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Quasi-Experimental Study of Transliminality, Vibrotactile Thresholds, and Performance Speed

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ABSTRACT: Transliminality[1] has been hypothesised to derive from weak or erratic cognitive mechanisms that are responsible for the active suppression (or gating) of irrelevant information from consciousness. It was therefore expected in a test of vibrotactile sensitivity that (i) individuals with high transliminality scores (HT) have lower thresholds than individuals with low transliminality scores (LT), (ii) the HT group take less time than the LT group to obtain a threshold, (iii) and the presence of a stimulus that competes for attention increases the time and thresholds of the HT group to a greater extent than those of the LT group. Fifty participants (17 HTs, 33 LTs) completed three repetitions of threshold testing using the CASE IV System while exposed to each of four competing auditory conditions (two Intensity x two Complexity). Results confirmed predictions, but only the intensity of the competing stimulus, rather than its relative complexity, interfered with the vibrotactile thresholds of the HT group.

[1] The concept of transliminality is relevant to parapsychology, and hence to this *Journal*, because it is very closely related to belief in, and alleged experience of, the paranormal (see Thalbourne & Houran, 2003) (Ed.).

INTRODUCTION

Our research program has pursued a cognitive conceptualisation of *transliminality*—a construct most recently defined as the "hypothesised tendency for psychological material to cross (*trans*) thresholds (*limines*) into or out of consciousness" (Thalbourne & Houran, 2000, p. 861). Psychologists have long speculated about transliminal ("across the threshold") processes (e.g., James, 1982; Myers, 1903; Usher & Burt, 1909; Freud, 1933; Lewin, 1936; Rugg, 1963; Landis, 1970; MacKinnon, 1971; Blatt & Ritzler, 1974; Virtanen, 1990; Hartmann, 1991), but the construct was only recently given an operational definition and method of measurement by Thalbourne (1998) in terms of a 29-item, true/false Transliminality Scale. Subsequent "top-down purification"[2] analyses of this measure (Lange, Thalbourne, Houran & Storm, 2000) revealed that 17 of the original 29 test items constituted a single, linear Rasch (1980) hierarchy. This Rasch-scaled version of Thalbourne's (1998) original measure, termed the *Revised Transliminality Scale* (RTS: Lange, Thalbourne, Houran & Storm, 2000), validates a common dimension underlying seven psychological domains: Hyperæsthesia (heightened sensitivity to environmental stimuli), (fleeting) Hypomanic or Manic Experience, Fantasy-Proneness, Absorption, Positive (and perhaps obsessional) Attitude towards Dream Interpretation, Mystical Experience, and Magical Ideation. The concept of transliminality bridges psychological concepts that have previously been regarded as independent domains. Accordingly, the psychological material that is hypothesised to cross thresholds can encompass a wide range of imagery, ideation, affect, and perception.

Experimental support for the hypothesis that transliminality scores correspond to differences in thresholds of awareness was recently provided by Crawley, French and Yesson (2002), who conducted a test of subliminal visual perception disguised as a computerised ESP "card-guessing" task. These authors hypothesised that participants scoring high on the 29-item Transliminality Scale would outperform those with low scores when given

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[2] "Top-down purification" refers to a set of Rasch scaling procedures outlined by Lange, Irwin et al. (2000) that identify and remedy differential item functioning in questionnaires, i.e., response biases related to extraneous variables such as respondents' ages, genders, or even cultures. Furthermore, Rasch scaling yields measures that have *interval-level* properties. It is important to address response biases, because they can elicit spurious factor structures of test items, as well as erroneous findings from statistical analyses (cf., Lange et al., 2000a, 2001). Therefore, the techniques outlined in Lange, Irwin, and Houran (2000) and in Lange, Thalbourne, Houran and Storm (2000) overcome the limitations of classical test theory and are considered the gold standard in scale construction.

primes, or "clues", to the correct choice of card, but not in the absence of primes. As predicted, higher transliminality scores were associated with a greater number of correct selections of the target-card on the primed trials, but not on the unprimed trials. In addition, a positive correlation was obtained between transliminality scores and detection accuracy as given by what is known as d-prime, but no correlation with the so-called beta measure of response bias. These findings suggest that transliminality was associated with greater sensitivity to priming (cues) but not with response bias. Comparison of the authors' original findings using the 29-item Transliminality Scale with those using the RTS indicates that the results of Crawley, French and Yesson (2002) are robust with respect to the measurement of transliminality (see Table 1).

Table 1
Zero-Order Correlations between the Dependent Variables from Crawley et al. (2002) and Two Versions of the Transliminality Scale ($N = 100$)

Variable	Transliminality Scale (29-items)	Revised Transliminality Scale (17-items)	$t(97)$
Primed Guesses	.240*	.286**	1.64, ns
Unprimed Guesses	.151	.142	---
D-Prime	.253*	.207*	1.61, ns
Criterion	–.038	–.087	---

* $p \leq .05$; ** $p \leq .01$

Thalbourne, Houran, Alias and Brugger (2001) argued that transliminality reflects cognitive disinhibition. For example, in the context of selective attention tasks the cognitive mechanisms responsible for active suppression (or gating) of irrelevant information from consciousness are hypothesised to be weak or erratic, such as in schizotypy and schizophrenic-like experience (Braff, Swedlow, & Geyer, 1999; Lieb, Denz, Hess, Schuettler, Kornhuber & Schrieber, 1996; Perry, Geyer, & Braff, 1999; Peters et al., 2000; Swerdlow & Geyer, 1998). Thalbourne and colleagues (2001) further suggested that this poor gating is related to a greater degree of functional "interconnectedness" or "hyperconnectivity" in the brains of highly transliminal persons. That is, gateways that normally operate to regulate processes involving frontal-subcortical loops (involved in inhibition—Chao & Knight, 1995; Fuster, 1999), and involving primary or secondary sensory areas and/or sensory association cortices, are open to a greater extent.

