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Body, dance and abstraction for spatial and structural comprehension in the first year of design education

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Abstract

The first year of design education is essential for students as it is their initial interaction with the design process. Awareness of the body through dance has the potential to reveal bodily experience in space. Abstraction of embodied experience contributes to realising the significance of the body and its analytical dimension for spatial and structural design. This study investigates the impact of embodied experience and abstraction on the architectural design process and the outcome through correlation and regression analysis. We observed that increasing awareness of the space through bodily movement and its drawn representation positively impacted students' success in architectural design. Also, the measures related to space and structure mainly advanced students' success in the final design. However, the association of the abstraction process with the final design remained limited. The study's contribution is the systematic and statistical evaluation of the relationship between body, movement, abstraction and architectural design by constructing a set of measures from various stages of the design studio. We hope our research will provide a basis for the upcoming discourse.

Keywords Body-space · Dance · Abstraction · Design education · Design process · Architecture

Introduction

Studies on the design process bring about advancement in the act of designing. Educational practices provide an experimental area for such a purpose. In this sense, design studios are critical to understanding the traditional design process and exploring its contemporary

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versions. The first year of design education is essential for the students as an initial interaction with the nature of the design process. Merleau-Ponty (1964) emphasised that experience is not a sum of visual, tactile, and audible givens. Likewise, the main goal of the studios is not just to give visual qualification but also to comprehend the spatial experience. Humans perceive things as a whole because unique structures of the things communicate all senses at once. Therefore, recognition of the body for designers is pre-requirement to design qualified and creative spaces. Dance, as interaction through movement, can reveal the potential of bodily experience in space. This embodied experience enables the association with structure as a foundational element of space. Practices of abstract representations can contribute to embodied experience in relation to space and structure.

Researchers have investigated body-space exercises to develop various models for awareness of the body in space (Caner Yüksel & Dinç Uyaroğlu, 2021; Ersoy, 2011; Hatıpoğlu et al., 2022; Sinnamon & Miller, 2021; Vroman et al., 2011). However, most studies do not provide a systematic analysis for evaluating bodily experience and abstraction in architectural design's spatial and structural configuration. This study aims to address this literature gap by empirically analysing the significance of the body, dance and abstraction on the spatial and structural quality of the architectural design. In the five-staged design studio, we designated a set of measures about the body, dance, abstraction, space and structure to evaluate students' submissions. We framed our research questions accordingly:

(1) What is the impact of the measures related to the body, dance, abstraction, space and structure during the design process on students' success in the final design?
(2) How can the measures related to the body, dance, abstraction, space and structure in the design process affect each other?

To address these questions, correlation analysis has been conducted to understand the association between calculated or assessed measures and the final success of the students. Then, the regression analysis is conducted to understand the strength of the relationship between these measures and the final score. The rest of the article is structured as follows. In Theoretical Background, we review the theoretical foundations of research by focusing on the role of first-year design studios, the relationship between bodily movements and spatiality through dance, and the abstraction process of bodily movements of dance for architectural design. In Research Design, we describe the research process by explaining participants, design tasks and procedures, and measures. In Findings, we present the statistical analysis methods and their results. In Discussion, we reflect on our findings related to the impact of measures on the final design and in between them. In Conclusion, we finalise the article with a general outline and recommendation for future studies.

Theoretical background

The first year of architectural design education

The nature of the design activity is complex and triggers open-ended arguments. The design process involves both finding and solving the problems. However, such problems cannot be comprehensively stated (Lawson, 2005). The design studios are critical to understanding the traditional design process and exploring its contemporary versions. Students experience several difficulties when they first encounter design education because there are several design solutions, and there is no optimal one. Such challenges led researchers and educators to have special attention to first-year design education. The Bauhaus school, founded in 1919, was one of the first initiatives that established basic design course (*vorkurs* in German). In schools' curricula, the basic design aims to apply the principle of universality by discovering the essence of geometry, aesthetics and simplicity (Hatıpoğlu et al., 2022). Following the foundations of the introductory course, it is important to review the current status of first-year design education.

