

Introduction

Since the time of Berger, EEG alpha has been identified as an idling rhythm characterizing relaxed wakefulness that is blocked (desynchronized) when visual processes are engaged by opening the eyes (1). This conceptualization has been exploited in a series of studies using EEG alpha as an index of relative cortical deactivation (i.e., greater alpha, less activation), particularly in regional studies of depression (2, 3). However, this same inverse relationship between EEG alpha and activation is also consistent with physical relaxation or inattention (i.e., anxious, distressed participants produce less alpha than are relaxed ones). Conversely, the greater EEG alpha seen in experienced meditators compared to controls has been attributed both to state-related changes and trait (i.e., persistent) differences (4).

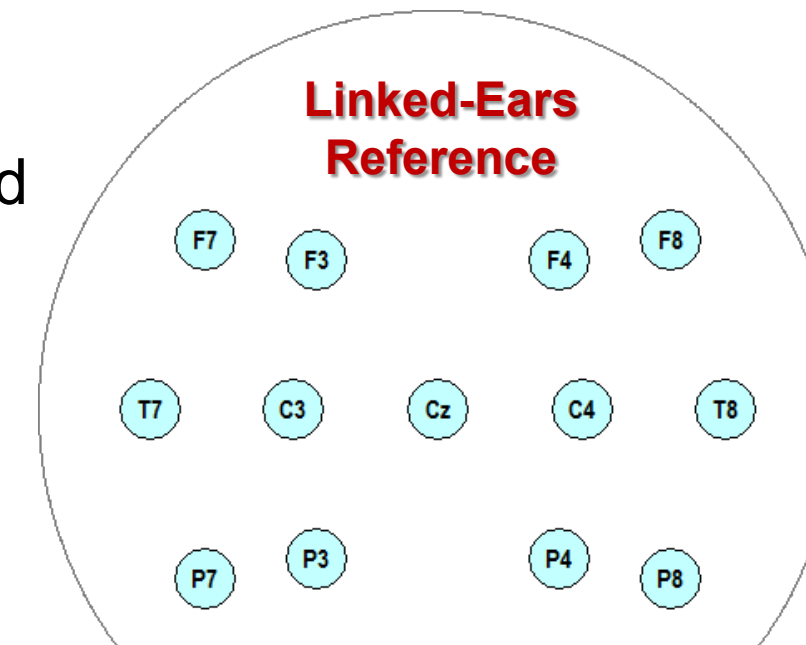
EEG alpha has been associated with risk for depression and response to treatment with antidepressants. EEG alpha power was elevated in euthymic adults who have recovered from depression (5), prompting the suggestion that alpha power might be able to identify a subgroup of depressed individuals at risk for a depression due to family history of affective disorders (6). We observed that offspring of two parents with MDD showed greater posterior, condition-dependent alpha (eyes-closed minus eyes-open) compared to those with neither or only one depressed parent (7), thereby supporting the transmission of a trait across generations. Prominent posterior alpha is also predictive of a good response to treatment with serotonergic antidepressants (8), but may not change following treatment (9). However, it is not yet known whether individuals who have positive outcomes following other treatments, or who have spontaneous remissions, might also show differences in posterior alpha.

An independent line of evidence links depression risk with personal spirituality and religion (10, 11). Self-reports of the importance of religion or spirituality are also consistent with a protective effect against recurrence of depression, particularly in adults with a history of parental depression (12). Religious beliefs and practices also tend to be transgenerational, and concordance of maternal and offspring religiosity is itself associated with risk for, and recovery from, depression (13). This protective role undoubtedly acts through neurobiological processes shared with other, better studied indices of depression risk and outcome. For example, religious affiliations and practices provide access to multiple mechanisms known to be protective against anxiety and depression, including social support networks, informal group and individual counseling, an environment intended to foster purposiveness and hope, and the personal practice of meditation and/or prayer. We therefore hypothesized that posterior EEG alpha (associated with treatment response) would differ in subgroups classified according to self-reports of attitudes about personal spirituality and religion.

