Augmenting Media with Thermal Stimulation

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Abstract. Thermal interfaces are a new area of research in HCI, with one of their main benefits being the potential to influence emotion. To date, studies investigating thermal feedback for affective interaction have either provided concepts and prototypes, or looked at the affective element of thermal stimuli in isolation. This research is the first to look in-depth at how thermal stimuli can be used to influence the perception of different media. We conducted two studies which looked at the effect of thermal stimuli on subjective emotional responses to media. In the first we presented visual information designed to evoke emotional responses in conjunction with different thermal stimuli. In the second we used different methods to present thermal stimuli in conjunction with music. Our results highlight the possibility of using thermal stimuli to create more affective interactions in a variety of media interaction scenarios.

Keywords: Thermal, stimulation, emotion, audio, visual, valence, arousal.

1 Introduction

Thermal stimulation is an emotive and salient feedback channel, but it has yet to be fully investigated. Thermal stimulation has a number of potential benefits for interaction. It can act as an alternative non-visual notification channel for situations that are too bumpy or noisy for vibrotactile and audio feedback. Thermal output is also entirely private; in contrast, vibrotactile feedback can sometimes still be heard or felt by others. It can augment both visual and non-visual displays to add an extra richness to the interaction experience. In particular, in many cases it may be possible to enhance or dampen affective (emotion/feeling) experience, such as in gaming, media or many other fields, as thermal stimulation is said to have an inherent emotional aspect [1]. Indeed, several systems have proposed the use of thermal stimulation as a way of conveying emotion or enhancing affect in users [2-7]; however, none of these systems have effectively determined methods for influencing emotion. Other work by Wilson et al. [8] and Salminen et al. [9] focus on user responses to a thermal stimulus, but do

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so in isolation, which ignores the possibility of using thermal stimuli to add extra affective richness to interaction. Nakashige et al. [7] presented a first attempt at this by presenting people with images of food and thermal stimuli. They found that in some limited cases thermal stimuli influenced the perception of the images, such as eliciting a feeling of a "loving home" from warm soup. However, their findings were for a very limited range of visual information (familiar warm and cold objects/scenes), as they did not explore the full range of uses for thermal stimuli, either in terms of content (i.e. beyond simply warm/cold objects) or affective response to that content. To overcome these shortcomings in understanding the application of thermal stimuli to alter the affective state of a user we conducted two studies. In the first we presented images which had been mapped to a variety of emotions [10] in conjunction with thermal stimuli. Our aim was to determine if presenting thermal stimuli with visual information could influence the user's affective experience/response. Following on from this, we conducted a second evaluation, where we used some of the temperature-emotion mappings to create different thermal sensations in conjunction with music. Our aim is to compare different thermal presentations for enhancing subjective emotional responses.

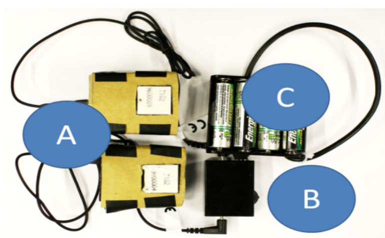
2 Related Work

There are a number of prototypes that use thermal stimulation for affect. Gooch [2] constructed a device to provide thermal feedback with the goal of increasing feelings of social presence in remote interactions. His findings indicated that the use of the device significantly increased the feeling of social presence. Hannah et al. [3] proposed a number of prototypes that use mobile devices for interacting with televisions for entertainment. One prototype used thermal stimuli to enhance media browsing by presenting cool stimuli for programs with cold themes and vice versa. Iwasaki et al. [4] present a prototype called the AffectPhone, a system that detects a user's emotional state and conveys this state via changes in the temperature of the back panel of the handset of the other user. Narumi et al. [5] developed the Thermotaxis system, where users are encouraged to explore a physical space using thermal stimuli by using hot and cold spots in the space. Lee and Lim [6] investigate the prospect of thermo-messaging, conveying information with thermal stimuli. Lee and Lim discuss an emotional aspect of thermal stimuli as being one of the benefits, but did not investigate this aspect in detail. As discussed earlier, Nakashige et al. [7] augmented images and a search game with thermal stimuli from adapted computer mice. They found that, in some cases, temperature could enhance emotional feeling when presented with congruent visual stimuli. Williams and Bargh [11] have demonstrated how thermal stimulation can influence perception of others and decision making. Most of these studies are proofs of concept and none discuss the mapping between different stimuli and emotions and, in many cases, do not provide robust evaluations.

