Emotional reactions to point-light display animations

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Abstract: Emotional reactions to basic, artificial, yet carefully controllable point-light displays (PLDs) were investigated with ratings of valence, arousal, approachability, and dominance. PLDs were varied by movement location (upper and lower) and intensity (10°, 20°, and 30° angular change) for angular upward and downward movements. Half of participants ($N = 28$) were told that PLDs were related to face while to other half nothing was hinted. Results showed that 20° and 30° angle lower location upward movements were rated as significantly more pleasant, relaxing, and approachable than corresponding upper location downward movements. Informed participants rated 20° and 30° angle lower movements as significantly more controllable than corresponding upper movements. Results are important from many perspectives, like for understanding human perceptual mechanisms. When using PLDs only a small amount of information needs to be transmitted. This enables low bandwidth requirements. As PLD visualisations are simple, there is no need for high-definition displays.

Author keywords: Point-light displays; biological movement; biological motion; emotions; face perception; human-computer interaction

ACM classification keywords: Laboratory experiments; Information visualization; Psychology

Research highlights:

- The aim of the experiment was to investigate emotional reactions to basic, artificial, yet carefully controllable point-light display (PLD) animations with the ratings of valence, arousal, approachability, and dominance.
- It was found that the PLDs convey emotional information.
- The knowledge of PLD processing can be valuable both for basic research and for human-computer interaction applications.

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1. INTRODUCTION

Point-light displays (PLDs) of biological movement patterns refer to the means of presenting complex information by relatively simple dot-based representations of original source of information. For example, a moving human body can be represented by a group of a few moving dots (Johansson, 1973). There is evidence that humans are able to distinguish biological movement patterns of human movements from other patterns of motion signals, like random movement of dots or movement of other mammals than humans. Johansson (1973) studied the perceptual capacity of recognising human movements using only PLDs of human walkers. The stimulus material of the experiments consisted of videos of moving persons, videotaped against a black background in black clothing so that only reflecting material attached on the limbs was visible while the actors moved. The participants were able to recognise spontaneously that the moving group of dots was a human walker. Further, people often associate movements, like PLD movements, to be related to social communication. Bassili (1976) found that temporal and spatial changes in the movements of two circles had an effect on participants' ratings on whether or not the circles were interacting with each other. For the explanations about the interaction participants used words like "chasing" and "following".

PLDs have also been used to study the recognition of face related information, including gender recognition, facial expression recognition, emotion recognition development, narrowed recognition in disorders, etc. PLDs showing facial movements have been used to investigate the development of sensitivity to gender information (Berry, 1991). Gender recognition based on facial expressions has been studied by comparing the recognition of gender from PLD representations and full face representations (Hill, Jinno, & Johnston, 2003). Emotion related information processing has been studied with PLDs in schizophrenia (Tomlinson et al., 2006), and infant development (Doi et al., 2008). Further, PLDs have been used in some brain-imaging studies to understand which regions of the brains are responsible of processing facial expression information (Atkinson, Vuong, & Smithson, 2012; Ichikawa et al., 2010).

In principle, PLDs offer means to investigate basic human perceptual processes. Bassili (1978; 1979) hypothesised that the movement in facial expressions is a key factor in evoking both the perception of a human face and the emotion related information in the face. In a series of studies by Bassili (1978; 1979), the usual features of the face, like eyes, nose, and mouth, were omitted, and only the facial movement was shown with PLDs. PLDs showing emotional facial expressions were made by real human actors by blackening the face and attaching contrasting spots on the face so that the videotaped expressions appeared only as series of movements of the spots. The participants watched at the emotional facial expressions videotaped in a PLD condition and in a real face condition. The results showed that recognition errors of emotional facial expressions were similar between the PLD condition and the real face condition. Further, the importance of different parts of the face in the facial expression recognition was investigated in both face-related conditions. It was found that visible lower part of the face was needed for the recognition of happiness, sadness, and disgust. Visible upper part of the face was needed for the recognition of surprise and anger.

Pollick et al. (2003) studied PLD visualisation of naturalistic emotional expressions of anger, happiness, sadness, and surprise. They varied the visualisation motion by spatial exaggeration and timing of the movements, and measured the effects of variations to the recognition and intensity ratings. They found that the manipulation of the spatial exaggeration had an effect on both the emotion recognition and the intensity ratings, whereas the manipulation of the movement timing had a small effect on the ratings of emotion intensity. Afzal et al. (2009) generated three different sets of animations from four datasets of facial emotional expressions to investigate how a certain set of feature points can convey affective content. In their animations, the same facial expressions were shown either by a PLD animation, a stick figure animation, or a 3D avatar. Interestingly, they found that the recognition rate of the expressions was higher with simple PLDs than with the 3D avatar. Matsuzaki and Sato (2008) investigated the critical number of dots needed for the recognition of the expressions of anger, happiness, sadness, and surprise with stationary dot patterns. The stimuli were generated from facial images. They varied the amount of dots to be 10, 14, 18, or 34, and found that the recognition rate of anger, happiness, and surprise improved when the number of dots increased from 10 to 18 dots. Increasing the dots up to 34 did not improve the recognition any further. In the case of sad expression, the recognition rate improved throughout the whole range of the amount of dots. Further, they investigated the recognition of the same expressions with 18 or less dots in two conditions. In one condition, called as a repetitive condition, a group of dots in an expressive representation was shown twice. In another condition, called as an apparent motion condition, the participants firstly saw a group of dots in a neutral representation, following a group of dots in an expressive representation. In their study, Matsuzaki and Sato found that the recognition performance was improved as the amount of dots increased. The recognition rates of happy and surprised expressions were higher overall than the recognition rate of sad and angry expressions. Additionally, they found that compared to the repetitive condition the apparent motion improved the recognition of angry, happy, and surprised facial expressions when the amount of dots was decreased. Still further, they investigated if the recognition of the expressions is affected by disturbing the apparent motion by placing a white field between the two frames, the neutral frame and the expressive frame. Here, the recognition rates were again compared between the apparent motion condition and the repetition condition. The result was that the recognition of an expression was disturbed when the white field was shown and the advantage of apparent motion compared to the repetition condition was lost. In sum, it seems that the recognition of an expression is possible even with minor spatial information as long as the motion of an expression is available. This was noticed in other experiment too (Cunningham & Wallrave, 2009).