The basic design course promotes abstract and conceptual thinking. Dealing with the grammar of the visual language, basic design equips the student with the knowledge of principles, rules and concepts of visual organisation (Wong, 1993). The primary purpose is not necessarily designing a physical building but elaborating the spatial arrangements through representation. For this reason, basic design education comprises an abstract world of lines, surfaces, volumes, colours and textures. However, basic design education is not restricted to visual language but includes experimental activities, improving students' cognitive abilities and creativity (Wong & Siu, 2012). Acquiring the basics of design by experimenting, creating, discovering—even incubating (Smith & Blankenship, 1991)—activates students in the process (Boucharenc, 2006, 2008). The acquired knowledge through the course composes the basis of their future education and professional practices.

Abstract and experimental stages in the basic design studio course are intended to improve the student's perception and creative thinking skills. In the studio process, the relationship between people and spatial organisation is recognised using the basic design principles. Recognising the body and space is crucial in initiating a design process in which abstract thinking and physical experience are interlaced. Such an experience-oriented approach helps students be aware of unspecified and unpredictable body actions in space (Erkenez & Ciravoğlu, 2020). Therefore, the mutual interplay of dance and body reveals the potential of corporeality and spatiality as the movement of the body enables the perception of the space.

Body, dance and spatiality

Exploration of the relationship between body and space plays a key role in architectural design education since the dynamic movement of the human body is the primary foundation for the interactive perception of space. The spatiality of architecture is bounded by bodily experience, as the body is the source of awareness and consciousness (O'Neill, 2001; Pallasmaa, 2012). Human understanding of physical reality would be inadequate without constant and mutual engagement between the body and the ever-changing geometries of space (Holl, 2000). The objects and space around us affect the possible action of our bodies. Therefore, the materiality of the body and space perform actively together (Tschumi, 1996). In other words, the potentials of the corporeality and spatiotemporal cosmos act collectively and coherently.

In Merleau-Ponty's theory, the body builds mental and intellectual acquaintance with the world (Carman, 2008; Morris, 2014). As an interface between mind and matter, the lived body or felt-body (*Leib*) indicates a phenomenological distinction with the physical body (*Körper*) in German philosophy (Griffero, 2014). Merleau-Ponty understood the lived body not as a passive and fixed object but as a series of actions and movements that provides human experience (Wrathall, 2005). Criticising Descartes's cartesian understanding of space for its dualist qualities separating the experience and matter, Merleau-Ponty considered the body not as located in space or time; instead, it inhabits space and time through movement (Langer, 1989; Matthews, 2002; Merleau-Ponty, 2012). Therefore, this phenomenological understanding of the body emphasised movement and interaction rooted in space.

As an interaction through movement, dance can reveal the untapped potential of bodily experience in space. The dance manifests the human body's mystery, limits, energy and resources (Valéry, 1983). In the act of dance, humans build numerous sensual interconnections with reality beyond the solid boundaries of the physical body (Snowber, 2012). This spatial interaction emphasises the ever-shifting dynamic relationship between the dancer's body and environment (Birringer, 2004). Moreover, choreography in dance has several common grounds with architecture in terms of spatiality and expression. Both disciplines deal with visual expressions in three-dimensional space to communicate (Mattingly, 1999). In this sense, dance strengthens embodied experience in space and introduces new potentialities in architectural design.

Conceiving the body movement as possible explorations in space, Rudolf Laban constructed a dynamic and continuous link between human's inner and outer experience (Bradley, 2009; Hodgson & Preston-Dunlop, 1990). Laban's analysis of the body-space relationship was twofold; "kinesphere" and "dynamosphere". While the kinesphere defined the immobile body's outer edges, the dynamosphere represented the dynamic movements of the body (Laban, 1966). In this understanding, there was an absolute interconnection between bodily architecture and the architecture of the movement (Maletic, 1987). The kinesphere did not pay attention to the spatiotemporal qualities of the environment and focused on the dynamic actions of the individual body (Schiller, 2003). To overcome this inadequacy, Schiller (2008) proposed "kinesfield", which defines the body as an interactive and dynamic medium acting jointly with the other objects in the environment. Since architecture is about the activity of single bodies and interrelated changing relationships of multiple bodies, both theories pave the way for the possible advanced version of corporeal architectural design.