To provide a more in-depth understanding of the effectiveness of thermal stimuli, Wilson et al. [8] examined responses to thermal cues in terms of subjective comfort and intensity. While this is useful for designing thermal interfaces, they do not provide guidelines for enhancing media with thermal stimuli. With a focus on emotion, Salminen et al. [9] investigated if thermal stimuli presented to the palm could influence emotional responses when measured with emotion-related subjective rating scales and changes in skin conductance response (SCR). Their results showed that two different methods for presenting warm stimuli elevated the ratings of arousal and dominance, and in some cases that warm and cold stimuli elevated the SCR. These final two studies indicate that thermal stimuli can be used to influence affect. However, these studies investigated thermal stimuli in isolation. As demonstrated by the research prototypes outlined earlier [2-7], thermal stimuli will be used in conjunction with different media e.g. audio, images etc. in the future, so there is a need to understand the impact of thermal stimuli on the perception of and interaction with media.

3 Equipment

For our studies we used a custom controller connected to a two-channel Peltier heat pump (Fig 1)[1]. Peltier heat pumps allow for a high level of control over temperature output and also allow for both heating and cooling from the same pump. Both Peltier devices could be independently controlled via Bluetooth, with the temperature set anywhere within the range of -20°C to +45°C, accurate to 0.1°C.

(1) 

(2) 

Fig. 1. (1)Thermal hardware used in the experiment consisting of microcontroller (B), Peltier stimulators (A, white squares) and battery pack (C). (2) Close up of Peltiers.

4 Evaluation 1: Influence of Thermal Stimuli on Visual Data

4.1 Design and Procedure

The aim of the first evaluation was to investigate the impact of thermal stimuli on visual information designed to evoke emotional responses. In order to provide emotionally stimulating visual information the International Affective Picture System (IAPS) [10] was used. The IAPS was developed to provide a set of normative emotional stimuli for experimental investigations of emotion and attention. From the IAPS collection, we selected 25 images, consisting of 5 images each from 5 emotional

[1] Built by SAMH Engineering.

areas selected according to the Russell Circumplex model of affect [12]. This model uses valence and arousal as parameters, valence refers to the please/displeasure continuum, arousal refers to the alertness. The 5 emotional areas we chose were: sad/depressed (low valence/low arousal), nervous/stressed (low valence/high arousal), alert/excited (high valence/high arousal), happy (high valence/low arousal) and calm/bored (low valence/low arousal). We tried to avoid images that could be associated with thermal stimulation e.g. images of warm coffee, etc.

A neutral starting temperature of 32°C was chosen as this is within the defined 'neutral zone' of thermal sensation [8,1]. The skin was adapted to this temperature before each trial session and was returned to it between each stimulus presentation. As thermal perception is bipolar, both warming and cooling stimuli were used. One thermal stimulus intensity point was used: 6°C, meaning the terminal points were 38°C and 26°C; two temperatures that are well removed from the cold and hot pain thresholds. This single intensity point was chosen to ensure that users felt the stimulus [8]. Two different rates of stimulus change (ROC) were used: 1°C/sec and 3°C/sec. Different ROC's were used as a user's perceived magnitude of the sensation is not based solely on the extent that the stimulator changes from skin temperature, but also by the ROC to that end point. For example, the same intensity (e.g. 6°C) will feel subjectively less intense when warmed/cooled at the slower ROC of 1°C/sec, compared to the faster 3°C/sec [8]. Thus different ROC could have an impact on perception of media. Thus a single stimulus consisted of warming or cooling to a set intensity (6°C) and at one of two ROC (1°C/sec or 3°C/sec), for example, warming 6°C at 1°C/sec. Including the 'control' stimulus of not changing the temperature when an image was presented, this meant there were 5 possible stimuli which are no thermal stimulation, warm slow, warm fast, cool slow and cool fast. Each possible thermal stimulus was presented with a single image from each of the 5 emotional spaces. The thermal stimuli were all presented to the Thenar eminence (the bulbous region of the palm adjoining the thumb) of the non-dominant hand. This was chosen as Wilson et al. [8] found it had the highest sensitivity.