The observed studies prove that simple facial PLDs have a serious potential to convey information about face presence, gender, and even emotional expressions with motion information. However, to understand more deeply the effect of movement on facial emotion related information processing there is clearly a need to create even more simplistic and systematically controlled representations of supposedly human facial movements. For this, in contrast to previous work, which used real facial information as a source for PLDs, we created a set of purely artificial and fully controllable PLDs. Such an approach makes it possible to better understand the effects of expression intensity, angular changes, and the location of a movement, for example.

As noted already by Bassili (1979), the human face can be divided into two parts in which the movements of facial expressions mainly take place, (1) to the upper part of the face which is the forehead area, including the eyes and eyebrows, and (2) the lower part of the face which includes the cheeks, the mouth area, and the jaw. Further, Bassili (1979) suggested that there appear certain directions of the facial expression movements. Simply put, the facial movements can be represented by upward and downward movements of the facial feature points, like the eyebrows and the mouth corners, including some angular and shape changes of the features. Based on these considerations we created highly basic, artificial, yet carefully controllable PLD animations, consisting of angular, upward and downward movements, in order to initially investigate both the movement information processing and the possible emotional response elicitation by the PLD animations. As many of the findings above deal with facial information, we were further interested in the role of the face related context when processing information that has basically no obvious relation to faces. This was investigated by informing one half of the participants of the face presence, while the other half did not have this information. By dividing the participants into two groups we expected to find out if the participants' reactions were similar or not despite the prior knowledge about the stimuli.

There are several approaches in theories of emotions. One is the discrete emotion theory (e.g., Ekman, 1992) saying that human emotion system consists of certain specific emotion patterns that are differentially represented in the brain and body. Following this the emotional reactions include specific brain activations, physiological responses, emotional experiences, and facial expressions. These specific sets of activations are frequently referred to as a set of basic emotions of happiness, sadness, surprise, anger, disgust, and fear. Many of the earlier studies investigating functionalities of PLDs have used this approach more or less explicitly as, for example, the PLDs have been created to represent slightly varying set of discrete emotional expressions. Further, the main purpose of the previous experiments has been to find out how accurately PLD representations of different expressions can be recognised. The recognition accuracy has been measured usually with forced choice questionnaires.

Another central theory of emotions is called as the dimensional theory of emotions. According to this theory, emotions consist of a set of dimensions that reflect appetitive or directional motivational (approach-withdrawal) behaviour, the intensity of the behaviour (calm-aroused), and the level of control one has over a situation or stimulation. The most used emotional dimensions are pleasantness (valence) and level of activation (arousal) (e.g., Osgood, 1952; Schlosberg, 1954; Russell, 1980; Bradley & Lang, 1994). According to, for example, Russell (1980) it is possible to locate the discrete affects to dimensions of valence and arousal. In respect to the measurement of emotional reactions along these dimensions there is a long history of developing rating scales. A frequently used method has been to use nine-point numeric bi-polar dimensional rating scales or the Self-Assessment Manikin (SAM) which is a pictorial method to make ratings of how one feels about various things like sounds and pictures. SAM (Bradley & Lang, 1994) has three dimensions called valence (varying from unpleasant to pleasant), arousal (varying from calm / relaxed to aroused), and dominance (varying from a feeling of being controlled to being in control). Further, the valence dimension has been argued to reflect appetitive processes (i.e., withdrawal-approach dimension) without actually asking the ratings of approachability (Lang et al., 1993). For this reason a fourth dimension called as approachability (varying from avoidable to approachable) has been used (e.g., Anttonen & Surakka, 2005).

There is a lot of evidence on the crucial meaning of emotions to nearly all types of human behaviour (Damasio, 1995). Following this the potential of emotions have been recognised also in the field of human-computer interaction (HCI). Affective computing is a field of research that aims to bring emotions into the HCI. It aims at developing emotionally intelligent computational devices which are able to recognise and express emotional information. Emotionally intelligent systems would also be able to adapt the systems' behaviour to the user's emotional reactions (e.g., Picard, 1997). In critique to Picard's original thoughts the interactional approach of emotions emphasizes the interactive nature of emotions when designing systems in respect to emotions. According to this view, emotions can be seen as situational products which are closely dependent on the context, interpretation, and interaction. At the same time, emotions contribute to the construction of the culture and the interactions between people. Interactional approach finds subjective experiences as more meaningful than physiological responses in respect to human emotions. Thus, the measurements should also reflect this impetus (Boehner et al., 2007). According to Norman (2013) emotions have a great effect to our preferences of using different products and according to him it is also crucial to take the users' emotional experiences into account during design process. So regardless of theoretical approach on emotions in HCI the importance of emotions has been clearly recognized.

Although most of the earlier studies using PLDs have mainly used the idea of discrete emotions as their background (e.g., asking people to recognise certain specific emotion categories), our study took the dimensional approach as the background. Firstly, in the field of HCI the use of the dimensional approach has a strong background. For example, Pfister, Wollstädter, and Peter (2011) measured emotional experiences towards messages of a computer system with the ratings of valence, arousal, and dominance. Secondly, as we did not use any specific facial expressions to extract our stimuli as had been done in earlier studies the use of dimensional approach was more realistic. Thus, the present aim was to investigate if the artificial PLD representations elicit emotional responses only by different angular upward and downward movements by means of dimensional ratings of emotions.

2. METHODS

2.1. Participants

Twenty-eight (14 male, 14 female) voluntary participants took part in the experiment. Their mean age was 30 years (range 19-46 years). All the participants had normal or corrected to normal vision by their own report. The participants were divided into two equal sized groups: (1) a group to which it was hinted that the animations were somewhat related to face area (called as informed group from now on) and (2) a group, to which this prior knowledge was not provided (called as non-informed group from now on).

