model.
[b] Random intercept-only model.

exert on gazing behavior while also highlighting interaction effects.

Third, social consequences of trait – eye movement links should be investigated. For example, it can be examined whether people perceive differences in others' gazing patterns and how they make sense of these in impression formation and personality judgments (Bayliss & Tipper, 2006). Not only should the manifestation of traits in gazing be studied (cue validity), but also whether gazing can function as a social cue for forming impression of others (cue utilization).

In summary, empirical and systematic research on the links between personality and oculomotor behavior has been scarce so far, but findings here lay important ground work and are promising that further research will yield (a) theoretically interesting (e.g., consistency of gazing across different contexts and trait manifestations in eye movement parameters) and (b) practically applicable findings (e.g., personality and motive assessment with eye-tracking technology) that are (c) interesting for personality, social, cognitive, and applied psychologists (e.g., in media and marketing research).

## 6. Conclusion

The current study presented evidence in a large sample that sub-clinical personality traits manifest in gazing behavior. Specifically, neuroticism, extraversion, openness, and BAS are associated with common eye movement parameters such as number of fixations, mean fixation duration, and dwelling time. A future goal will be to determine which eye movement parameters are indicative of personality, which are not, and why this is the case to explore to what extent eyes can be used as "windows to personality."

## Acknowledgments

We thank our undergraduate research assistants Pia Dröber, Christian Karlegger, and Katja Schneider for their help in acquiring subjects and collecting the data. We also thank Jonas Bösch for programming the animations used as stimuli in this study.

## References

Angleitner, A., & Ostendorf, F. (1994). Temperament and the big-five factors of personality. In C. F. Halverson, G. A. Kohnstamm, & R. P. Martin (Eds.), *The developing structure of temperament and personality from infancy to adulthood* (pp. 69–90). Hillsdale, NJ: Lawrence Erlbaum.

Back, M. D., Schmukle, S. C., & Egloff, B. (2009). Predicting actual behavior from the explicit and implicit self-concept of personality. *Journal of Personality and Social Psychology, 97*, 533–548.

Balcetis, E., & Dunning, D. (2006). See what you want to see: Motivational influences on visual perception. *Journal of Personality and Social Psychology, 91*, 612–625.

Bayliss, A. P., & Tipper, S. P. (2006). Predictive gaze cues and personality judgments: Should eye trust you? *Psychological Science, 17*, 514–520.

Borkenau, P., & Ostendorf, F. (1993). *NEO-Fünf-Faktoren-Inventar (NEO-FFI) nach Costa und McCrae*. Göttingen: Hogrefe.

Brebner, J. (1985). Personality theory and movement. In B. D. Kirkcaldy (Ed.), *Individual differences in movement* (pp. 27–41). Lancaster, England: MTP Press.

Brooks, C. I., Church, M. A., & Fraser, L. (1986). Effects of duration of eye contact on judgments of personality characteristics. *The Journal of Social Psychology, 126*, 71–78.

Buss, D. M. (1996). Social adaptation and five major factors of personality. In J. S. Wiggins (Ed.), *The five factor model of personality: Theoretical perspectives* (pp. 180–207). New York: Guilford Press.

Buss, A. H., & Plomin, R. (1975). *A temperament theory of personality development*. New York: Wiley.

Canli, T. (2006). *Biology of personality and individual differences*. New York: Guilford Press.

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology, 67*, 319–333.

Ceballos, N. A., & Bauer, L. O. (2004). Effects of antisocial personality, cocaine and opioid dependence, and gender on eye movement control. *Psychological Reports, 95*, 551–563.

Cloninger, C. R., Svrakic, D. M., & Przybeck, T. R. (1993). A psychobiological model of temperament and character. *Archives of General Psychiatry, 50*, 975–990.

Corr, P. J. (2008). *The reinforcement sensitivity theory of personality*. Cambridge: Cambridge University Press.

Costa, P. T., Jr., & McCrae, R. R. (1992). *Professional manual: revised NEO personality inventory (NEO-PI-R) and NEO five-factor inventory (NEO-FFI)*. Odessa, FL: Psychological Assessment Resources.