Fig. 2. Thenar placed on Peltiers

Each participant was sat at a desk upon which there was a computer monitor and mouse. The Peltier stimulators lay on the desk in front of the participant, facing up so that the users could lay the Thenar of their non-dominant hand on the stimulators (see Fig 2). At the start of each condition, the stimulators were set to a neutral temperature of 32°C for 1 minute so as to adapt the skin to this temperature. After the adaption period, all 25 images and thermal stimulus combinations were presented in a random order. A stimulus presentation comprised of 10 sec. of thermal stimulus while viewing the image followed by a return to the neutral temperature and at least 20 sec. of adaptation, the image was only present during the thermal stimulus. Once the stimulation was over, two 9-point Likert scales appeared on screen asking the participants to rate the image in terms of intensity (from "weak" to "intense") and pleasantness (from "negative" to "positive"). The independent variables were: rate of change (1°C/sec or 3°C/sec), direction of change (warm or cool), and image emotion (sad/depressed, nervous/stressed, alert/excited, happy and calm/bored). The dependent variables were: subjective intensity (arousal) and subjective pleasantness (valence).

Thirteen participants took part in our evaluation; the majority were staff or students at the University. The group consisted of 10 males and 3 females, with an average age of 28. All were right handed and were paid £6.

4.2 Results and Discussion

A Friedman's analysis of variance by ranks was used to analyse the effect of direction of change (warm and cool), rate of change (1°C/sec or 3°C/sec) and image emotion (sad/depressed, nervous/stressed, alert/excited, happy and calm/bored), with Wilcoxon pairwise comparisons. Table 1 shows the impact of direction on the average valence and arousal values for each of the emotional groups. Direction of change was found to have a significant effect on valence for the excited emotion ($\chi2$ (2)=9.875, p=0.007). Post hoc Wilcoxon T (adjusted alpha = 0.0167) comparisons showed significant differences in the perceived valence between cool and constant (z=2.653, T=83, p=0.008). As well as these significant changes some interesting trends were observed. In general, warm changes result in higher valence and arousal values in comparison with cool, with some exceptions. Also, again with some exceptions, thermal stimulation increases arousal, but decreases valence in comparison with no changes in thermal stimulation.

Table 1. Average, median and standard deviation for valence and arousal for each emotion and direction of stimulation

	Valence					Arousal				
	Bored	Excited	Happy	Sad	Stressed	Bored	Excited	Happy	Sad	Stressed
Warm	6.308 6.5 1.517	4.692 4.5 2.131	7.462 7.5 1.449	3.385 3 1.098	2.346 2 1.294	3.654 3 2.190	6.308 7 1.995	4.308 4 2.259	5.731 6 1.710	6.731 7 1.733
Cool	6.154 6 1.617	4.308 4 1.892	7 7 1.265	2.961 3 1.183	2.615 2.5 1.359	3.462 3 2.044	6.615 7 1.768	3.615 3 1.551	5.346 6 1.875	6.038 6 1.949
Constant	7.077 7 1.320	6.538 4 1.450	7.538 8 1.330	2.462 3 0.967	2.769 3 1.013	3.154 2 2.340	5.692 6 2.250	2.846 2 2.075	6.154 6 1.345	5.923 7 2.431

Table 2 shows the impact of rate of change on the average valence and arousal values for each of the emotional groups investigated. Rate of change was found to have a significant effect on valence for the excited emotion ($\chi2$ (2)=11.878, p=0.003). Post hoc Wilcoxon T comparisons showed significant differences in the perceived valence between 3°C/sec and constant (z=2.816, T=85.5, p=0.005). As well as these significant changes some interesting trends were observed. A comparison of the two ROC shows that they have similar arousal values; however the faster ROC has a higher valence value indicating that it was more pleasant. In comparison with no stimulation, there are mixed results but the ROC does not seem to have as large an impact as the direction of change did.