Modern dance theorist Merce Cunningham evaluated the body's movements not depending on directions but the divergent conditions of the dancer in the process (Copeland, 2004). After criticising the mechanisation of space and the body's formal actions, Cunningham proposed a new understanding of body and space where freedom is essential (Cunningham, 1952). This perspective spanned the boundaries of the body, space and time by accepting the body as an intermediate reality. For Cunningham, the moments transcending the body play a crucial role in revealing blind spots waiting to be exposed (Noland, 2013). In this sense, the potential actions in/within space are neither expressions of geometrical boundaries of body movement nor limited by linear space. Instead, there are momentary reflections of the dancer's inner feelings and thoughts interconnected with the ever-changing environment.

Deconstructivist choreographer William Forsythe recognised the dance as a volumetric performance, actualising senses and imagination as material reality (Forsythe, 2011). Forsythe deconstructed Platonic ideal forms and proposed decentered choreographic bodies organised in space connected to other bodies and the environment (Brandstetter, 1998; Spier, 2011). This understanding presented a vision of geometrical space consisting of connected points on the dancer's body that generates limitless movements (Forsythe & Kaiser, 1999). For Forsythe (1995), however, the dancer does not invade the space but lets the body dissolve through movement (Siegmund, 2011). Therefore, the body's movement projects joint realisations of physical, visual and emotional experiences as patterns and behaviours in space (Huschka, 2010). From points through lines to volume, Forsythe's dance theory represented an unconditional bodily movement in space that reveals the discontinuities in the unity of choreography.

The body is an inseparable part of human experience as the source of senses, feelings and movements. Dance is a platform that reveals the potential of bodily actions. The outlined perspectives on the relationship between body, dance and space reveal various essential aspects of corporeality. These features provide specific criteria for creating a design process where the bodily experience plays a key role. One way to display the essence of bodily experience is the abstraction method. By illustrating the geometric equivalents of corporeality, abstraction provides a critical technique to be used in the design process.

Abstraction, Body and Dance in the Design Process

The Latin origin of the word abstraction is "abstrahere", which means detaching or dragging away (Zimmer, 2003). By eliminating details and revealing the essences of reality, abstraction illustrates the spontaneous or pre-planned relations embedded in the unity and parts of things (Levy & Bechtel, 2013). Abstraction as an essential cognitive (and corporeal) activity helps humans make sense of the world. Scientists use abstraction to analyse the universe and generate scientific models (Russell, 1930). For the last three centuries, abstraction has been an outstanding topic amongst the art theories related to form, aesthetics and image-making (Morgan, 1992, 1994). Abstraction is also a critical topic regarding the relationship between body, dance and space.

Wassily Kandinsky attempted to understand the connections between the body, movement, and parts through abstraction (Fischer & Rainbird, 2006; Huxley, 2017). In Kandinsky's theory, the point turns into a line under the effect of external tension stemming from movement (Becks-Malorny, 2003). By recognising the flow of the dancer's body as the composition and harmony of continuous pure lines, Kandinsky represented several photographs of dancer Gret Palucca by the abstract configurations (Funkenstein, 2012; Kandinsky, 1926, 1947). A deep quest for the ideal geometrical composition to investigate body movement in space let Kandinsky formulate transferable relations of body movement with line formation (Funkenstein, 2007; Kandinsky, 2002). For this reason, abstraction was utilised to exclude the details of the human body and transform its movement into abstract geometrical expressions. However, the abstraction does not have to be understood as merely geometric interpretation as it also uncovers the potential of bodily experience.

The choreographer Oskar Schlemmer defined abstraction twofold: detachment of the parts from the whole and generalisation of the composition (Feuerstein, 2002; Schlemmer, 1961). Beyond the formal abstraction neglecting the dynamic potentials of body motion, Schlemmer studied lived bodily experience with abstract mathematical forms and material to reveal unfolded capacities of embodied experience (Trimingham, 2004). Even though Kandinsky and Schlemmer both explored geometric abstraction, their theories correspond to different perspectives. Kandinsky understood space as the sequence of fixed body forms and evaluated the motion from the outside as optical reality. On the other hand, Schlemmer realised space as a medium for uninterrupted flow of the body and the motion in itself as performance and effort (Sutil, 2014). For this reason, these two methods provide a diverse understanding of the abstraction for bodily experience in the architectural design process.