Consistent with this hypothesis, Houran, Kumar, Thalbourne, and Lavertue (2002) and Thalbourne, Houran, Alias, and Brugger (2001) found strong positive correlations between scores on the RTS and scores on a questionnaire measure of synesthesia derived by Tellegen from the Absorption Scale (Tellegen & Atkinson, 1974). Marks (2000) described synesthesia as the situation where "an inducing stimulus produces, at the same time, two kinds of sensory response: the primary sensory experience that is normally associated with that stimulus and, anomalously, a secondary experience in another modality," such as "seeing a color in response to a sound" (p. 121). In addition, there are "weak" forms of synesthesia, which pertain to cross-sensory correspondences expressed through language, perceptual similarity, and perceptual interactions during information processing (Martino & Marks, 2001).

Abraham (2000) concluded that, "synesthesia . . . reflects heightened connectivity between adjacent cerebral regions" (p. 1018), and Ramachandran and Hubbard (2001) presented a detailed hyperconnectivity model of synesthesia. Furthermore, items on the RTS directly refer to or are associated with phenomena that parallel synesthesia (Glicksohn, Steinbach & Elimalach-Malmilyan, 1999), including physiognomic perception (fusion of perception and feeling) and structural eidetic imagery (fusion of imagery and perception). Werner (1948) referred to such de-differentiation of sensory modalities as syncretic cognition, whereas Baron-Cohen, Harrison, Goldstein, and Wyke (1993) spoke of a breakdown of modularity. For an initial review of these cognitive concepts in relation to transliminality, see Thalbourne (2000b).

Cognitive disinhibition has been proposed to lead to lower thresholds (see Definition Box, next page), such as in hyperesthesia[3] (heightened sensitivity to sensory stimulation), and less response inhibition, such as suggested by negative correlations between scores on the RTS and the Cattell 16PF (Russell & Karol, 1994) factors of "rule-consciousness" and "self-control" (Lange, Thalbourne, Houran & Storm, 2000). While transliminality is positively associated with schizotypal and schizophrenic-like experience (Thalbourne, 1998; Thalbourne, Bartemucci, Delin, Fox & Nofi, 1997), it is possible that moderately elevated levels of transliminality

[3] Besides being a core constituent of the transliminality construct, Thalbourne (1996; Thalbourne et al., 1997) found that transliminality correlated positively with measures of hyperesthesia that differed from those incorporated into the RTS.

can be beneficial. For example, the positive relation of transliminality to various forms of syncretic experience might explain why those scoring high on the RTS exhibit creative personalities (Thalbourne, 2000a). Werner argued that artistic perception and creative thinking rely on syncretic experience (Barten, 1983; Barten & Franklin, 1978). De-differentiation allows for a flexibility of perception and thought (cf. Ehrenzweig, 1953), as categories dissolve, become entwined, and in general interact, much as an interactionist approach to metaphor and metaphoric thinking would advocate (Glicksohn & Goodblatt, 1993).

About thresholds

Technically, threshold is defined as a boundary; thus, it acts to separate things. For example, it might separate detection of a stimulus from recognition of a stimulus. As a perceptual concept, threshold can be used in different ways, most notably to define minimal levels of stimulation. In that way, it answers such questions as, “How loud must a tone be for a person to hear it?” or, “How bright must a light be for a person to be able to see it?” Therefore, having a relatively *low* threshold entails being able to detect or recognise *low levels* or amounts of a given stimulus, whereas a relatively *high* threshold entails detecting or recognising a given stimulus only when there are relatively *high levels* or amounts of the stimulus. In other words, with respect to a given level of a stimulus, people with low sensory thresholds are very sensitive to that stimulus, whereas people with high sensory thresholds are insensitive to that same stimulus.

An experiment by Shaw and Conway (1990) is relevant to these ideas. These researchers examined differences in which high- and low-creative participants (as defined by Torrance, 1966) used conscious and non-conscious clues to solve anagrams. During tachistoscopic presentation, high- and low-creative participants solved anagrams in three primed-clue conditions: conscious, non-conscious (individual thresholds were determined), and control (no clues). They found that high-creative individuals had significantly faster threshold times and used more non-conscious clues and non-consciously primed conditions than did low-creative individuals. These findings agree conceptually with those of Crawley et al. (2002), as well as the cognitive formulation of transliminality described above.