Day, M. E. (1970). Don't teach till you see the direction of their eye movements. *The Journal of Special Education, 4*, 233–237.

de Fruyt, F., van de Wiele, L., & van Heeringen, C. (2000). Cloninger's psychobiological model of temperament and character and the Five-Factor model of personality. *Personality and Individual Differences, 29*, 441–452.

Denissen, J. J. A., & Penke, L. (2008). Individual reaction norms underlying the Five Factor Model of personality: First steps towards a theory-based conceptual framework. *Journal of Research in Personality, 42*, 1285–1302.

DeYoung, C. G., & Gray, J. R. (2009). Personality neuroscience. Explaining individual differences in affect, behavior, and cognition. In P. J. Corr & G. Matthews (Eds.), *Cambridge handbook of personality* (pp. 323–346). New York: Cambridge University Press.

Duchowsky, A. T. (2007). *Eye tracking methodology: Theory and practice* (2nd ed.). London: Springer.

Etaugh, C. F. (1972). Personality correlates of lateral eye movement and handedness. *Perceptual and Motor Skills, 34*, 751–754.

Etaugh, C. F., & Rose, M. (1973). Lateral eye movement: Elusive personality correlates and moderate stability estimates. *Perceptual and Motor Skills, 37*, 211–217.

Fleeson, W., & Noftle, E. E. (2008a). The end of the person-situation debate: An emerging synthesis in the answer to the consistency problem. *Social and Personality Psychology Compass, 2*, 1667–1684.

Fleeson, W., & Noftle, E. E. (2008b). Where does personality have its influence? A supermatrix of consistency concepts. *Journal of Personality, 76*, 1355–1385.