2.2. Apparatus

A standard laptop PC (Dell Latitude E6530 with 2.60 GHz processor and 8 GB RAM) with 64 bit Windows 7 Enterprise (SP 1) was running E-Prime 2.0 experiment generator software (Psychology Software Tools, Pittsburgh, PA). The external display was a 24" Samsung SyncMaster 2443BW with screen resolution of 1920 × 1200 pixels. For rating tasks the participants used a standard keyboard. The experiment was run in a sound-attenuated laboratory premises.

2.3. Stimuli

The PLDs were designed as two horizontal rows, which can be also called as reference lines, consisting of 6 equally-sized white dots fitted into an imaginary square and located on a plane black background, as the Figure 1 (left column) shows. The width of the square was approximately 25% of the display width and the diameter of a dot was approximately 10% of the square width. This initial configuration of dots was defined as a neutral PLD representation. Based on the design of the neutral PLD, six different stimulus animations were created. Two movement locations and directions were used: (1) an upward movement of the four outermost dots on the lower location (Figure 1, upper part), and (2) a downward movement of the four innermost dots (two on each side) on the upper location (Figure 1, lower part). Three intensities were defined for both movements as different approximate angles of the movements from the neutral position to the apex of the movement: 10° for the minimum, 20° for the medium, and 30° for the maximum movement (see Figure 1).

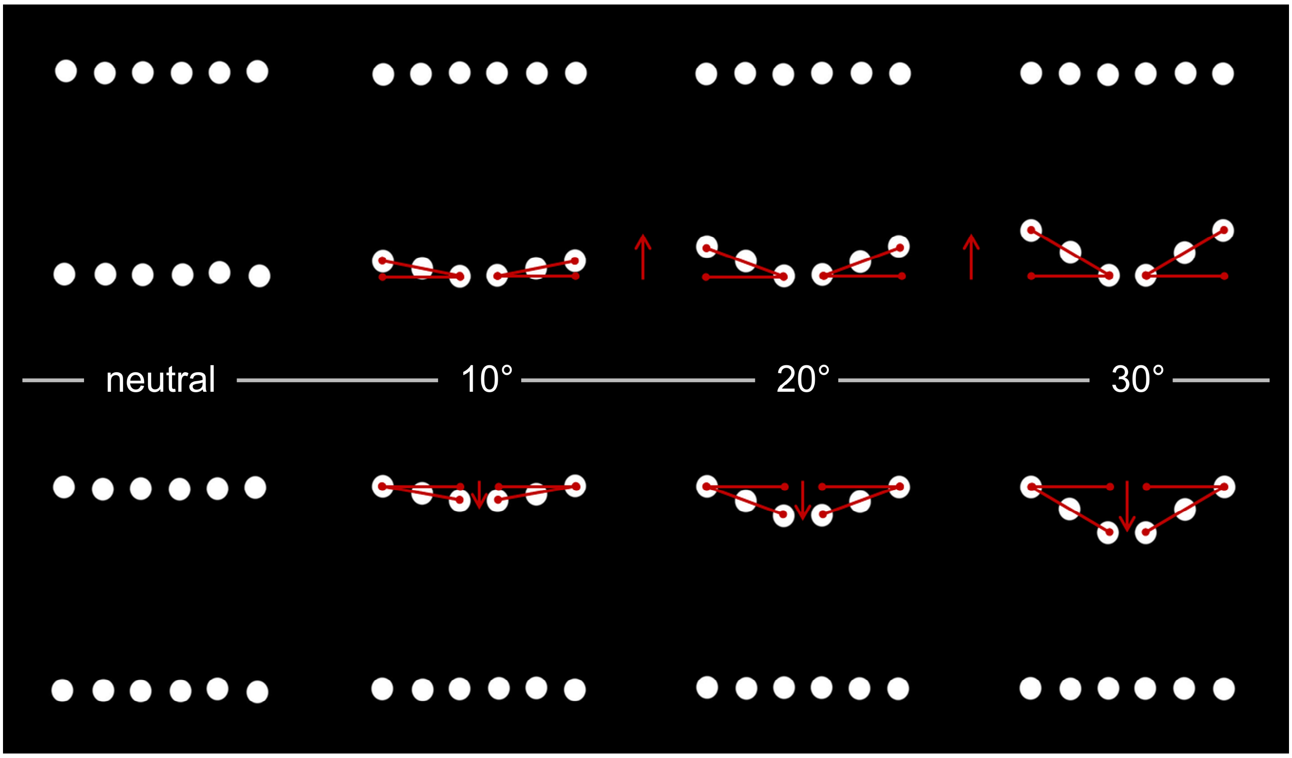

Figure 1. The PLD stimuli. Left column: the neutral position (i.e., the start and the end) of all of the stimuli. The upper part: the three lower location upward movement stimuli in their final positions, minimum, medium, and maximum intensity from left to right, respectively. The lower part: the three upper location downward movement stimuli in their final positions, minimum, medium, and maximum intensity from left to right, respectively.

Each PLD animation was divided in five equally long phases, all lasting five states: 1) At the start, all dots were fluctuating around their start positions in a small 1 × 1 pixel neighbourhood (Figure 1, left column); 2) Either the upward movement of the four outermost dots of the lower row started (Figure 1, upper part) or the downward movement of the four innermost dots of the upper row started (Figure 1, lower part). The other eight dots were fluctuating in place; 3) At the apex of the movement (i.e., when the final position of the dots of a given intensity movement was reached; see Figure 1), all dots were fluctuating in place; 4) The four migrated dots started their return movement towards the neutral position, either upwards or downwards depending on the previous movement. The other eight dots were fluctuating in place; 5) The migrated dots reached the original place on the row and all twelve dots were fluctuating in place (Figure 1, left column). As the time sequence for an animation transition duration from one state to another was 500 milliseconds and in total there was 25 states per animation, the length of an animation was 12 seconds. The frame rate of the animation was supporting a smooth playback with more than 30 frames per second.