However, it has been proposed that even moderately elevated levels of transliminality can impair attentional processes and screening function. In particular, Houran and Thalbourne (2003) recently found that

RTS scores showed a strong positively association ($r = .59$, $p < .001$) with scores on a seven-item, true/false questionnaire of self-reported aberrations in everyday memory, such as “When listening to another person I am easily distracted by my own thoughts”, and “I can always put my finger on an important document” (reverse scored). This finding was interpreted to mean that those who score high on the RTS experience periodic lapses in memory due to an increased state of activation, or due to retrieval-attentional problems caused by interference from competing internal and external stimuli that bombard consciousness. Psychological integration requires interconnectedness, but integration and attentional processes will be compromised (Nasrallah, 1985) when the interconnectedness is not selective (O’Kusky et al., 1988; Witelson, 1985).

Following from the above, the present study of transliminality and “vibrotactile” (i.e., vibration/touch) thresholds tests the following hypotheses: (i) individuals with high transliminality scores (HT) have lower thresholds than individuals with low transliminality scores (LT); (ii) the HT group takes less time than the LT group to determine a threshold; and (iii) the presence of a stimulus that competes for attention increases the time and thresholds of the HT group to a greater extent than those of the LT group. For our purposes, a competing stimulus is categorised in terms of relative *intensity* and relative *complexity*. We expect that a high-intensity stimulus interferes with selective attention more than does a low-intensity stimulus. Furthermore, we expect a static stimulus, like “white” noise, will interfere less with selection attention than a dynamic stimulus (such as a musical arrangement with lyrics). Accordingly, white noise is categorised here as a low complexity stimulus and music as a high complexity stimulus.

METHOD

Participants

A sample of 50 participants ($M = 23.14$ years; $SD = 2.95$; range = 18-29; 56% women) was recruited from the general community and local area colleges with a snowball sampling approach (see e.g., Babbie, 1989). This approach was used to assist in identifying participants between the ages of 18 and 30, which is an age-bracket with relatively constant vibrotactile sensitivity (Dyck, 1994).

Participants received no remuneration for their assistance. The selection procedure yielded 17 individuals (7 men, 10 women) who scored above the Rasch mean (HT: $M = 29.06$, $SD = 2.56$) on the RTS and 33 (15 men, 18 women) who scored below the Rasch mean (LT: $M = 23.51$, $SD = 1.43$). This difference between these two transliminality groups is significant, $t(48) = -9.61$, $p < .001$, but we note that the mean RTS score of the HT group indicates that these participants have *moderately* elevated rather than extreme trait levels of transliminality (cf. Lange, Thalbourne et al., 2000, Table 3, p. 606). Furthermore, participants were asked to indicate on a cover sheet (participants were identified by a numbering system) if they had been diagnosed with any mental condition, such as schizophrenia or schizotypy. None of the participants reported any psychopathologies. For these reasons, the HT group was expected to conform to our hypotheses.

Materials

1. *The Revised Transliminality Scale (RTS)*: The 17-item RTS (Lange, Thalbourne, Houran, & Storm, 2000) is a Rasch-scaled version of Thalbourne's (1998) original 29-item, true/false scale (Form B). While all 29 items were administered, twelve items from the original scale were excluded from the scoring of the test due to age- and gender-related response biases (cf. Houran, Thalbourne, & Lange, 2003). Raw scores range from 0 to 17, which are subsequently converted to Rasch-scaled scores. The Rasch scores are used for analysis, and range from 13.70 (no endorsement of any item on the RTS) to 37.30 (endorsement of all items on the RTS). Lange, Thalbourne et al. (2000) set a Rasch-scaled mean of 25 (*SD* = 5) for the RTS. As scores are at an interval-level of measurement, those above the Rasch mean indicate higher trait levels of transliminality compared to those below the Rasch mean. The Rasch reliability of the RTS is .82 (Lange, Thalbourne et al., 2000), which translates to a KR-20 reliability coefficient of .85. Furthermore, Houran et al. (2003) reported a test-retest reliability of .82 for this measure over an average of seven weeks based on the data from Thalbourne (2000a).

Items from the RTS that respectively correspond to low, medium, and high levels of transliminality include, (low) "My thoughts have sometimes come so quickly that I couldn't write them all down fast enough;" (medium) "I can **clearly feel again** in my imagination such things as: the feeling of a gentle breeze, warm sand under bare feet, the softness of fur, cool grass, the warmth of the sun and freshly cut grass;" and (high) "For several days at a time I have had such a heightened awareness of sights and sounds that I cannot shut them out."

2. *Computer Aided Sensory Evaluator (CASE) IV System*: The CASE IV System (Version 4.26: WR Medical Electronics Co., 1995) is an automated diagnostic device for detecting and characterising sensory thresholds. The CASE IV quantified participants' vibrotactile thresholds by controlling the amplitude of a series of non-invasive vibrotactile stimuli and recording the participants' responses.

Vibration was at 125 cycles per second and the amplitude was variable between 0 and 576 micrometers. The cantilevered design provided a 30-gram preloading force. The pad of the second finger of the participants' non-dominant hand was placed under the stimulating stylus, and the height of the stimulator was adjusted to compensate for different finger dimensions. The height adjustment knob was then used to level the vibration stimulator.