Body, dance and abstraction are essential elements to reveal and formalise the potential of bodily experience in architectural design studios. Sinnamon and Miller (2021) designated an exercise to develop architecture students' awareness of bodily experience in the concept design stage and tested its impact on cognitive focus, motivation and risk-taking. Ersoy (2011) developed a heuristic model called "Building Dancing" for architectural students to develop their recognition of bodily experience. However, the model was limited to the body exercises of students where they were trying to perform objects and building forms.

Vroman et al. (2011) used motion capture technologies to simulate dancers' consecutive bodily movements and produced diverse spatial 3D models. Although there was a direct connection between bodily experience and architectural design, the final design outputs were not challenged by any architectural design criteria. Caner Yüksel and Dinç Uyaroğlu (2021) applied a teaching model in an architectural design studio to develop students' understanding of body-space relationships through contact improvisation, reflective observation, three-dimensional abstractions and spatial design. However, students were instructed to select only one movement to design the final model, which is very restrictive regarding the potential spatial arrangements. For this reason, there is a need for further analysis to evaluate bodily experience and abstraction in spatial configuration.

Research design

Participants

In the first year of their degree, fifty-one students from the department of architecture (33 women, 18 men) participated in this study as partial fulfilment of a requirement for the basic design course. In order not to be directive, no information was given about the final design task at the beginning of the study. They were not aware of the goal of the study. The final submissions, at the end of all sessions, were assessed as an overall evaluation and given final scores by the tutors of the course. There were ten tutors. However, the authors of the article did not comment in order not to cause any manipulation in the meeting for the last decisions of final scores by the rest of the tutors (6 people). These tutors were blind to the goals of the research. As a conditional grouping, the final scores of the participants were divided into three groups: high-overall (between 95 and 80 points; $n=15$); mid-overall (between 75 and 60 points; $n=21$); low-overall (between 55 and 25 points; $n=15$).

Design task and procedure

A five-staged design process was carried out. Each stage investigated the relationships between body, dance, abstraction, space and structure. The design task was prepared based on body, dance and abstraction discourse related to space in the literature. All participants were provided with the same design task. Each subject was asked to solve a design problem. They did not know about the details of the final project until the last stage came up. This process allowed the students to carry out unconditioned body, dance and abstraction explorations without concern for the final design task. An overview of each design briefs is provided in Table 1, Fig. 1.

The detailed review of the five-staged design process is shown in Fig. 1. Each stage focuses on various pairwise connections between the parameters of the article (i.e., body, dance, abstraction, space and structure) through the designated set of measures (Fig. 2). This multi-layered process makes it possible to analyse the relationship between the parameters. Participants used various modes to produce their work including mental practice, bodily presence, documentation, drawing, and modelling. They also had different sub-processes such as analysis, abstraction, exercise and evaluation.

The participants were asked to design a structure using the units from their own bodies' abstraction. Since Lawson (2005) claims that the design process is built chiefly via subjective value judgments, we encouraged students to create their choreography as a source. This challenge allows us to evaluate spatial and structural reflections of students' bodily experiences. Thus, we could observe the effect of body movements and abstract drawings on spatial and structural organisation, addressing the implication of the research questions. The designer's perception of volume is not limited to merely the body's shape when the design problem expects to produce the architectural space instead of an abstract model (Hatıpoğlu et al., 2022). It is consistent with the aim of this research that considers the body and abstraction rather as a part of understanding the space than the geometric shape of the body.

Measures

A set of measures are employed to evaluate five submissions at the end of each stage to understand the effects of the body, dance and abstraction on the design of space and structure. The measures are produced depending on the theoretical background and review of the submissions for each stage to address the research questions. Five sessions for five submissions, were held to determine additional criteria by discussing students' works. Subsequently, 14 measures were integrated and grouped as in Fig. 2.