2.4. Procedure

After signing a written consent, the participants were seated in front of the display with a viewing distance of 60 cm. Then the purpose of the experiment was described to the participants. For the non-informed group it was told that the purpose was to investigate the basic mechanisms of animation perception, and for the informed group, the participants were told that the purpose was to investigate the basic mechanisms of face perception.

The participants had a practice session before the experimental trial. At the start of the practice, the four bi-polar nine-point emotional scales measuring valence (varying from unpleasant to pleasant), arousal (from relaxing to arousing), approachability (from avoidable to approachable), and dominance (from a feeling of being controlled to being in control) were explained to the participant carefully with written instructions. The rating scales were varying from -4 to +4 and 0 was representing a neutral experience. After this, the participants used the rating scales to rate five practice animations which were played in a randomised order. The animations during the practice trial were totally different than the animations shown during the experimental trial. Finally, it was ensured that the participants were ready to start the experimental trial. During the trial, the six different animations were played and rated one by one five times in a randomised order; thus, there were 30 rating tasks per participant during the experimental trial. After the rating task was finished, the participants answered to an end-questionnaire containing the following questions:

1. Did the seen animations remind you about any objects or things you have seen in real world?
2. Did you rate different animations differently? If you did, in what way the ratings differed?
3. Did you see a face in the animations?
4. If you think you saw a face, which parts of the face were present?
5. If you think you saw a face, what happened on the different parts of the face?

For the non-informed group the end-questionnaire was given in two separate sheets so that the questions 1-2 were shown in the first sheet and the questions 3-5 in the second. The two sheets were used in order to avoid the answers to the questions 1-2 being affected by the way the questions 3-5 were formulated.

Finally, the actual purpose of the experiment was debriefed to the participants. Conducting the experiment took approximately 45 minutes in total.

2.5. Data analysis

The ratings were analysed using a three-way mixed model Analysis of Variance (ANOVA) with experimental condition (i.e., non-informed and informed) as a between subject factor and movement location (i.e., lower and upper part) and intensity of the movement (i.e., minimum, medium, and maximum) as within subject factors. If the sphericity assumption of the data was violated, the Greenhouse-Geisser-corrected degrees of freedom were used to validate the F statistics. Pairwise Bonferroni corrected t-tests were used for post hoc tests when needed.

The questionnaire answers were coded as follows: for the question no. 3, only “yes” answer was calculated, and both “no” and any hesitative answers were recorded as “no” answers to not only to question no. 3 but to questions no. 4 and no. 5 as well. Four of the participants (14.3%) did not provide any answers to the questions no. 1 or 3, that is, they did not get any associations related to the animations. For the question no. 2, the two most common answers were identified, and if the answer did not fall into these two categories, it was recorded as miscellaneous (misc.). The two most common answers were that the participant made the ratings based either on the intensity of the movement or on the particular part of the face. Four of the participants (14.3%) did not provide any answers to the question no. 2.

3. RESULTS

3.1. Valence

For the valence ratings (see Figure 2), a three-way 2 × 2 × 3 (experimental condition × movement location × intensity) mixed model ANOVA showed a statistically significant main effect of movement location, $F(1, 26) = 12.94$, $p < 0.01$; and a statistically significant interaction of the main effects of movement location and intensity, $F(1.60, 41.58) = 10.49$, $p < 0.01$. Main effects of experimental condition and intensity or other interactions of the main effects were not statistically significant.

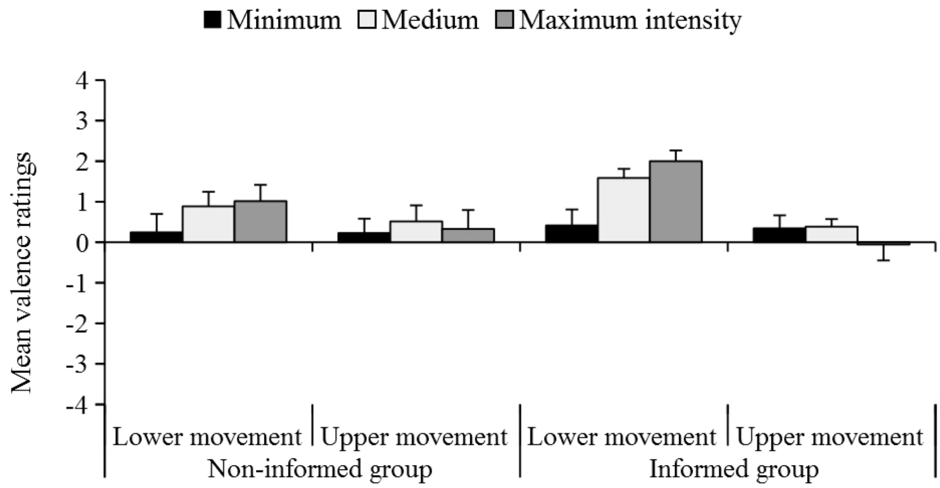

Figure 2. Mean valence ratings and standard error of the means (S.E.M.s) for different stimuli in the two experimental conditions.

Because of the statistically significant interaction of movement location and intensity (see Figure 3), one-way ANOVAs with movement location as a factor were conducted separately for each intensity. The effect of movement location was not significant for minimum intensity. The ANOVA showed a significant effect of movement location for medium intensity, $F(1, 27) = 9.96$, $p < 0.01$. Post hoc pairwise comparisons showed that medium lower movements were rated as significantly more pleasant than medium upper movements, $MD = 0.79$, $p < 0.01$. The ANOVA showed a significant effect of movement location for maximum intensity, $F(1, 27) = 13.69$, $p < 0.01$. Post hoc pairwise comparisons showed that maximum lower movements were rated as significantly more pleasant than maximum upper movements, $MD = 1.37$, $p < 0.01$.

