**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 less dominant than corresponding upper movements. Results are important from many perspectives, like for understanding human perceptual mechanisms and mediation of information with low bandwidth and computational requirements because only small amount of information is required for transition and presentation of information.

**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.
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. Gender recognition studies have been made to understand similarities and differences between children and adults in facial expression recognition (Berry, 1991), and also to compare differences between PLD face representations and real face presentations in the recognition tasks (Hill, Jinno, & Johnston, 2003). Emotional information processing has been studied by PLD 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 the 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 of facial expressions is a key factor in evoking both the perception of a human face and the emotion related information of 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 the facial movement was shown with the PLD technique. 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. Additionally, a series of non-human movements were constructed with otherwise the same technique as the PLDs of human facial expressions, but the spots were placed on a piece of foam and the movement was created by crushing the foam. The results showed that the participants distinguished the facial movements from the movements made with the foam. 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 the 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, more research is needed with even more simplistic and systematically controlled representations of supposedly human facial movements in order to understand more deeply the effect of movement on facial information processing.

The knowledge of human perceptual capabilities could be utilised in human-computer interaction in various ways. For example, facial PLDs can be potentially useful in improving systems of artificial intelligence which actively and unobtrusively recognise facial expressions of a computer user from video input. Thus, 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. Furthermore, the knowledge of the minimal information needed to convey emotional information can be used to develop technology-mediated communication. With PLDs it is possible to provide information cues in instant messaging and internet telephony software, groupware applications, and social media services. When using PLDs only a small amount of information is needed 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.
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 two basic 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. The other 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. In respect to the measurement of 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 rating scale to make ratings of how one feels about various things (e.g., Osgood, 1952; Schlosberg, 1954; Bradley & Lang, 1994). The most used emotional dimensions are pleasantness (valence) and level of activation (arousal). 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). These three rating scales have been often used in the field of human-computer interaction for measuring the ratings of emotional experiences of the users. For example, Pfister, Wollstädt, and Peter (2011) measured emotional experiences towards messages of a computer system with the ratings of valence, arousal, and dominance. 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. For instance, Anttonen and Surakka (2005) used the rating scales of valence, arousal, and approachability when they investigated the use of embedded, unobtrusive heart rate measurement, which in turn can be used to measure emotional reactions in a novel, noninvasive manner. Further, these three scales were used to measure the emotional reactions towards synthesized speech (Ilves & Surakka, 2013). Moreover, all the four scales, namely, valence, arousal, dominance, and approachability were used to measure the emotional reactions to different haptic stimulations which can be used to communicate affective content (Salminen et al., 2008). As our aim was to use highly controlled PLD animations which had not been generated on the basis of
using naturalistic human faces in PLD modelling, and which had no obvious reference to faces, it was evident that for the present purposes the dimensional theory of emotions was more applicable.

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 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 neutral PLD representation. Based on the design of a
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: $10^\circ$ for the minimum, $20^\circ$ for the medium, and $30^\circ$ for the maximum movement (see Figure 1).

Each PLD animation was divided in five equally long phases, all lasting five frames: 1) At the start, all dots were fluctuating around their start positions in a small $1 \times 1$ 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). An animation transition consisted of 25 frames, displayed at a rate of about 2 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. At the end of the experiment, the participants answered 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?
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 $2 \times 2 \times 3$ (experimental condition $\times$ movement location $\times$ 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.

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, $F(1, 27) = 9.96, p < 0.01$. 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, $MD = 1.37, p < 0.01$.

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 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 3), a three-way \( 2 \times 2 \times 3 \) (experimental condition \( \times \) movement location \( \times \) 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.

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 4), a three-way $2 \times 2 \times 3$ (experimental condition $\times$ movement location $\times$ 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.

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, $F(1, 27) = 7.18, p < 0.05$. 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, $MD = 1.28, p < 0.01$.

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 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 5), a three-way $2 \times 2 \times 3$ (experimental condition $\times$ movement location $\times$ 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.

In order to analyse the interaction between experimental condition, movement location, and intensity, two separate two-way $2 \times 3$ (movement location $\times$ 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.

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4. DISCUSSION

Our results showed that the simple, abstract PLD animations evoked emotional reactions. 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 more dominant 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 seen from Figure 5, the informed participants gave overall higher dominance ratings than the non-informed participants. It seems that within the informed group the participants felt themselves to be in more control when they had the prior knowledge of face presence. Moreover, as seen from Figure 5, it seems that the participants in the two experimental condition groups rated the lower expressions differently. The non-informed participants rated the animations to be more dominant the more intense the movement was, while opposite ratings were given by the informed group. Even though the main effect of the intensity was not significant on either of the groups, this observation is extremely interesting. As seen from Table 1, the non-informed participants described that their ratings were based not on the facial expression but on the intensity of the movement. So, it might have happened that both of the movements, the upper and the lower, seemed to be less controllable within this experimental group the more intense the movement was. In the case of the informed participants, as seen from Table 1, the ratings were based on the face part more often than on the intensity of the movement, and thus, it might be possible that especially the ratings of dominance were affected by the prior knowledge the participants had got.
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.
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. We suggest that artificial PLDs have the potential to convey socio-emotional information in, for example, technology-mediated communication between the users. With the help of PLDs the users could associate hints of their ongoing emotions or feelings in technology mediated discussions, personal electronic diaries, and feeds in social media services, for example. The plain animations could be transmitted fast and computationally effectively. 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. The 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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Figure 1 legend: 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.

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

Figure 3 legend: Mean arousal ratings and S.E.M.s for different stimuli in the two experimental conditions.

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

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

Table 1 legend: Results of the end-questionnaire.
![Chart showing mean approachability ratings for different groups and movement intensity levels.](image-url)
### Table 1: Results of the end-questionnaire.

<table>
<thead>
<tr>
<th>Question</th>
<th>Non-informed</th>
<th>Informed</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saw a face</td>
<td>50.0%</td>
<td>85.7%</td>
<td>67.9%</td>
</tr>
<tr>
<td>Saw upper face</td>
<td>35.7%</td>
<td>85.7%</td>
<td>60.7%</td>
</tr>
<tr>
<td>Saw lower face</td>
<td>50.0%</td>
<td>85.7%</td>
<td>67.9%</td>
</tr>
<tr>
<td>Saw frown</td>
<td>35.7%</td>
<td>71.4%</td>
<td>53.6%</td>
</tr>
<tr>
<td>Saw smile</td>
<td>50.0%</td>
<td>85.7%</td>
<td>67.9%</td>
</tr>
<tr>
<td>Rated based on the face part</td>
<td>0.0%</td>
<td>35.7%</td>
<td>17.9%</td>
</tr>
<tr>
<td>Rated based on the intensity</td>
<td>42.9%</td>
<td>21.4%</td>
<td>32.1%</td>
</tr>
<tr>
<td>Rated based on misc.</td>
<td>28.6%</td>
<td>35.7%</td>
<td>32.1%</td>
</tr>
</tbody>
</table>