Methods

EEG methods

Resting EEG was measured while subjects sat quietly during four 2-min periods (eyes open or closed, counterbalanced) and avoided blinking and eye and body movements (fixation for eyes open). Scalp EEG (13 sites, plus right ear, left ear reference, digitally re-referenced to linked-ears; bipolar blinks and horizontal eye movements) was measured using an electrode cap (Electro Cap International). The EEG was recorded using a Bioamplifier system (James Long Company) at a gain of 10 K and a band pass of .01–30 Hz. EEG data were continuously acquired at 200 samples/sec and segmented off-line into consecutive 1.28-sec epochs every .64 sec (50% overlap). Epochs contaminated by blinks, eye movements, or movement-related artifacts were excluded using a rejection criterion of $\pm 100\mu\text{V}$ on any channel, followed by interactive rejection of remaining artifacts (7).



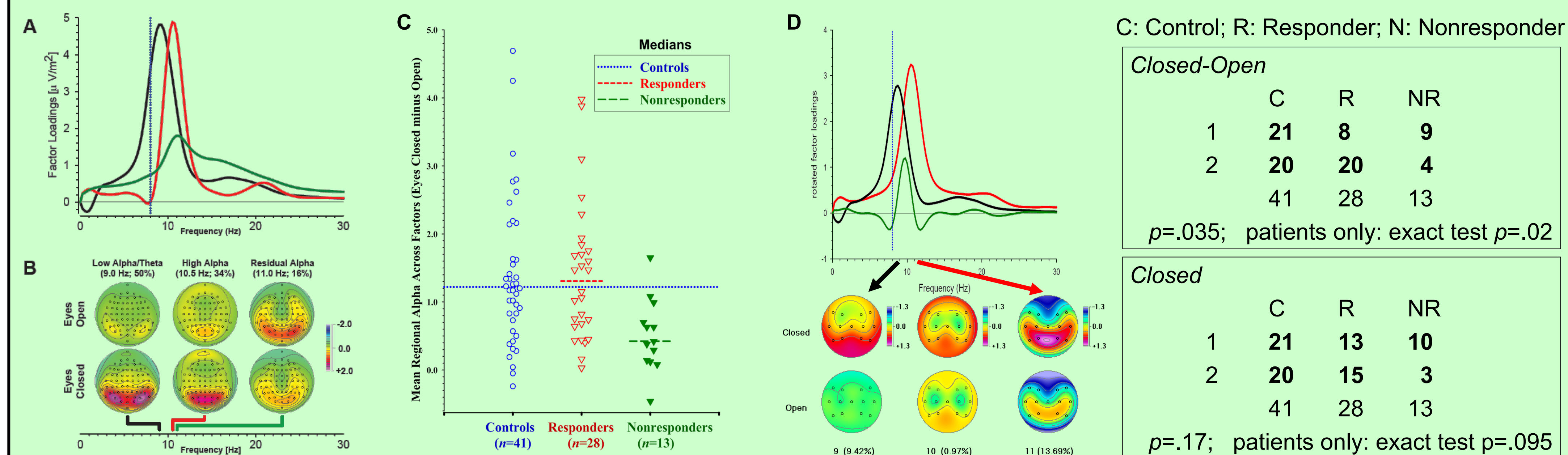
CSD-fPCA

Artifact-free EEG epochs were transformed to CSD using a spherical spline Laplacian ($\lambda = 10^{-5}$; 50 iterations; $m = 4$) (14, 15). The DC offset of each epoch was removed, and the EEG was tapered over the entire 1.28 sec using a Hanning window (16). CSD power spectra were computed, converted to amplitude spectra (17), and subjected to unrestricted, covariance-based frequency PCA (fPCA; Varimax rotation) (18). Alpha was identified and quantified from well-defined spectral, topographic, and condition (eyes-closed maximum) criteria (8).