Table 2. Average, median and standard deviation for valence and arousal for each emotion and ROC

	Valence					Arousal				
	Bored	Excited	Happy	Sad	Stressed	Bored	Excited	Happy	Sad	Stressed
1°C/sec	6 6 1.523	4.346 4 2.190	7.154 7 1.156	3.385 3 1.329	2.769 2.5 1.366	3.115 3 1.818	6.231 7 1.861	4.385 4 2.041	5.269 6 1.823	6.231 6.5 1.796
3°C/sec	6.461 7 1.581	4.654 5 1.832	7.308 8 1.569	2.962 3 0.916	2.192 2 1.234	4 3 2.298	6.692 7 1.892	3.538 3 1.794	5.808 6 1.744	6.538 6.5 1.944
Constant	7.077 7 1.320	6.538 6 1.450	7.538 8 1.330	2.462 3 0.967	2.769 3 1.013	3.154 2 2.340	5.692 6 2.250	2.846 2 2.075	6.154 6 1.345	5.923 7 2.431

5 Evaluation 2: Influence of Thermal Stimuli on Audio

5.1 Design and Procedure

The aim of the second evaluation was to evaluate the impact different methods of presenting thermal stimuli (using some findings from the first evaluation) on listening to music. This evaluation focused on three different emotional areas in the Russell Circumplex model of affect [11]: happy, sad and exciting. Happy and sad were chosen as they are quite different, also many studies of emotion and music have identified happy and sad pieces of music [13,14]. Exciting was chosen as it was most influenced by thermal stimulation in comparison with other emotions in the first evaluation.

The music pieces were chosen based on the dynamics in the music, this was chosen due to its presence in nearly all music. Mohn [15] showed that loud volume is often an identifiable characteristic in happy music, while conversely low volume is an identifiable characteristic of sad music. It was also shown that surprising (close to exciting in the emotional spectrum) was identifiable by ascending dynamics/volume [15]. The happy and sad pieces were all directly used in studies of emotion and music [13,14], while the exciting pieces were chosen to be of the same genre as the others and to match the musical elements in exciting music (as identified above). An excerpt of approximately one minute in length that contained appropriate dynamics was selected from each of the following pieces. The happy pieces were Alfven, 'Midsommervarka' (25s – 1m 23s); Beethoven, 6th Symphony 'Pastoral' (3s – 1m 2s) and Vivaldi, 'La Primavera' (Le Quattro Stagioni Op8 Rv269) (1m 6s – 1m 58s). The sad pieces were Albioni, Adagio Gminor (6m 48s – 7m 52s); Barber, Adagio for Strings (3s – 1m 11s) and Faure, Elegie Cminor Op24 (9s – 1m 14s). The exciting pieces were Beethoven, Symphony 9 2mvt. 'Molto Vivace' (3s – 1m 21s); Mozart, 'Eine Kleine Nactmusik' 1mvt. Allegro (4s – 57s) and Dvorak, 'Slavonic Dances' Op46 No.1. (1s – 1m 6s).

For each emotion three different presentation styles for the thermal stimulus were chosen. The first presentation type was no stimulus i.e. staying at a neutral temperature. The second was a constant temperature. The final was what we called pulsing, in this presentation mode certain points were chosen in the music track to present thermal stimulus for 10 seconds at a time. 10 seconds was chosen as an arbitrary presentation time. In order to choose when the thermal stimulus should be presented we analysed the dynamics in the audio track. For the happy music the pulse occurred at the highest volume peak; for the exciting pieces the pulses started 3 seconds before their peak, as one of their key classifying elements is their ascending dynamics, crescendos, into peaks; and for the sad pieces the pulse occurred at the lowest volume level. There are other potential presentation styles and parameters we could have chosen, but the intention of the experiment was not to be exhaustive but rather compare the merits of a small set of presentation styles. As well as using different presentation styles for the different music excerpts, different thermal stimuli were also chosen based on the results from the first evaluation. The two non-neutral stimuli will change from either neutral (30^{0}C) to hot (38^{0}C), if the current emotion of the excerpt is happy or exciting, or neutral to cool if excerpt is sad (22^{0}C). It should be noted that we are using larger intensity changes in comparison with the first evaluation, the aim was to evoke more of a response from the participants, these temperatures are still removed from pain thresholds [1]. In all cases the ROC was 3°C/sec. The task was split into 3 conditions based on emotions, with the order of emotion groups rotated. Participants were seated, in front of a computer monitor, with their non-dominant hand resting on the Peltiers (see Fig 2). Their dominant hand will be used to control the computer mouse to answer questions on-screen. They listened to music using a set of headphones. The skin under the Peltiers was adapted to neutral for 1 minute at the beginning of this experiment. In each emotional block participants heard one of the music excerpts and received a thermal stimulus via one of the presentation techniques. The order of presentation technique and music excerpt was randomised. Once the stimulation was over, two 9-point Likert scales appeared on screen asking the participants to rate the music in terms of intensity (from "weak" to "intense") and pleasantness (from "negative" to "positive"). The independent variables were: presentation type (constant, pulse or none) and music emotion (sad/depressed, alert/excited and happy). The dependent variables were: subjective intensity (arousal) and subjective pleasantness (valence). After the 3 excerpts within an emotional group have been played, the participants were asked to rate their experiences in terms of preference, emotion and stimulation. Nine participants took part in our evaluation; the majority were staff or students at the University. The group consisted of 6 males and 3 females, average age of 22.33 years.