Quantitative measures

Some measures (11 out of 14 measures) have quantitative aspects and were calculated three times by different researchers. The first and second researchers calculated the measures on the submitted design. Then, the third researcher checked earlier scores with submissions and made the final decision. This double-check was implemented to be sure about the score of each measure.

The variety of chosen dance videos was calculated depending on emerging forms of the dance. Here, there is no figure for dance videos that students found on the internet. The students were not invited in any way toward a particular form of dance. For the variety of choreography in students' dance, the videos were paused as the dance moves varied. Following each pause, + 1 point was given to the study. For the fluidity of body movements in students' dance, researchers have started with 5 points as the highest score. They paused the video when there was a discontinuity in movements and reduced its score by − 1 point. For the extent of the occupied volume by the body in students' dance, videos were analysed by colouring the occupied volume. The studies with the maximum red areas were calculated as 5 points, whereas the minimum red areas as 1 point. Figures 3 and 4 illustrate the outcomes of participants as high and low-scored examples (Top: high-scored, Bottom: low-scored).

For the amount of lines representing the volume, researchers calculated the amount of lines used for the flow and volume between body drawings. The drawings with the highest amount of lines were determined as 5 points, whereas the drawings without lines as 1 point. For the extent of the occupied volume by the body in the selected scenes, the body drawings were hatched from their outermost points (see, Fig. 10). The studies with the maximum hatch were calculated as 5 points, whereas the minimum hatch as 1 point.

Table 1 Design briefs

Design brief-1: body and dance
Watch dance videos, and create a unique choreography with the moves from videos. Record your own dance video (15–20 s)

Design brief-2: body and superposed abstraction
Pause your video 10 times. Sketch all bodies and their abstract form in two papers

Design Brief-3: production of units
Choose five scenes from your own dance video
Use the given 5×5 square template and place them:
1st column: Screenshots
2nd column: Concrete sketches of bodies
3rd column: Semi-abstract sketches of bodies
4th column: Full-abstract sketches of bodies
5th column: Wood models (as units) of sketches from the 4th column

SCREENSHOT 1	BODY-MOVEMENT 1	ABSTRACTION STAGE-1	ABSTRACTION STAGE-2 (UNIT-1)	MODEL OF UNIT-1
SCREENSHOT 2	BODY-MOVEMENT 2	ABSTRACTION STAGE-1	ABSTRACTION STAGE-2 (UNIT-2)	MODEL OF UNIT-2
SCREENSHOT 3	BODY-MOVEMENT 3	ABSTRACTION STAGE-1	ABSTRACTION STAGE-2 (UNIT-3)	MODEL OF UNIT-3
SCREENSHOT 4	BODY-MOVEMENT 4	ABSTRACTION STAGE-1	ABSTRACTION STAGE-2 (UNIT-4)	MODEL OF UNIT-4
SCREENSHOT 5	BODY-MOVEMENT 5	ABSTRACTION STAGE-1	ABSTRACTION STAGE-2 (UNIT-5)	MODEL OF UNIT-5

Design Brief-4: production of modules and combinations
Develop models as modules and combinations by using different units from an earlier stage

Design Brief-5: from dance to the space
Select at least 2 units. Design a structure for bodily experiences and make a model (with wood sticks). Draw sections, and perspectives. The size of the structure should be around 250m3. The scale is 1/20

Briefs have been shortened for the article by researchers

Figure 5 illustrates the outcomes of participants as high and low-scored examples (Left: high-scored, Right: low-scored).

For the number of units used in the structure, students have marked used units in later stages. First, they proposed five units and were free to choose how many and which units to use. Researchers have calculated used units as 5 points for maximum use and 1 point for minimum use. Researchers have examined the 3D dimensionality of units for the spatiality of the produced unit and scored whether they give multiple perspective potential. Figures 6 and 7 illustrate the outcomes of participants as high and low-scored examples (Top: high-scored, Bottom: low-scored).

For the variety of methods for combining units, researchers have classified four techniques: (1) different scale same units, (2) different scale different units (3) same scale same units (4) same scale different units. The participant who used all corresponds to 4 points, whereas those who used one of them were calculated as 1 point.