CSD-fPCA feasibility with 13-channel montage:

Using data from 67-channel and 31-channel montages (17, 8), current generator patterns underlying EEG alpha were likewise identified and quantified using reference-independent CSD-fPCA for the present, substantially lower density montages (see inset below). It was concluded that the medial posterior sites provided a conservative characterization of posterior alpha as a classifier for prediction of treatment response to serotonergic antidepressants.

Feasibility for 13-Channel Montage



Using 67-channel EEG, CSD-fPCA factors (A) characterized posterior alpha (B) by low alpha/theta, high alpha, and residual alpha (8, 17). The median condition-dependent posterior alpha power for healthy controls (C) provided an effective criterion for predicting serotonergic antidepressant response (positive predictive value: 93.3; specificity: 92.3). Furthermore, supplementary analyses indicated that a 16-channel montage provided a comparable classification.

All CSD-fPCA analyses reported in (8) were repeated using only the present 13 sites (D). Despite spatial undersampling, factor loading peaks were comparable for the two main alpha factors, also yielding posterolateral and posteromedial factor score topographies.

The resulting classifications were best for the medial pair of posterior electrodes, although weaker than for the full 67-channel montage.

Conclusion: CSD-fPCA from this low-density montage provides a conservative, if suboptimal, characterization of posterior alpha