Dyck et al.'s (1993) adaptive 4, 2, and 1 stepping algorithm was used for threshold testing. Testing began at an intermediate level (13 micrometers). The stimulus increased (if not felt) or decreased (if felt) by four steps to the point of turnaround (felt at the higher level when not felt at lower levels, or not felt at the lower level when it had been felt at the higher level). After the first turnaround, stepping was in steps of two. After the second turnaround, stepping was done by steps of one. A total of twenty stimulus events were used. Five of these were randomly distributed null stimuli.

Procedure and Design

Participants were given a brief introduction to the study that involved a review of its basic protocol. The administration of the RTS was sequentially counterbalanced with threshold determination. The following statement was read to participants immediately before the threshold testing:

> This is a test of your ability to detect a vibration. The test is not painful. It usually takes from three to four minutes. The stimulus may feel like vibration, buzzing, trembling, or rumbling. Some people cannot describe it, but they know a stimulus was given. All you have to do is decide whether you felt a stimulus during the interval when the number "1" is displayed. You will feel the stimulator resting on your finger at all times. I will ask you to decide whether you felt an additional vibrating or other mechanical stimulus during the presentation of number "1" on the display. After the number "1" has disappeared, you should push "yes" if you felt a vibration, or "no" if you did not feel a vibration. Please get comfortable, relax your hand, and do your best. As you complete this task, you will be listening to various sounds through a set of headphones. Once again, the object is to determine the smallest vibration you can feel. Do you have any questions?

During administration of the CASE IV test, a LED alerted participants of the impending onset of a test-interval. The participant was presented with a series of stimuli varying in amplitude using an adaptive 4, 2, and 1 test algorithm (Dyck et al., 1993), i.e., the amplitude of the subsequent stimulus was dependent upon this participant's response. The participants indicated "present" or "absent" during each stimulus interval by pressing a response key. This algorithm determined the amplitude of the next stimulus presented. During the course of a given test, the system determined the participants' vibrotactile thresholds in micrometers and scaled in 'just noticeable differences' (JNDs). When the test was complete, the CASE IV stored the participants' data on the computer for later analysis.

Participants received three practice intervals to minimise training effects and to ensure that they understood the procedure for the vibrotactile test. Intervals consisted of three runs of twenty threshold determination trials (as per the 4, 2, and 1 stepping algorithm), while the participant was exposed to each of four competing auditory stimuli presented over a set of headphones. Thus, the participant completed three trials for each auditory condition, and the average threshold for each condition was used for analysis. One auditory condition involved listening to a low-amplitude (56 db SPL, conversation level in a very quiet environment) recording of white noise. The second condition involved listening to a low-amplitude recording of a musical arrangement judged by the experimenters to be equal to the low-amplitude noise condition in overall loudness. The third condition involved listening to a moderate-amplitude (70 db SPL, conversational level in an office environment) recording of white noise, and the fourth condition involved listening to a moderate-amplitude recording of the previous musical arrangement judged by the experimenters to be equal to the moderate-amplitude noise condition in overall loudness. Each participant completed threshold determination for each of the four auditory conditions. The presentation order of the auditory conditions was randomised across participants.

The CASE IV system generated the white noise. A Koss stereo (Model No. PC38G) was used to present the musical selection (the song "Abacab" by the music group *Genesis*). This song was selected for its variance in musical notes and its relatively long duration of 252 seconds. The stereo was set to play continuously during the music conditions. Participants received a five-minute break between each of the four auditory conditions. The vibrotactile thresholds and times to obtain a threshold were recorded for each of the three runs of twenty trials and then averaged to produce a mean threshold and a mean time of completion for each of the four auditory conditions. The administrator of the threshold test (J.H.) was blind to whether participants were in the HT or LT group.

Data Analysis

A mixed-effects factorial ANOVA was used to assess vibrotactile thresholds. Transliminality (low vs. high) and Gender (male vs. female) were the between-subject variables, and Intensity (low vs. high) and the Stimulus Dynamics (white noise vs. music) were the within-subject variables. The Tukey procedure was used for all post hoc analyses. Estimates of effect sizes for the ANOVAs were computed with partial eta squared, which gives the proportion of variance in the dependent variable that is associated with levels of an independent variable (Tabachnick & Fidell, 1996).

RESULTS

Thresholds

The high Transliminality (HT) group (M = 7.15, SD = 2.11) evidenced significantly lower thresholds than the low Transliminality (LT) group (M = 12.45, SD = 2.06), $F(1, 46) = 74.16$, $p < .001$, eta-squared = .617. No significant interactions of Transliminality with Gender or Stimulus Dynamics were found (F's < 1). A significant interaction between Transliminality and Intensity was found, $F(1, 46) = 78.15$, $p < .001$, eta-squared = .629.

As depicted in Figure 1, the threshold of the LT group did not significantly change as a function of the competing stimulus intensity ($M_{low} = 12.37 \pm 2.05$, $M_{high} = 12.65 \pm 2.07$, $p = .81$), whereas thresholds for the HT group were increased in the presence of the higher intensity stimulus ($M_{low} = 5.13 \pm 2.47$; $M_{high} = 9.22 \pm 2.46$, $p < .01$). We note that this is still lower than the mean threshold of the LT group (9.22 vs. 12.37, $p < .01$). Thresholds for the experimental conditions were computed as the average of the threshold obtained on three successive runs of twenty trials. The average intercorrelation between threshold values for the three trials was .983. In spite of the practice trials given before data collection, there was a small decrease in threshold values across the three trials (9.88 ± .31; 9.81 ± .31; 9.71 ± .31, respectively). This .17 decrease in threshold was significant, $F(2, 92) = 5.73$, $p < .01$, eta-squared = .111, and may reflect slight fatigue in participants over the course of the testing.