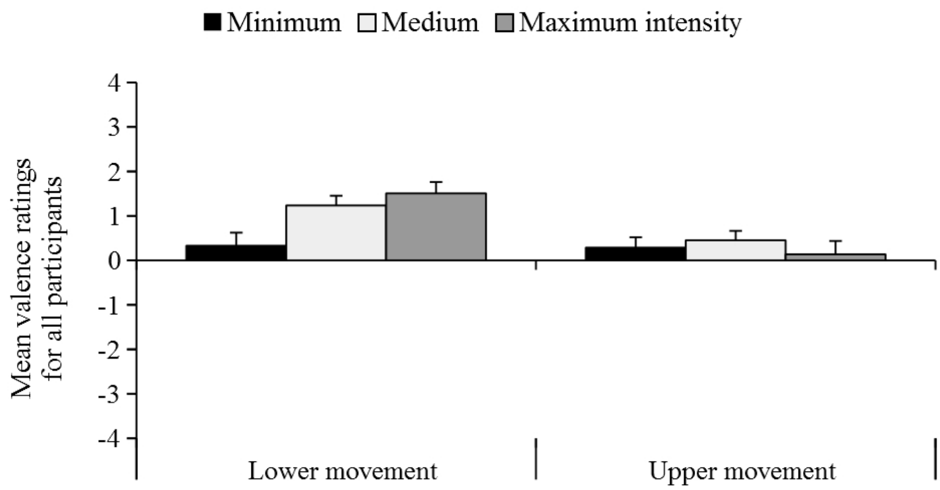

Figure 3. Mean valence ratings and standard error of the means (S.E.M.s) for different stimuli for all the participants.

Further, because of the significant interaction (see Figure 3), one-way ANOVAs with intensity as a factor were conducted separately for both movement locations. The effect of intensity was not significant for upper movements. The ANOVA showed a significant effect of intensity for lower movements, $F(1.32, 35.60) = 8.49$, $p < 0.01$. Post hoc pairwise comparisons showed that medium lower movements were rated as significantly more pleasant than minimum lower movements, $MD = 0.91$, $p < 0.05$; and maximum lower movements were rated as significantly more pleasant than minimum lower movements, $MD = 1.18$, $p < 0.01$. Other pairwise comparisons were not statistically significant.

3.2. Arousal

For the arousal ratings (see Figure 4), a three-way 2 × 2 × 3 (experimental condition × movement location × intensity) mixed model ANOVA showed a statistically significant main effect of movement location, $F(1, 26) = 13.09$, $p < 0.01$; and a statistically significant main effect of intensity, $F(1.42, 36.81) = 27.40$, $p < 0.001$. Main effect of experimental condition or interactions of the main effects were not statistically significant.

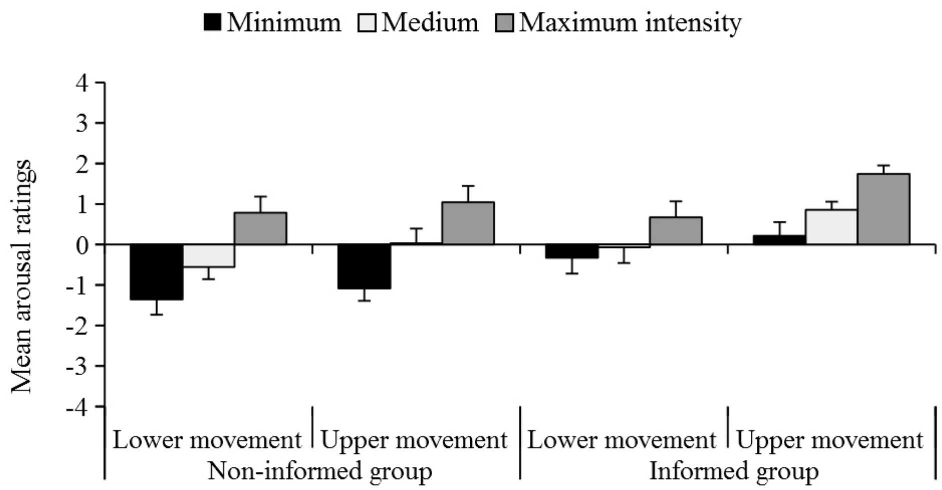

Figure 4. Mean arousal ratings and S.E.M.s for different stimuli in the two experimental conditions.

Post hoc pairwise comparisons for movement location averaged over experimental condition and intensity showed that upper movements were rated as significantly more arousing than lower movements, $MD = 0.61$, $p < 0.01$.

Post hoc pairwise comparisons for intensity averaged over experimental condition and movement location showed that maximum intensity was rated as significantly more arousing than medium intensity, $MD = 1.00$, $p < 0.001$; maximum intensity was rated as significantly more arousing than minimum intensity, $MD = 1.70$, $p < 0.001$; and medium intensity was rated as significantly more arousing than minimum intensity, $MD = 0.70$, $p < 0.05$.

3.3. Approachability

For the approachability ratings (see Figure 5), a three-way 2 × 2 × 3 (experimental condition × movement location × intensity) mixed model ANOVA showed a statistically significant main effect of movement location, $F(1, 26) = 9.57$, $p < 0.01$; and a statistically significant interaction of the main effects of movement location and intensity, $F(1.53, 39.71) = 4.84$, $p < 0.05$. Main effects of experimental condition and intensity or other interactions of the main effects were not statistically significant.