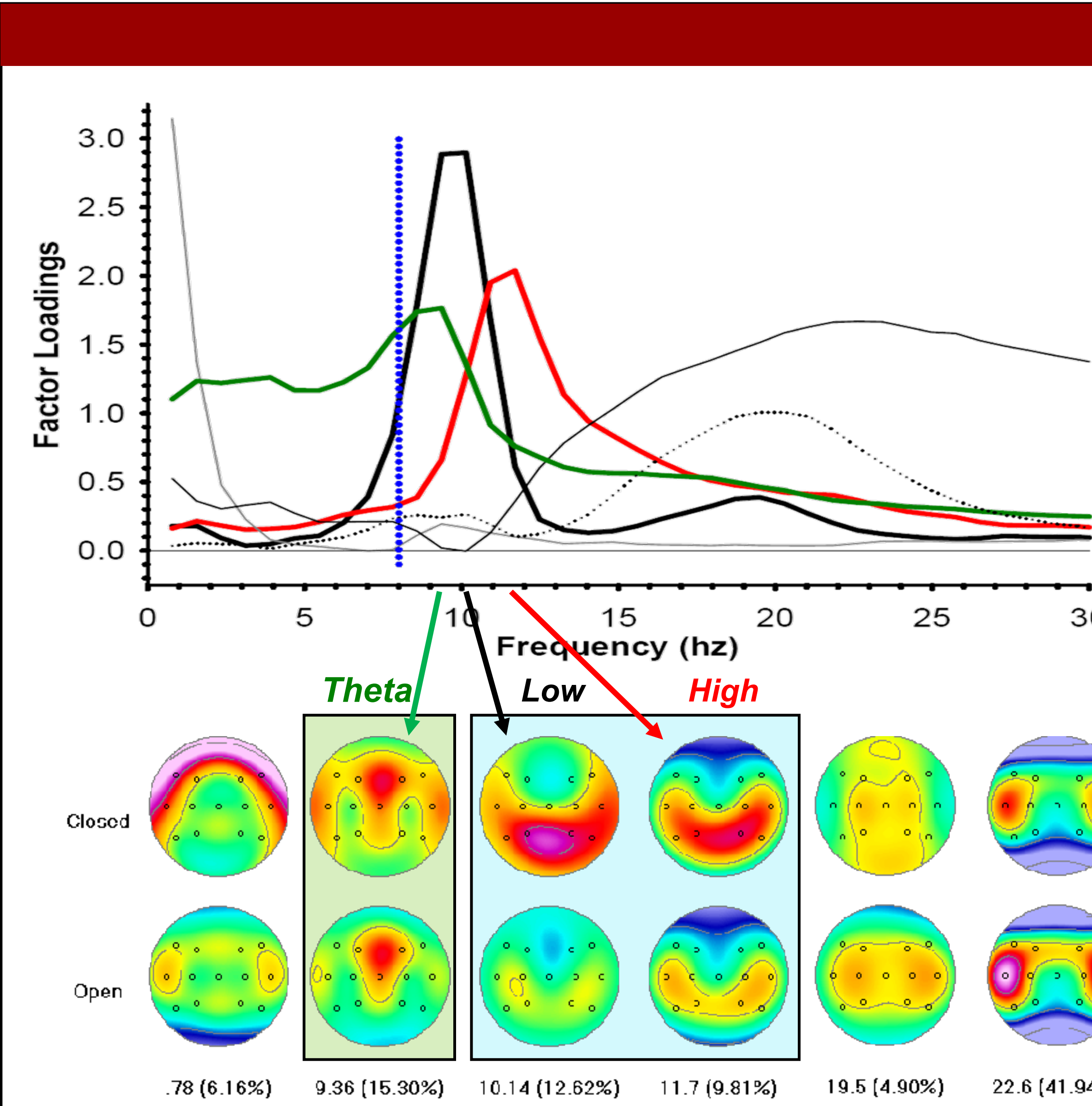


Fig. 1A. CSD-fPCA solution distinguished **Low** and **High** alpha factors with topographies and condition dependencies expected for posterior alpha (8). However, in contrast to previous studies, midline frontal **Theta** was represented as a distinct factor. Although of theoretical importance, topographic and condition-related characteristics allow it to be discounted as a measure of posterior alpha. Exploratory analyses of theta, ocular, and muscle artifact suggested no effects of interest.

Results

Alpha Differences by Importance Groupings

The 12 participants who rated religion as **Important** at the *initial* assessment showed significantly greater medial-posterior CSD alpha across conditions when compared to 40 rated as **Not Important** ($t = 3.9$, $df = 50$, $p < .001$). In contrast, alpha **did not differ** between 20 rated as important and 32 rated not important at the second assessment (Time 20; at EEG). The relationship between the **changing Importance** and alpha is evident in Fig. 1B by comparing the 12 who rated religion **Important** at the initial assessment and those who **Migrated In** later.