Time to measure thresholds

The same mixed-effects factorial design was employed to analyse the amount of time that the self-paced participants took to arrive at a threshold.

There were no significant main effects or interactions that involved Stimulus Dynamics or Gender. However, there was a significant interaction between Transliminality and Intensity, $F(1, 46) = 15.49$, $p < .001$, eta-squared = .252. As shown in Figure 2, the intensity effect (longer completion times when the competing stimulus was more intense) was larger for the HT group ($M_{low} = 110.09$ sec., $SD = 2.93$ vs. $M_{high} = 119.08$ sec., $SD = 4.73$, $p < .001$) than for the LT group ($M_{low} = 120.86$ sec., $SD = 12.77$ vs. $M_{high} = 122.48$ sec., $SD = 8.02$, $p = .81$).

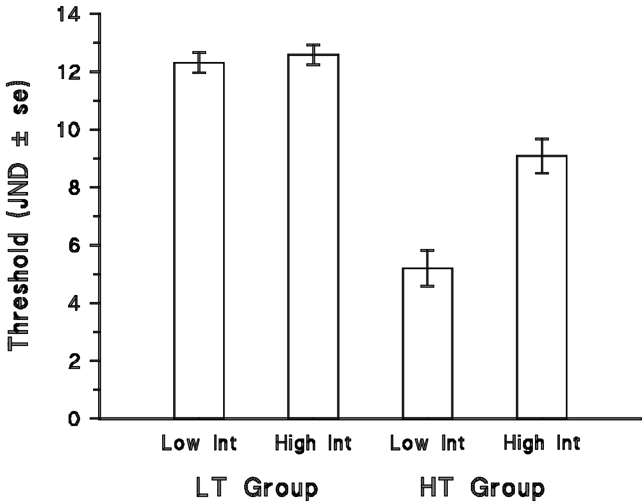

Figure 1. Vibrotactile thresholds of the low and high Transliminality groups during simultaneous masking by low and high auditory Intensity conditions.

The only other significant effects were the resulting main effects of Transliminality, $F(1, 46) = 7.59$, $p < .01$, eta-squared = .142, and Intensity, $F(1, 46) = 32.07$, $p < .001$, eta-squared = .411. Time to complete threshold determination was also recorded on the three successive trials. The average intercorrelation for time to determine threshold values for the three trials was .784. There was a small increase in the time to determine threshold values across the three trials (117.63 ± 1.190; 118.11 ± 1.303; 118.65 ± 1.411, respectively), and this increase of 1.02 seconds was significant, $F(2, 92) = 3.56$, $p < .05$, eta-squared = .072. This combination of decreased thresholds and increased time to reach a threshold might reflect a small effect of a speed-accuracy trade-off.

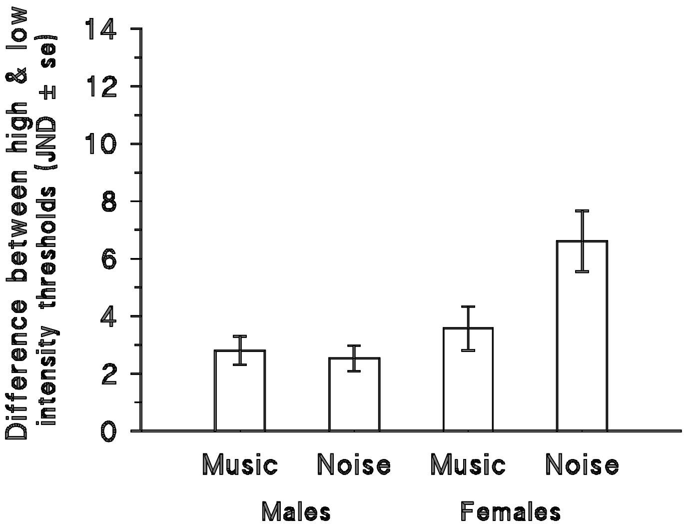

Figure 2. Difference in thresholds between high and low Intensity conditions for each Complexity stimulus by Gender.

Intensity Effects

Intensity of the competing auditory stimulus interacted with all variables; however, the effect size for any of these effects (except the Transliminality x Intensity effect discussed above) was very small. In an effort to understand the higher order interactions involving Intensity, separate analyses were run for the LT and HT groups. When only the LT group was considered, we failed to find any significant interactions of Intensity with Stimulus Dynamics or Gender (p's > .49). When only the HT group was considered, the interaction of Intensity x Stimulus Dynamics x Gender was significant, $F(1, 15) = 33.49$, $p < .001$, eta-squared = .691.

A plot of this interaction (see Figure 3) revealed a difference in threshold related to the intensity of the competing stimulus that was approximately the same for the music stimuli and the noise stimuli for males (–0.04) and a little smaller for music than for noise stimuli for females (+3.03).