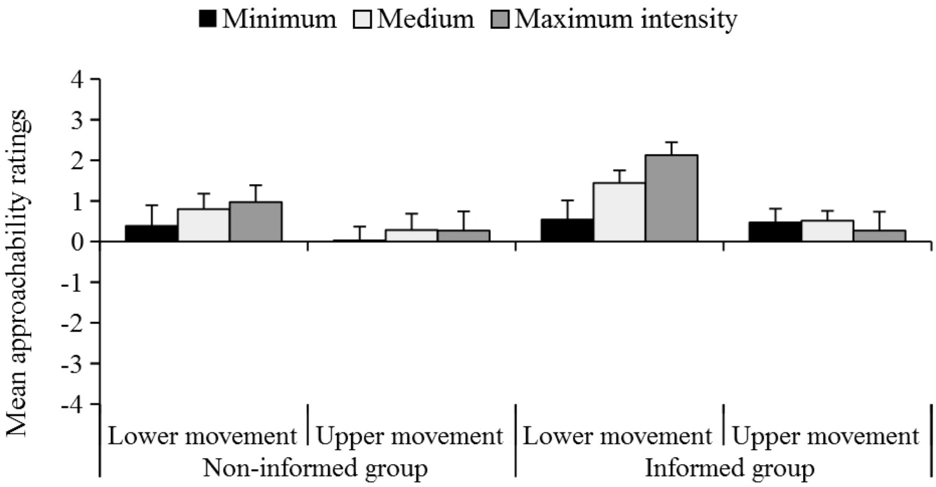

Figure 5. Mean approachability ratings and S.E.M.s for different stimuli in the two experimental conditions.

Because of the statistically significant interaction of movement location and intensity (see Figure 6), one-way ANOVAs with movement location as a factor were conducted separately for each intensity. The effect of movement location was not significant for minimum intensity. The ANOVA showed a significant effect of movement location for medium intensity, $F(1, 27) = 7.18$, $p < 0.05$. Post hoc pairwise comparisons showed that medium lower movements were rated as significantly more approachable than medium upper movements, $MD = 0.72$, $p < 0.05$. The ANOVA showed a significant effect of movement location for maximum intensity $F(1, 27) = 10.44$, $p < 0.01$. Post hoc pairwise comparisons showed that maximum lower movements were rated as significantly more approachable than maximum upper movements, $MD = 1.28$, $p < 0.01$.

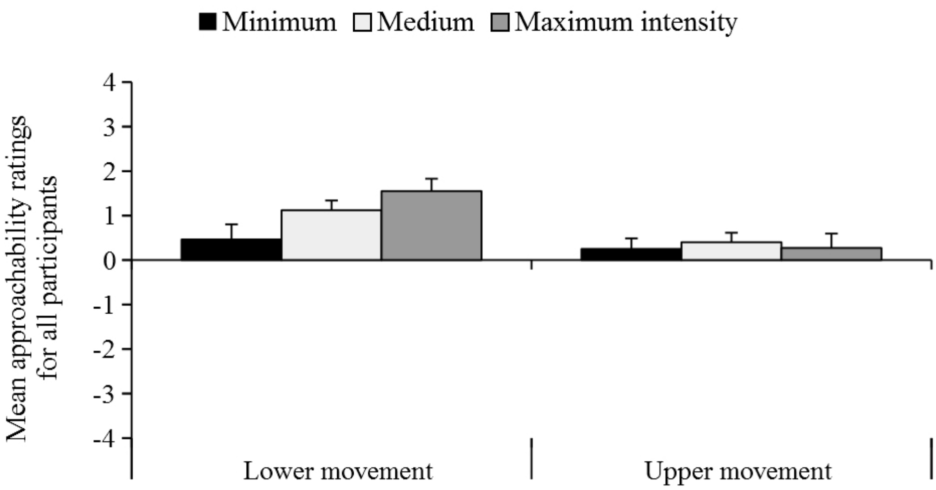

Figure 6. Mean approachability ratings and S.E.M.s for different stimuli for all the participants.

Further, because of the significant interaction (see Figure 6), one-way ANOVAs with intensity as a factor were conducted separately for both movement locations. The effect of intensity was not significant for upper movements. The ANOVA showed a significant effect of intensity for lower movements, $F(1.36, 36.71) = 5.42$, $p < 0.05$. Post hoc pairwise comparisons showed that maximum lower movements were rated as significantly more approachable than minimum lower movements, $MD = 1.09$, $p < 0.05$. Other pairwise comparisons were not statistically significant.

3.4. Dominance

For the dominance ratings (see Figure 7), a three-way 2 × 2 × 3 (experimental condition × movement location × intensity) mixed model ANOVA showed a statistically significant main effect of experimental condition, $F(1, 26) = 6.61$, $p < 0.05$; a statistically significant main effect of movement location, $F(1, 26) = 12.82$, $p < 0.01$; and a statistically significant interaction of the main effects of experimental condition, movement location, and intensity, $F(2, 52) = 3.24$, $p < 0.05$. Main effect of intensity or other interactions of the main effects were not statistically significant.

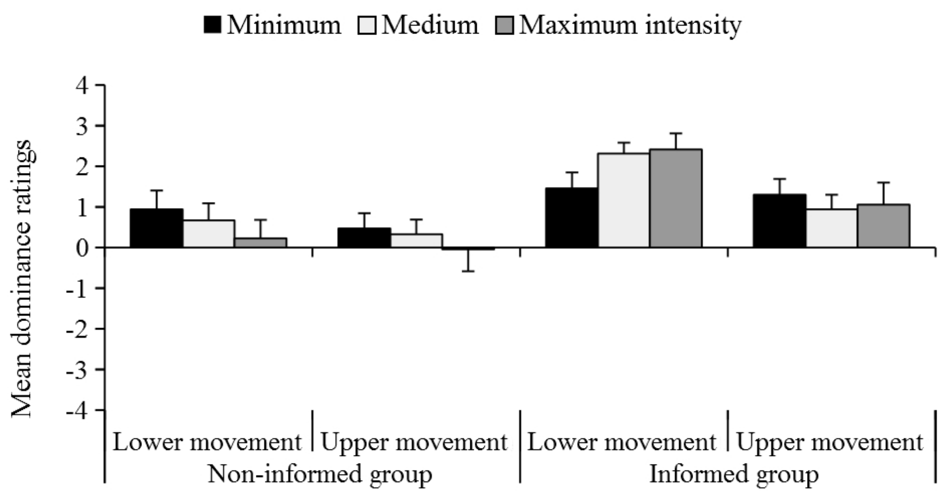

Figure 7. Mean dominance ratings and S.E.M.s for different stimuli in the two experimental conditions.