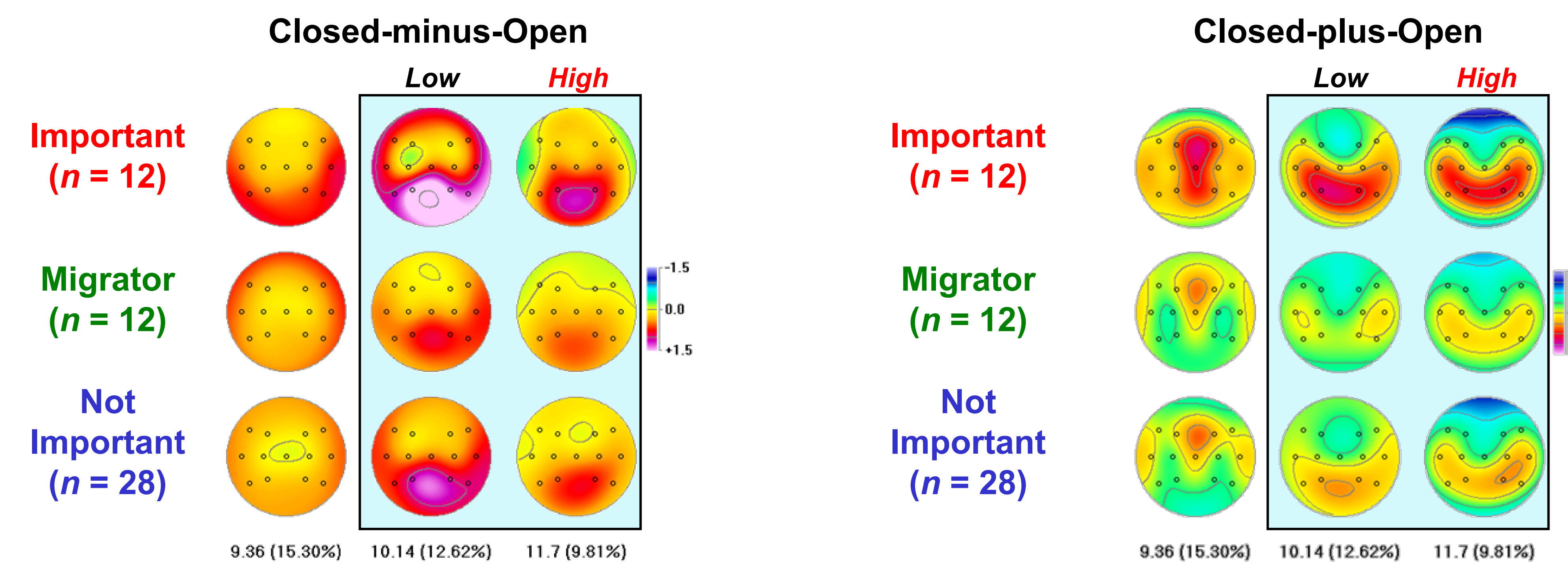


Fig. 1B. Factor score topographies by group (cf. Table 1). Participants who reported religion to be **Important** at Time 10 showed greater posterior alpha than those who **Migrated In** at Time 20, both for condition-dependent alpha (left) and overall alpha (right).

	Time 10	Time 20 (at EEG)
Not Important	40	32
Important (IMP)	12	20
Totals	52	52

	Time 10	Time 20 (at EEG)
Not Important	28	32
Stable (NOT)	28	28
Migrate In (MIG)	0	4
Important (IMP)	12	20
Stable	8	12
Migrate Out	4	8

Participants

Fifty two participants were part of a longitudinal high-risk study in offspring of depressed or nondepressed probands (19). Included in the information collected were participant responses on the personal importance of religion at the time of the EEG recording, as well as their initial responses ten years earlier. The classifier questions was "How important is religion to you?" ("Highly Important" vs. all other responses on 4-point scale). At the initial session (Time 10), 40 were classified as "Not Important", while only 12 were classified as "Important". However, by the followup (Time 20), the number of participants classified as "Important" increased to 20, owing to 12 who increased their ratings at Time 20 (**Migrate In**). The remaining 28 were **Stable in their report of "Not Important."**

$N = 52$ (33 female); Age 36 yrs ± 6.9 (SD)

	No MDD (n = 29)	MDD (n = 23)	
Low Risk:	17	4	
High Risk:	12	19	
Important	6	6	Low Risk: 6, High Risk: 6
Migrator	7	5	Low Risk: 2, High Risk: 10
Not Import.	16	12	Low Risk: 13, High Risk: 15