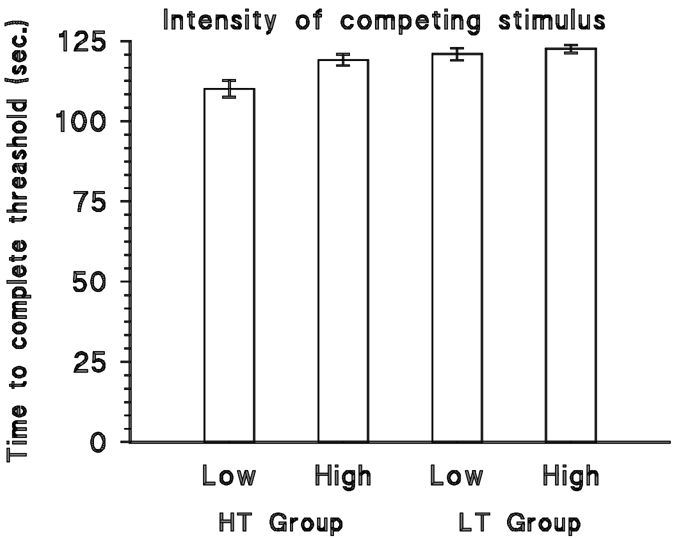

Figure 3. Time for the low and high Transliminality groups to complete thresholds during simultaneous masking by low and high auditory Intensity conditions.

The statistically significant differences due to Stimulus Dynamics or Gender for the HT group appear to be very small (in the order of the trial-to-trial variability of threshold measurement) and not systematically related to the treatment.

Possible Response Biases

Two participants (both from the HT group) evidenced a false positive, each on just one occasion. These two individuals obtained mean threshold values that ranked the second to lowest (M = 12.32 JND) and the highest (*M* = 22.42 JND) within the HT group. The false positives occurred during the white noise condition (one at high intensity and one at low intensity). In particular, the individual who made the false positive during the high-intensity/white noise condition received the 7th lowest mean threshold within the HT group (*M* = 25.16 JND), whereas the individual who made the false positive during the low-intensity/white noise condition received the second lowest mean threshold within the HT group (*M* = 3.50 JND). The lack of false positives prevented us from calculating indices of sensitivity or response bias. However, it appears that false positives were nearly absent for both Transliminality groups, i.e., participants from both groups indicated that a vibration was present only when they seemed absolutely confident. Furthermore, the false positives did not correspond to the individuals with the lowest thresholds in the HT group. Accordingly, we conclude that response biases cannot entirely account for the lower vibrotactile thresholds of the HT group.

DISCUSSION

Crawley et al. (2002) showed that high scores on transliminality are associated with greater sensitivity to priming cues. Our study complements their work by demonstrating that scores on transliminality are also related to actual changes in sensory thresholds. As expected, the HT group evidenced significantly lower vibrotactile thresholds than the LT group. These findings suggest that attentional mechanisms of the HT group are more easily affected than those of the LT group.

For example, the thresholds of the LT group did not significantly vary with differences in the Intensity or dynamics of the competing auditory stimulus, but the thresholds of the HT group increased in the presence of a competing stimulus of high Intensity. However, even when the vibrotactile thresholds of the HT group were affected by a competing stimulus of high Intensity, their thresholds were still significantly lower than the thresholds of the LT group. The thresholds of the HT group did not increase in the presence of a dynamic stimulus, which could mean that the musical arrangement did not possess the qualities that interfere with attentional mechanisms or inhibit sensory gating.

Besides lower thresholds, the HT group consistently demonstrated faster times to obtain a threshold (i.e., complete the testing) than the LT group. Additional work is needed to determine whether this effect reflects faster processing at the sensory level and/or more disinhibition on the motor level, but, taken together with the fact that these quicker times were associated with lower thresholds in the HT group, it indicates that this effect of speed cannot be attributed to a speed-accuracy tradeoff. Analysis of the times to obtain a threshold pattern in the HT group provided further indication of weaker sensory gating or cognitive mechanisms regarding attention as compared to the LT group. The Intensity of the competing stimulus negatively affected the time to obtain thresholds for both Transliminality groups, but the Intensity effect was strongest for the HT group. Lastly, the magnitude of the interaction of Intensity x Stimulus Dynamics x Gender suggests that this finding is a minimal effect at best. In fact, the magnitude was no greater than the fluctuation in magnitudes found in repeated trials of the threshold testing.

The cumulative findings from this study can be interpreted as being broadly consistent with the idea proposed by Thalbourne et al. (2001) that transliminality involves enhanced hyperconnectivity among frontal-subcortical loops and primary or secondary sensory areas and/or sensory association cortices, which is expressed behaviourally as a weaker ability to gate or ignore irrelevant stimuli. Nevertheless, additional research is needed to confirm these results with other sensory modalities and with alternative research designs. For instance, a two-interval forced-choice task might be a more effective method to estimate the influence of possible response bias. Moreover, stronger evidence for the ideas of Thalbourne et al. (2001) would come from studies that directly relate RTS scores to differences in the hypothesised brain activity.