In order to analyse the interaction between experimental condition, movement location, and intensity, two separate two-way 2 × 3 (movement location × intensity) ANOVAs for the two experimental conditions were conducted. The two-way ANOVA for non-informed group did not reveal any significant main effects or interactions. The two-way ANOVA for the informed group showed a statistically significant main effect of movement location, $F(1, 13) = 10.61$, $p < 0.01$; and a statistically significant interaction of main effects of movement location and intensity, $F(2, 26) = 5.00$, $p < 0.05$.

Because of the statistically significant interaction of movement location and intensity, one-way ANOVAs with movement location as a factor were conducted separately for each intensity. The effect of movement location was not significant for minimum intensity. The ANOVA showed a significant effect of movement location for medium intensity, $F(1, 13) = 17.55$, $p < 0.01$. Post hoc pairwise comparisons showed that medium lower movements were rated as significantly less dominant than medium upper movements, $MD = 1.37$, $p < 0.01$. The ANOVA showed a significant effect of movement location for maximum intensity, $F(1, 13) = 8.17$, $p < 0.05$. Post hoc pairwise comparisons showed that maximum lower movements were rated as significantly less dominant than maximum upper movements, $MD = 1.36$, $p < 0.05$.

Further, because of the significant interaction, one-way ANOVAs with intensity as a factor were conducted separately for both movement locations. The effect of intensity was not significant for either of movement locations.

3.5. End-questionnaire

Table 1 shows the distribution of answers per question per group in percentages.

Table 1. Results of the end-questionnaire.

Question	Non-informed	Informed	All
Saw a face	50.0%	85.7%	67.9%
Saw upper face	35.7%	85.7%	60.7%
Saw lower face	50.0%	85.7%	67.9%
Saw frown	35.7%	71.4%	53.6%
Saw smile	50.0%	85.7%	67.9%
Rated based on the face part	0.0%	35.7%	17.9%
Rated based on the intensity	42.9%	21.4%	32.1%
Rated based on misc.	28.6%	35.7%	32.1%

4. DISCUSSION

Our results showed that using the dimensional approach to emotions the simple, abstract PLD animations were rated statistically significantly differently from each other. Although our PLDs did not originate from naturalistic facial behaviours, it is likely that the designed PLDs were automatically processed by the participants in a way that resembles processing of naturalistic faces. It has been found that humans see faces in even random patterns that have at least some configured properties of faces (Hadjikhani et al., 2009). Our stimuli definitely imitated the face configuration (i.e., upper and lower part) presenting controlled, non-random movement. Thus, when contrasting our findings of PLD animations to other researchers' earlier findings, we will use sources that have investigated more directly facial information processing.

First of all, the ratings of valence showed that the participants rated the lower movement as significantly more pleasant than the upper movement with both 20° and 30° intensities. Previously it has been noted that both static (Adolph & Alpers, 2010) and dynamic (Ku et al., 2005; Sato & Yoshikawa, 2007; Schrammer et al., 2009) full-bodied facial expressions have an effect on emotional valence ratings. In previous studies the participants rated the smiling expressions as more pleasant than the frowning expressions. Additionally, we found that the minimum intensity lower movement was rated as significantly more un-pleasant than the medium and maximum intensity lower movements. This has been noted also previously (Ku et al., 2005). Thus, our findings seem to be in line with the earlier studies investigating facial perception mechanisms.

Moreover, the ratings of arousal showed that the upper movement was rated as significantly more arousing than the lower movement. This finding is in line with the findings of Ku et al. (2005) and Schrammel et al. (2009). Further, there appeared a linear relationship of the rating score and the intensity, so that the minimum intensity was rated as more relaxing than the medium or maximum intensity, and then again, the medium intensity was rated as more relaxing than the maximum intensity. These results are again similar to the results by Ku et al. (2005). In their study, both of the expressions, interpreted as happy and angry expressions, were rated as more arousing the more intense the expression was. Further, it has been found that both happy and angry expressions have been rated as more arousing than neutral expression (Adolph & Alpers, 2010; Sato & Yoshikava, 2007). Therefore, the findings of our experiment are again similar to the previous findings about face perception.

Additionally, the ratings of dominance showed an interaction of the movement direction and the intensity, but only within the informed group. Within this group it was noticed that the upper movements were seen as less controllable than the lower movements with the medium and the maximum intensity levels. Previously, Schrammel et al. (2009) found that the interaction with virtual avatars consisting of facial expressions and eye contact with the participant had an effect to the ratings of dominance. When the eye contact between the avatar and the participant was mutual and the avatar was smiling, the participants rated that they were in more control of themselves than in the case when avatars' facial expression was angry. Again, our results are in line with the earlier results. Furthermore, as shown in Figure 7, the informed participants rated the animations overall to be more controllable than the non-informed participants did and thus, it seems that the informed participants felt themselves to be in more control over the animation when they had the prior knowledge of face presence. Maybe this finding also reflects the argument made by Boehner et al. (2007) emphasising the case that emotions can be seen as situational products which are closely dependent on the context. Thus the prior knowledge in our study changed the frame of interpretation.

Putting together the ratings of valence, arousal, and dominance, it seems that at the two highest intensity levels of selected PLDs, the experienced emotional reactions were significantly more positive to lower movement than to upper movement. This is also reflected in the ratings on the approachability scale. Here, the combination of the expression and the intensity again affected the given ratings so that the lower movements were rated as significantly more approachable than the upper movements on the medium and maximum levels of the movements. These findings are highly intriguing also for the reason that looking at the stimuli (see Figure 1), one can see that the end results of upper and higher movements are exactly the same in form. Only the location (up or down) is changed. This could add to the arguments of Bassili (1979) that not only the movement but also the location of presented information is highly meaningful for the human perceptual processing. This suggestion is in line also with earlier findings showing that upper face information is needed for "negative" emotional information and lower face information is needed for "positive" emotional information. For example, it has been found that for happy expressions, the lower face bears more important information than the upper face, and for angry expressions, the upper face information is more important than the lower face (Bassili, 1979).