	Female	Male
Important	10	2
Migrator	9	3
Not Import.	14	14

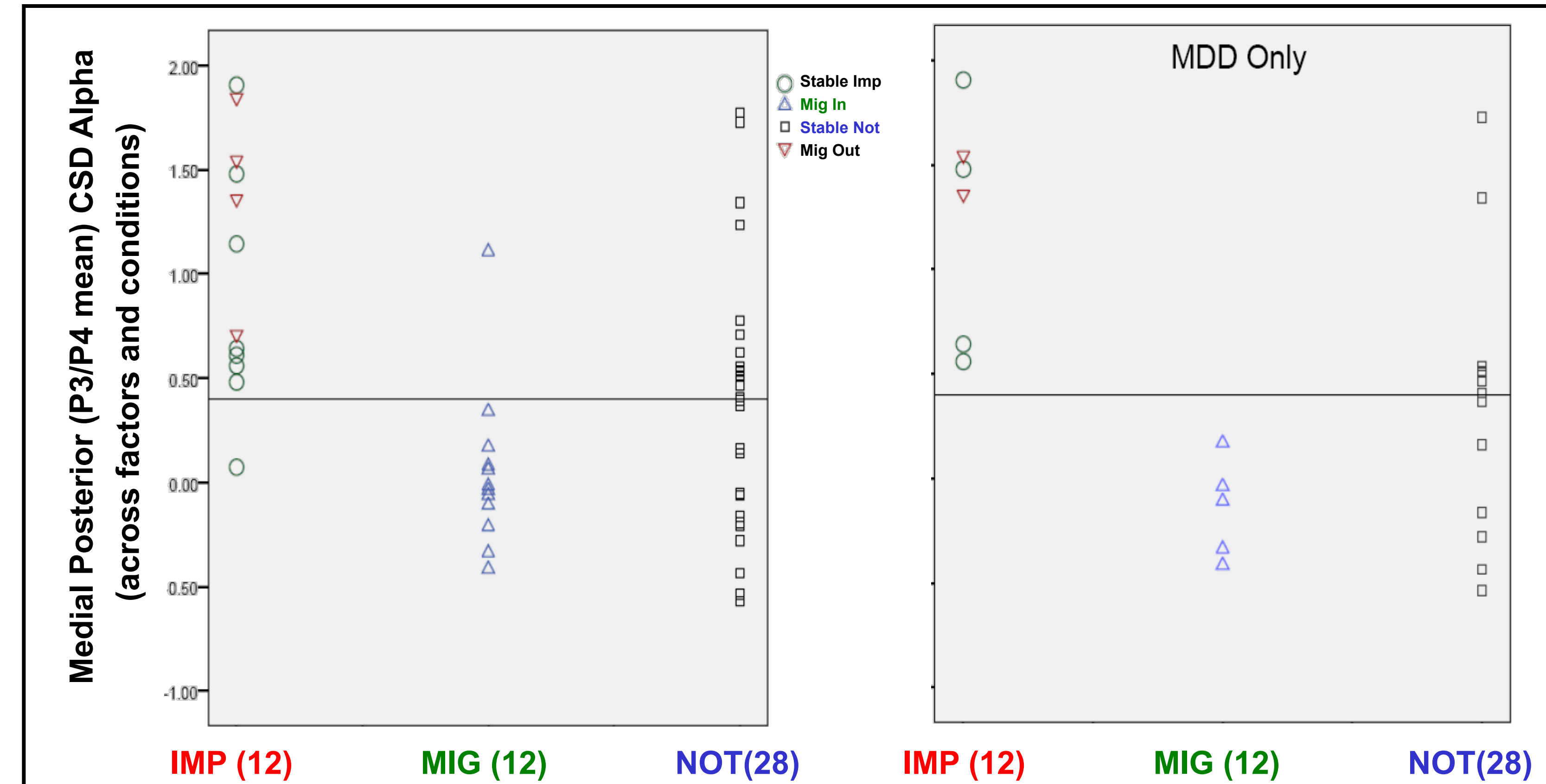


Fig. 2. When classified by median posterior alpha for **Not Important**, those who **Migrated In** showed significantly less alpha than those classified as **Important** at the initial assessment.