5.2 Results

Table 3 shows the average responses in terms of valence and arousal. None of the differences were found to be significant, but the general trend was that the pulsing presentation style increased arousal across all emotions in comparison with no stimulus. The pulsing also increased reported valence for excited and decreased valence for sad, these emotions are associated with high and low valence respectively. However for happy there is a small decrease in valence. The constant presentation technique increases arousal in the sad and excited categories, but decreases it in the happy category. Constant also increased reported valence for happy and decreased valence for sad, again these emotions are associated with high and low valence respectively. However for excited there is a small decrease in valence. None of these changes in perception were found to be statistically significant.

Table 3. Average and standard deviation for valence and arousal data for each emotion and presentation type

	Happy		Sad		Excited	
	Valence	Arousal	Valence	Arousal	Valence	Arousal
None	6.444 (1.589)	5.778 (2.167)	3.111 (1.269)	6.000 (2.000)	6.778 (1.302)	5.778 (2.224)
Constant	6.889 (1.167)	5.667 (1.732)	2.667 (1.000)	6.111 (2.315)	6.667 (1.732)	5.889 (1.691)
Pulse	6.333 (1.732)	6.222 (2.108)	3.000 (0.866)	6.444 (2.007)	7.000 (0.866)	6.778 (0.667)

The user preferences for the different presentation techniques are shown in Table 4. For exciting pieces of music the participants found the pulse presentation technique to be the most emotive, stimulating and preferable. In contrast, for exciting, the constant presentation technique was found to be the least emotive and stimulating, and as preferable as no presentation. For happy there was very little difference between all presentation styles, although no thermal presentation technique was reported as being more emotive than pulse or constant. Finally for the sad pieces, users had a slight preference for the pulse; no stimulation was the least emotive, but in contrast was reported as being the most stimulating. None of these differences were statistically significant. To gain more insight into user preferences, other feedback provided by the users were analysed. It seemed that previous associations with some of the classical pieces for some users may have caused unexpected results. In particular Barbers Adagio, a sad piece, has been sampled in a modern song so for many it had more positive connotations. Physical separation of the stimuli sources meant that several users felt that there was a disconnection between the audio and thermal (music from headphones, heat on hand). This prevented a unified experience, in some cases causing the thermal stimuli to distract from the music (P7 “I'm very conscious of the thermal sensation. If it were more subtle then perhaps it could --it may have been and I didn’t notice it”). In addition some of the participants found the thermal stimuli to be too intense, in particular the warm changes (P3 “didn't really like the hot feeling”; P4 “although being an awesome track, the temperature was too warm and this made the song not very enjoyable”). Despite this many participants enjoyed the thermal sensations in conjunction with the music (P2 “the increasing heat along with the crescendo made it more intense”; P4 “both cold and warm sensation added something to the emotions felt, compared to the normal-temperature sensation”).