Franks, C. M. (1963). Ocular movements and spontaneous blink rate as functions of personality. *Perceptual and Motor Skills, 16*, 178.
Furr, R. M. (2009). Personality psychology as a truly behavioral science. *European Journal of Personality, 23*, 369–401.
Furtner, M. (2006). Processes of information processing. Experimental perception psychological analysis with eye tracking (eye movement analysis). Doctoral Dissertation. University of Innsbruck, Austria.
Furtner, M. R., Rauthmann, J. F., & Sachse, P. (2009). Nomen est omen: Investigating the dominance of nouns in word comprehension with eye movement analyses. *Advances in Cognitive Psychology, 5*, 91–104.
Furtner, M. R., Martini, M., & Sachse, P. (2011). Intrinsische Motivation, Self-Leadership und Selbstregulation in der Mensch-Computer Interaktion. [Intrinsic motivation, self-leadership, and self-regulation in human–computer interaction]. In S. Schmid, M. Elepfandt, J. Adenauer, & A. Lichtenstein (Eds.), *Reflexionen und Visionen der Mensch-Maschine-Interaktion – Aus der Vergangenheit lernen, Zukunft gestalten (S. 222–227)*. Düsseldorf: VDI Verlag.
Furtner, M., & Sachse, P. (2008). The psychology of eye-hand coordination in human computer interaction. In D. Cunliffe (Ed.), *Proceedings of the Third IASTED International Congress on Human Computer Interaction* (pp. 144–149). Anaheim: ACTA Press.
Goldberg, J. H., & Wichansky, A. M. (2003). Eye tracking in usability evaluation: A practitioner's guide. In J. Hyönä, R. Radach, & H. Deubel (Eds.), *The mind's eye: Cognitive and applied aspects of eye movement research*. Amsterdam, The Netherlands: North-Holland.
Gray, J. A. (1982). *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system*. Oxford University Press.
Gray, J. A. (1987). *The psychology of fear and stress*. Cambridge, England: Cambridge University Press.
Gray, J. A. (1990). Brain systems that mediate both emotion and cognition. *Cognition and Emotion, 4*, 269–288.
Gray, J. A. (1991). The neuropsychology of temperament. In J. Stelau & A. Angleiter (Eds.), *Explorations in temperament* (pp. 105–128). New York: Plenum.
Gray, J. A., & McNaughton, N. (2000). *The neuropsychology of anxiety*. Oxford: Oxford University Press.
Haley, G. A. (1971). Effects of personality factors and increased eye movement on a size-matching measure of scanning. *Journal of Abnormal Psychology, 77*, 303–307.
Iacono, W. G., & Lykken, D. T. (1979). Eye tracking and psychopathology: New procedures applied to a sample of normal monozygotic twins. *Archives of General Psychiatry, 36*, 1361–1369.
Isaacowitz, D. M. (2005). The gaze of the optimist. *Personality and Social Psychology Bulletin, 31*, 407–415.
Isaacowitz, D. M. (2006). Motivated gaze: The view from the gazer. *Current Directions in Psychological Science, 15*, 68–72.
Jacob, R. J. K., & Karn, K. S. (2003). Eye tracking in human–computer interaction and usability research: Ready to deliver the promises. In J. Hyönä, R. Radach, & H. Deubel (Eds.), *The mind's eye. Cognitive and applied aspects of eye movement research* (pp. 573–605). Amsterdam: Elsevier.
Jensen-Campbell, L. A., Rosselli, M., Workman, K. A., Santisi, M., Rios, J., & Bojan, D. (2002). Agreeableness, conscientiousness, and effortful control processes. *Journal of Research in Personality, 36*, 476–489.
John, O. P., & Srivastava, S. (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. In L. A. Pervin & O. P. John (Eds.), *Handbook of personality: Theory and research* (2nd ed., pp. 102–138). New York: Guilford.
Joos, M., Rötting, M., & Velichkovsky, B. M. (2003). Die Bewegungen des menschlichen Auges: Fakten, Methoden und innovative Anwendungen. In G. Rickheit, T. Herrmann, & W. Deutsch (Eds.), *Psycholinguistik/Psycholinguistic. Ein internationales Handbuch/An international handbook* (pp. 142–168). Berlin & NY: de Gruyter.
Kaspar, K., & König, P. (2011). Overt attention and context factors: The impact of repeated presentations, image type, and individual motivation. *PLOS ONE, 6*(7), e21719. doi:10.1371/journal.pone.0021719.
Keiser, H. N., & Ross, S. R. (2011). Carver and Whites' BIS/FFFS/BAS scales and domains and facets of the Five Factor Model of personality. *Personality and Individual Differences, 51*, 39–44.
Land, M. F. (2007). Fixation strategies during active behaviour: A brief history. In R. P. G. van Gompel, M. H. Fischer, W. S. Murray, & R. L. Hill (Eds.), *Eye movements: A window on mind and brain* (pp. 75–98). Amsterdam: Elsevier.
Libby, W. L., & Yaklevich, D. (1973). Personality determinants of eye contact and direction of gaze aversion. *Journal of Personality and Social Psychology, 27*, 197–206.
Luke, D. A. (2004). *Multilevel modeling*. Thousand Oaks, CA: Sage Publications.
MacDonald, K. B. (1995). Evolution, the Five-Factor Model and levels of personality. *Journal of Personality, 63*, 525–567.