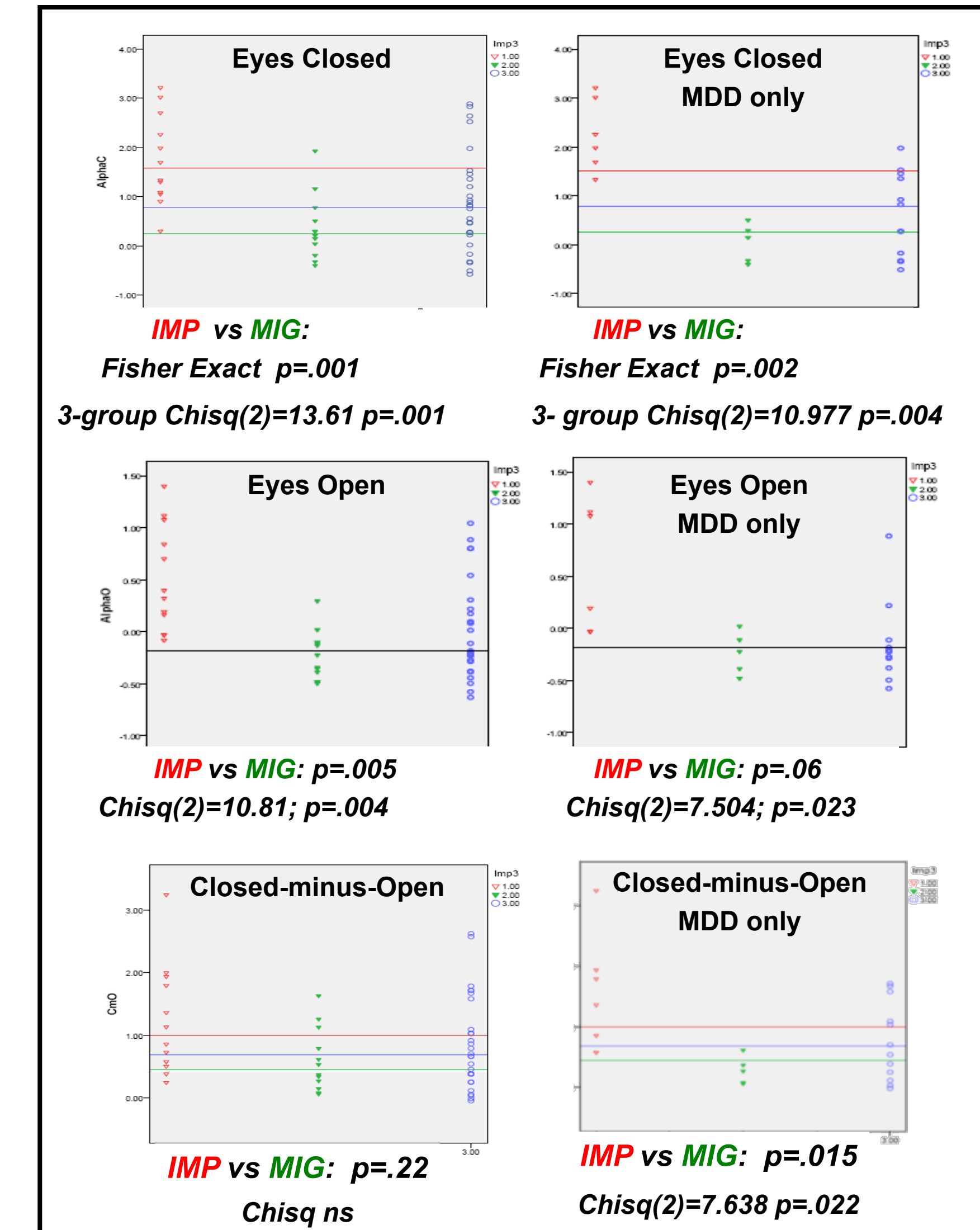


Fig. 3. This difference was evident for analyses restricted to participants with a lifetime history of depression, but not those with no depression history. Similar findings were obtained for both conditions, yielding a diminished open-minus-closed difference that attained significance only for MDD.

Conclusions

- Individuals who differ in personal Importance of religion do not systematically differ in posterior alpha. However, those who considered religion Important differed depending on the timing of their assertion: Early reports (**Important**) were associated with prominent alpha, and later reports (**Migrated Into** religion) with low alpha.
- These differences were clearest for individuals with a history of depression.
- The differences are not likely to be due to volatility related to this question, because the few initial **Important** responders who changed their reports (**Migrated Out**) did not differ in alpha from others in this group.
- More data are needed to distinguish the contributions of trait and adjustment strategy to these differences.

References

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