The HT group consistently outperformed the LT group in responding to vibrotactile stimuli that were simultaneously presented with competing auditory stimuli, but the decreased ability of the HT group to gate (i.e., ignore) competing stimuli of higher intensity could suggest that there is a point at which increased levels of transliminality change from being functional (such as in promoting creativity) to maladaptive (such as promoting schizotypal and schizophrenic-like experience). In other words, the trend towards higher thresholds for the HT group depicted in Figure 1 might be extended with stimuli of even higher levels of intensity and thereby lead to thresholds in the HT group that exceed those in the LT group. This speculation speaks to one referee's comment that, aside from the competing auditory stimuli, perhaps HT scorers cannot ignore other types of stimulation, such as somatic-internal sensations and various forms of mental imagery, affect, and cognition that could intrude upon the conscious awareness of HT participants during the threshold testing. Thus, it might be predicted that HT scorers would generally show higher, not lower, sensory thresholds. Our findings of lower thresholds and quicker times to obtain those thresholds in the HT group do not support this idea for at least moderately high Rasch levels of transliminality. However, we agree that extreme scorers on the RTS (e.g., schizophrenics) would be expected to exhibit higher thresholds compared to other experimental groups, as well as show a speed-accuracy trade off. Interestingly, Saoud et al. (2000) recently presented results consistent with this basic speculation.

From a psychometric perspective, our findings and those of Crawley et al. (2002) bolster the construct validity of the RTS. Until the recent experimental work linking transliminality to empirical thresholds, the validity of the scale was based on correlations with a number of anticipated attitudinal and experiential phenomena. William James (1982) provided an especially cogent and vivid description of some expected manifestations of transliminal processes:

> If the word 'subliminal' is offensive to any of you . . . call it by any other name you please, to distinguish it from the level of full sunlit consciousness. Call this latter the A-region of personality, if you care to, and call the other the B-region. The B-region, then, is obviously the larger part of each of us, for it is the abode of everything that is latent and the reservoir of everything that passes unrecorded or unobserved. It contains, for example, such things as all our momentarily inactive memories, and it harbors the springs of all our obscurely motivated passions, impulses, likes, dislikes, and prejudices. Our intuitions, hypotheses, fancies, superstitions, persuasions, convictions, and in general all our non-rational operations come from it. It is the source of our dreams, and apparently they may return to it. In it arise whatever mystical experiences we may have, and our automatisms, sensory or motor; our life in hypnotic and 'hypnoid' conditions, if we are subjects to such conditions; our delusions, fixed ideas, and hysterical accidents, if we are hysterical subjects; our supra-normal cognitions, if such there be, and if we are telepathic subjects. It is also the fountainhead of much that feeds our religion. (pp. 483-484)

The comprehensive listing of the various correlates of the RTS in Table 1A (see APPENDIX) nicely parallels the early speculations of William James.

The findings summarized in the APPENDIX also update Thalbourne's (2000c) review of transliminality. Since the construct of transliminality is supported by evidence from psychometric, personality, behavioural, and cognitive realms, it provides an updated conceptual framework for reinterpreting psychological concepts such as absorption, "openness to experience", imaginative involvement, fantasy proneness, "flexibility of repression" and ego-permissiveness. Transliminality is not a synonym for these concepts, but rather it is a construct that subsumes them within a single dimension. Therefore, it is to be expected that RTS scores correlate with many cognitive, affective, perceptual, and behavioural processes.

On the other hand, future research might profitably examine the construct specificity of the Revised Transliminality Scale. Such efforts might reveal that this instrument has applications beyond theoretical research and can perhaps be a valuable measure for use in clinical or other applied contexts. Transliminality might therefore be theoretically and clinically important in understanding the proposed continuum within the general population along which ordinary and pathological forms of thought and perception may be mapped (Claridge, 1990, 1997; Johns, Nazroo, Bebbington & Kuipers, 2002; Posey & Losch, 1983-1984; Prentky, 1989).

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APPENDIX

Table 1A.
Comprehensive Summary of Correlations† between the Revised Transliminality Scale and Salient Attitudinal Variables and Experiential Phenomena

Attitudinal/Personality Variables	**Correlation with Revised Transliminality Scale**	**Reference**
Cattell's 16PF		
A (warmth)	.20*	Lange, Thalbourne, Houran & Storm (2000)
G (rule-consciousness)	-.20*	″
M (abstractedness)	*.36**	″
Q_1 (openness to change)	.22*	″
TM (tough-mindedness)	-.32*	″
SC (self-control)	-.21*	″
Openness to Experience	.33‡, *	Thalbourne (2000b), reanalysis
Religiosity	.48‡, **	Thalbourne & Delin (1999)
Hartmann's Boundary Questionnaire—total score	.66**	Houran, Thalbourne, & Hartmann (2003)
Hartmann's Boundary Questionnaire—categories		
Sleep/Wake/Dream	.52‡, **	″
Unusual Experiences	.57‡, **	″
Thoughts/Feelings/Moods	.63‡, **	″
Childhood/Adolescence/ Adulthood	.23‡, **	″
Interpersonal	.23‡, **	″
Sensitivity	.31‡, **	″
Neat/Exact/Precise	.28‡, **	″
Edges/Lines/Clothing	.41‡, **	″
Opinions about Children/Others	.17‡, **	″
Opinions about Organisations/Relationships	.38‡, **	″
Opinions about Peoples/Nations/Groups	.32‡, **	″
Opinions about Beauty/Truth	.32‡, **	″