Further, it was found that the ratings of the two minimum intensity movements did not differ statistically on any of the scales. This might be because some of the participants reported the upper movements being either "angry" or "thoughtful". Possibly the smallest upper movement resembled more the latter than the first. Moreover, some of the participants reported that some of the lower movements were "shy", and one also mentioned that some of the movements were "melancholy" (contrasting some other movements being "happy"). Here it is possible that the small lower movement evokes conflicting or neutral reactions in such a way that the ratings between the upper and lower movements did not differ that much in the minimum intensity level.

Based on the findings from the end-questionnaire, presented in Table 1, the non-informed participants described that their ratings were not based on the face part but on the intensity of the movement or some miscellaneous effect. At the same time, the diversity of the answers of the informed group was wider as they reported that their ratings were based also on the face part. Yet, the statistical analysis of the rating data showed that the difference based on the experimental group was significant only in the dominance scale. As discussed above, it seems that the ratings of dominance were affected by the prior knowledge the participants had got but the other ratings were not.

Finally, it is highly interesting to notice that the non-informed participants did not rate based on the face part but at the same time half of the participants within this experimental group did recognise the face, especially the lower face with smiling expression (see Table 1). Possibly it has happened that as they did not have the same pre-knowledge as the other experimental group, they recognised the face and the expressions but did not explicitly use this information for the ratings. It seems that the facial information processing was implicit and automatic within the non-informed group as there were no other differences between the two experimental groups than within the dominance scale ratings. Further, it is interesting to notice that the participants in both experimental groups recognised more often the smiling expression than the frowning expression. This in turn seems to be in line with the previous experiments with PLDs (e.g., Bassili, 1979) and with full-face presentations (e.g., Bartneck & Reichenbach, 2005). Also the recognition of the lower face more often than the recognition of the upper face (see Table 1) might be related to this.

Previously it has been noticed that PLDs generated on the basis of real human actors' movements showing, for example, emotional facial expressions can convey emotional information (e.g., Afzal et al., 2009; Cunningham & Wallrave, 2009; Matsuzaki & Sato, 2008; Pollick et al, 2003). Here, our results show that artificially generated PLDs were associated to facial movements and emotions even though PLDs were generated without naturalistic facial starting point. Further, the previous research has found that facial expressions presented by animated faces have an effect to the affective ratings (e.g., Ku et al., 2005; Sato & Yoshikawa, 2007; Schrammer et al., 2009). The current results are in line with the previous results even though our representations were much more simple and abstract than the previously used facial representations.

The current results can be utilised in HCI and in affective computing in various ways. For example, simplistic PLDs can reveal spatial position and movement of facial points which are sufficient for conveying particular emotional information to the observer. These spatiotemporal patterns of facial PLDs can be used in building facial representations which are compact yet descriptive enough for the classification purposes. Thus, facial PLDs can be potentially useful in improving systems of artificial intelligence which actively and unobtrusively recognise facial expressions of a user from video input or some other measurement.

On the other hand, we suggest that artificial PLDs have the potential to convey socio-emotional information in, for example, technology-mediated communication between the users. With PLDs the users could associate hints of their ongoing emotions or feelings in technology mediated discussions, personal electronic diaries, feeds in social media services, instant messaging and internet telephony software, groupware applications, and social media services. When using PLDs only a small amount of information needs to be transmitted. This enables low bandwidth requirements. As PLD visualisations are simple, there is no need for high-definition displays. The presentation of PLDs is sparse, and might even be superimposed on something else without being too obtrusive. Recording and visualisation of socio-emotional information can be useful and important, for example, for communication purposes, memory support, and attaching emotional hints to picture sequences in life logging type applications.

In respect to life logging Sas et al. (2013) measured emotional arousal with skin conductance measurement together with life logging photo recordings. From the each participant's data four instances with highest arousal values and the four instances with lowest arousal values were first extracted. Then photos associated with extracted arousal values were shown to the participants who were to tell what they recalled from the photos at the time they were taken. As a measure of the recall of episodic memory the richness of the memory was used. The results showed that the participants were able to recall richer information from those pictures that were associated with high arousal than those associated with low arousal.

Another system developed for memory support, *AffectAura*, measures a wide variety of user data, including, for example, valence of facial expressions, skin conductance for arousal recording, user location, and user's computer use. The data was converted to visualise affective information of events, like valence and arousal. Additionally other information cues, like user location and activity of computer use, were shown. From the user study it was found that the affective information was helpful for recalling the past events but only after the users had gone through the other information cues the system provided. It was found that the presentation of the affective information was too complex to be fully understandable. Thus, there is a need to design simpler ways to represent emotion related information (McDuff et al., 2012).

PLD representations have the potential of being simpler yet recognisable and unobtrusive representations. Hence they could be simple enough visualisations that could be used together with, for example, life logging systems. PLDs can be connected to the captured picture data automatically by suitable behaviour measurement techniques, like mobile and wearable facial activation measurement device (e.g., Gruebler & Suzuki, 2014; Rantanen et al., 2013a; 2013b). Such a measurement device can track facial expressions, like smiling and frowning, during life logging. Tracked expressions can then be converted to PLD representations. PLDs can be used as tags of the valence and arousal of user's life logs to bring back moments of smiling and frowning. Furthermore, PLDs have the potential to convey the emotional tone of the recorded moments to another person going through the recorded data. In this way life logging can become a more deeply shared socio-emotional experience.

5. CONCLUSIONS

Our results showed that abstract and artificially created PLDs can evoke emotional reactions in the spectator both with and without prior information that PLDs are somewhat related to human faces. In sum, the results show that the participants perceived the medium and maximum intensity lower movements as significantly more pleasant, relaxing, and approachable than the corresponding upper movements. Additionally, the informed participants perceived the medium and maximum intensity lower movements as significantly less dominant than the corresponding upper movements. These results suggest that artificial PLDs have the same kind of effect than the full-bodied facial animations have on the emotional reactions of the observers. The results provide new knowledge for meditating emotionally meaningful information.

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