Marshall, M. A., & Brown, J. D. (2006). Trait aggressiveness and situational provocation: A test of the traits as situational sensitivities (TASS) model. *Personality and Social Psychology Bulletin, 32*, 1100–1113.
Matsumoto, K., Shibata, S., Seiji, S., Mori, C., & Shioe, K. (2010). Factors influencing the processing of visual information from non-verbal communications. *Psychiatry and Clinical Neurosciences, 64*, 299–308.
McAdams, D. P. (1992). The five-factor model in personality: A critical appraisal. *Journal of Personality, 60*, 329–361.
McCrae, R. R., & John, O. (1992). An introduction to the five-factor model and its applications. *Journal of Personality, 60*, 174–214.
Mikunda, C. (2002). *Kino spüren: Strategien der emotionalen Filmgestaltung [Feeling the cinema: strategies for emotional film-making]*. Wien: WUV Universitäts-Verlag.
Nguyen, H. N., Mattingley, J. B., & Abel, L. A. (2008). Extraversion degrades performance on the antisaccade task. *Brain Research, 1231*, 81–85.
Ohno, T. & Mukawa, N. (2004). A free head, simple calibration, gaze tracking system that enables gaze-based interaction. In *Proceedings of the 2004 symposium on eye tracking research and applications, Eye tracking research and application* (pp. 115–122).
Ohno, T., Mukawa, N., & Yoshikawa, A. (2002). Freegaze: A gaze tracking system for everyday gaze interaction. In *Proceedings of the 2002 symposium on eye tracking research and applications, Eye tracking research and application* (pp. 125–132).
Pinheiro, J. C., & Bates, D. M. (2000). *Mixed-effects models in S and S-PLUS*. New York, NY: Springer.
Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology, 32*, 3–25.
Posner, M. I. (1995). Attention in cognitive neuroscience. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 615–624). Cambridge, MA: MIT Press.
R Development Core Team, (2011). R: A language and environment for statistical computing [Computer software]. Vienna, Austria: R Foundation for Statistical Computing.
Rothbart, M. K., & Derryberry, D. (1981). Development of individual differences in temperament. In M. E. Lamb & A. L. Brown (Eds.). *Advances in developmental psychology* (Vol. 1, pp. 37–86). Hillsdale, NJ: Erlbaum.
Scholten, M., van Honk, J., Aleman, A., & Kahn, R. (2006). Behavioral inhibition system (BIS), behavioral activation system (BAS) and schizophrenia: Relationship with psychopathology and physiology. *Journal of Psychiatric Research, 40*, 638–645.
Schwender, C. (2001). *Medien und Emotionen: Evolutionspsychologische Bausteine einer Medientheorie [Media and emotions: Evolution psychological building blocks for a media theory]*. Wiesbaden: Deutscher Universitäts-Verlag.
Siever, L. J. (1982). Smooth pursuit eye tracking impairment: Relation to other 'markers' of schizophrenia and psychologic correlates. *Archives of General Psychiatry, 39*, 1001–1005.
Siever, L. J., Keefe, R., Bernstein, D. P., Coccaro, E. F., Klar, H. M., Zemishlany, Z., et al. (1990). Eye tracking impairment in clinically identified patients with schizotypal personality disorder. *American Journal of Psychiatry, 147*, 740–745.
Smits, D. J. M., & Boeck, P. D. (2006). From BIS/BAS to the Big Five. *European Journal of Personality, 20*, 255–270.
Snijders, T. A. B., & Bosker, R. J. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. Thousand Oaks, CA: Sage Publications.
Strobel, A., Beauducel, A., Debener, S., & Brocke, B. (2001). Eine deutschsprachige version des BIS/BAS-Fragebogens von Carver und White. *Zeitschrift für Differentielle und Diagnostische Psychologie, 22*, 216–227.
Sundar, S. S., Kalyanaraman, S., Martin, C., & Wagner, C. (2001, May). Arousal, memory, and impression-formation effects of animation speed in Web advertising. In *Paper presented at the 51 st annual conference of the International Communication Association*, Washington, DC.
Terburg, D., Hooiveld, N., Aarts, H., Kenemans, J. L., & van Honk, J. (2011). Eye tracking unconscious face-to-face confrontations: Dominance motives prolong gaze to masked angry faces. *Psychological Science, 22*, 314–319.
Thaker, G. K., Cassady, S., Adami, H., Moran, M., & Ross, D. E. (1996). Eye movements in spectrum personality disorders: Comparison of community subjects and relatives of schizophrenic patients. *American Journal of Psychiatry, 153*, 362–368.
van Lieshout, C. F. M. (2000). Lifespan personality development: Self-organising goal-oriented agents and developmental outcome. *International Journal of Behavioral Development, 24*, 276–288.
Vazire, S., & Carlson, E. N. (2010). Self-knowledge of personality: Do people know themselves? *Social and Personality Psychology Compass, 4*, 605–620.
Wilkowski, B. M., Robinson, M. D., Gordon, R. D., & Troop-Gordon, W. (2007). Tracking the evil eye: Trait anger and selective attention within ambiguously hostile scenes. *Journal of Research in Personality, 41*, 650–666.
Yik, M. S. M., & Russell, J. A. (2001). Predicting the Big Two of affect from the Big Five of personality. *Journal of Research in Personality, 35*, 247–277.