Attitudinal/Personality Variables	**Correlation with Revised Transliminality Scale**	**Reference**
Whitely Index (Hypochondriacal Tendencies)	.30‡, **	Houran, Kumar, Thalbourne, & Lavertue (2002)
″	.22*	Houran, Wiseman, & Thalbourne (2002)
Cognitions About Body and Health Questionnaire		
Bodily Weakness	.19**	Houran et al. (2002)
Intolerance of Bodily Complaints	.16**	″
Autonomic Sensations	.29**	″
Screening for Somatization Symptoms questionnaire	.25**	″
Behavioural/Experiential Phenomena	**Correlation with Revised Transliminality Scale**	**Reference**
Creativity	.42**	Thalbourne (2000a) reanalysis
Tellegen's seven-item Synesthesia scale	.61**	Houran, Wiseman, & Thalbourne (2002)
Seven-item memory aberration scale	.53**	Houran & Thalbourne (2003)
Primed subliminal perception (visual)[a]	.29**	Crawley, French, & Yesson (2002)
D-prime subliminal perception (visual)[a]	.21*	″
Three-item dream recall scale	.17‡, a	Thalbourne & Delin (1999)
Lucid dreaming (Australian sample)	.37**	Thalbourne & Houran (2000), further analysis
Lucid dreaming (US sample)	.34**	″
Spadafora & Hunt's (1990) Dream Scale		
Archetypal	.39**	Lange, Thalbourne, Houran & Storm, 2000)

Behavioural/Experiential Phenomena	**Correlation with Revised Transliminality Scale**	**Reference**
Fantastic Nightmare	.24*	″
Posttraumatic Nightmare	.48**	″
Lucid	.42**	″
Prelucid	.35**	″
Night Terror	.46**	″
Hood's Mysticism Scale	.66‡, **	Thalbourne & Delin (1999)
Mystical Experience Ratings	.51‡, **	″
Absorption (corrected for item overlap)	.72‡, **	Thalbourne (1998)
Anomalous Experiences Inventory		
Paranormal Experience	.65**	Thalbourne (2001)
″	.65**	Houran et al. (2002)
Paranormal Belief	.58**	Thalbourne (2001)
″	.54**	Houran et al. (2002)
Paranormal Ability	.61**	Thalbourne (2001)
″	.48**	Houran et al. (2002)
Encounter subscale	.61**	Houran & Thalbourne (2001)
″	.46**	Houran et al. (2002)
Poltergeist subscale	.51**	Houran & Thalbourne (2001)
″	.45**	Houran et al. (2002)
Rasch-Tobacyk's Revised Paranormal Belief Scale		
New Age Philosophy	.47**	Thalbourne (2001)
″	.52**	Houran, Wiseman, & Thalbourne (2002)
Traditional Paranormal Beliefs	.37**	Thalbourne (2001)
Traditional Paranormal Beliefs	.33**	Houran, Wiseman, & Thalbourne (2002)
Mental Experience Inventory		
Paranormal Belief (Australian sample)	.54**	Thalbourne & Houran (2000), further analysis
(US sample)	.59**	″

Behavioural/Experiential Phenomena	Correlation with Revised Transliminality Scale	Reference
Paranormal Experience (Australian sample)	.75**	″
(US sample)	.77**	″
Sense of Being High (Australian sample)	.57**	″
(US sample)	.57**	″
Daydreaming (Australian sample)	.57**	″
(US sample)	.46**	″
Sense of Mental Potency (Australian sample)	.68**	″
(US sample)	.43**	″
Introspection (Australian sample)	.71**	″
(US sample)	.60**	″
Success rate on test of psi (hitting on *I Ching* hexagrams)[a]	.26**	Storm & Thalbourne (1998-1999)
Total number of discrete 'haunt' experiences reported during a parapsychological field study	.22**	Houran, Wiseman, & Thalbourne (2002)
Total number of different modalities of 'haunt' experience reported during a parapsychological field study	.21*	″
Personal Philosophy Inventory (Persinger, 1984)		
General Temporal Epilepsy Scale	.72[‡], **	Thalbourne, Houran, & Crawley (2003)
Complex Partial Epileptic Signs	.71[‡], **	Thalbourne, Houran, & Crawley (2003)
All Temporal Lobe Signs	.70[‡], **	″
Sense of Presence	.57[‡], **	″
Liberal (Exotic) Beliefs	.56[‡], **	″
Depersonalisation	.55[‡], **	″
Auditory-Vestibular Experiences	.53[‡], **	″

Behavioural/Experiential Phenomena	**Correlation with Revised Transliminality Scale**	**Reference**
Visual Images	.52‡, **	″
Paranormal Experiences	.48‡, **	″
Hypomania	.39‡, **	″
Intense Meaning	.38‡, **	″
Olfactory Experiences	.37‡, **	″
Perseveration	.36‡, **	″
Hypergraphia	.26‡, **	″
Rare (Psychotic-like)	.24‡, **	″
Limbic Motor	.23‡, **	″
Acquiescence Response Bias	.23‡, **	″
Conservative Religious Beliefs	.21‡, **	″

Notes: † Spearman rank-order correlations unless otherwise noted
‡ Pearson correlations as reported in the original sources
[a] $p = .06$ (two-tailed); * $p \leq .05$; ** $p \leq .01$