Table 4. Median rankings for different comparison of presentation techniques

	Con. Exc.	Con. Hap.	Con. Sad	Pul. Exc.	Pul. Hap.	Pul. Sad	Non. Exc.	Non. Hap.	Non. Sad
Prefer	2	2	2	1	2	1.5	2	2	2
Emotive	2.5	2.5	2	1	2	2	2	1.5	3
Stimulating	3	2	2	1	2	2	2	2	1

6 Discussion and Conclusion

This work has highlighted some potential benefits of using thermal stimulation to enhance affect, but has also raised some interesting research questions. Thermal stimulation had an effect on the perceived valence and arousal of both visual and audio media. In general thermal stimulation increases the arousal of media interaction in comparison with no stimuli; also warm stimuli make an interaction more pleasant than cool stimuli. Some feedback from the user evaluations also raised a number of issues which could be investigated in future work. Firstly, some users were very aware of the separation of sources of stimuli, future work will look at the positioning of thermal stimulation to create a more unified experience. Secondly, when the stimulation end point was changed in the second evaluation many participants found the stimuli to be distracting rather than enhancing the experience. A broader range of stimuli should be investigated to match specific media/experiences. Thirdly participants preferred "pulsing" stimulation which matched the content of the media more than constant stimulation. This indicates that matching the stimulation to the content can enhance media more than flat/constant stimulation. More research is needed to match different stimuli with the different content of different media. In conclusion this research has highlighted many future research directions for enabling affective thermal interfaces. Overall this work is an important first step to the realisation of those interfaces and has highlighted the potential of using thermal interfaces to influence the affective perception of multimedia.

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References

1. Stevens, J.C.: Thermal Sensibility. In: Heller, M.A., Schiff, W. (eds.) The Psychology of Touch. Lawrence Erlbaum, New Jersey (1991)
2. Gooch, D.: An Investigation into Communicating Social Presence With Thermal Devices. MSc Dissertation, University of Bath:1-390 (2009)

3. Hannah, D., Halvey, M., Wilson, G., Brewster, S.: Using Multimodal Interactions for 3D TV and Multimedia Browsing. Paper Presented at the 9th International Conference on Interactive Television, EuroITV (2011)
4. Iwasaki, K., Miyaki, T., Rakimoto, J.: AffectPhone: A Handset Device to Present User's Emotional State with Warmth/Coolness. In: BIOSTEC 2010 (B-Interface Workshop), pp. 1–6 (2010)
5. Narumi, T., Akagawa, T., Seong, Y.A., Hirose, M.: Thermotaxis. In: SIGGRAPH 2009, p.1 (2009)
6. Lee, W., Lim, Y.-K.: Thermo-message: exploring the potential of heat as a modality of peripheral expression. Presented at the 28th of the International Conference Extended Abstracts on Human Factors in Computing Systems (2010)
7. Nakashige, M., Kobayashi, M., Suzuki, Y., Tamaki, H., Higashino, S.: "Hiya-Atsu" media: augmenting digital media with temperature. In: Proceedings of CHI 2009, Boston, MA (2009)
8. Wilson, G., Halvey, M., Brewster, S.A., Hughes, S.A.: Some Like it Hot? Thermal Feedback for Mobile Devices. Paper Presented at the ACM CHI Conference on Human Factors in Computing Systems, Vancouver, Canada (2011)
9. Salminen, K., Surakka, V., Raisamo, J., Lylykangas, J., Pystynen, J., Raisamo, R., Makela, K., Ahmaniemi, T.: Emotional Responses to Thermal Stimuli. Paper Presented at the 13th International Conference on Multimodal Interfaces, ICMI (2011)
10. Lang, P.J., Bradley, M.M., Cuthbert, B.N.: International affective picture system (IAPS): Affective ratings or pictures and instruction manual. Paper Presented at the Technical Report A.8. University of Florida, Gainesville, FL (2008)
11. Williams, L.E., Bargh, J.A.: Experiencing physical warmth promotes interpersonal warmth. Science 322(5901), 606–607 (2008)
12. Russell, J.A.: A Circumplex Model of Affect. Journal of Personality and Social Psychology 39(6), 1161–1178 (1980)
13. Baumgartner, T., Elsslen, M., Jancke, L.: From emotion perception to emotion experience: Emotions evoked by pictures and classical music. International Journal of Psychophysiology 60(1), 34–43 (2006)
14. Kreutz, G., Ott, U., Teichmann, D., Osawa, P., Vaitl, D.: Using music to induce emotions: Influences of musical preference and absorption. Psychology of Music 36(1), 101–126 (2007)
15. Mohn, C., Argstatter, H., Wilker, F.-W.: Perceptions of six basic emotions in music. Psychology of Music 39(4), 503–517 (2011)