Researchers have analysed different unit sizes in the final design for the number of the used different scales. For the fluidity of the final structure, separable parts were overviewed. The study was scored 5 points when the structure constitutes an inseparable wholeness. Figure 8 and 9 illustrate the outcomes of participants as high and low-scored examples (Left: high-scored, Right: low-scored).

Qualitative measures

Other measures (3 out of 14 measures) have qualitative aspects and were assessed by two judges on a scale of 1–5 (1 is low and 5 is high). These measures are as follows:

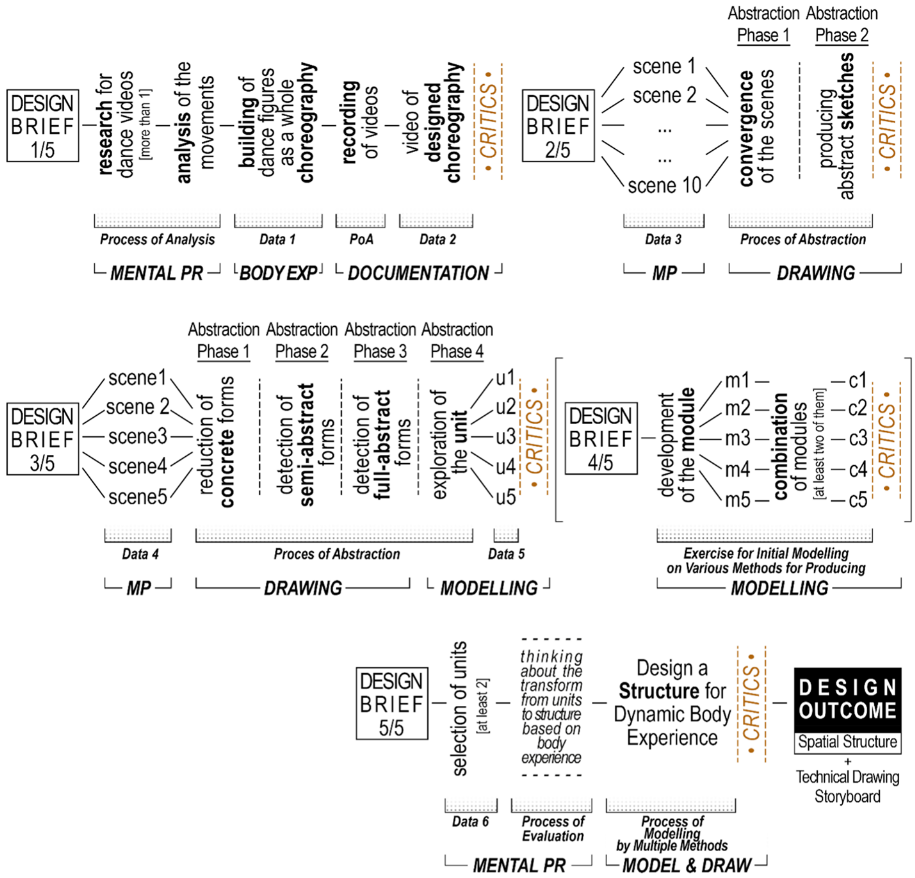

Fig. 1 Summary of the design process (PoA process of analysis; mental PR mental practice; Body EXP body Experience; MP mental practice; u1 unit 1; m1 modul 1; c1 combination 1)

Recognition of the structural features of the body; Refinement of the details of the body by preserving its main characteristics; The quality of the initial module/combination exercises (see, Fig. 10—Left: high-scored, Right: low-scored and Fig. 11—Top: high-scored, Bottom: low-scored).

For refinement of the details of the body by preserving its main characteristics, the judges assessed the success of creating units by abstracting the body movement without losing its main geometric arrangement. The authors added red circles to the initial abstract-body drawing (in the second column). The red circles have turned to grey if students missed main characteristics of the body in the abstract drawing (in the third column). Grey-circled drawings indicate less successful outcomes. For recognition of the structural features of the body, the success of creating units by preserving structural elements of body movements were asked to assess. Straight lines between red circles in the figure point out the success level of this measure (they are successful if they have structural lines but fail if they have weak lines). For the quality of the initial module/combination exercises, the success of creating space and using structural elements was assessed by the judges.

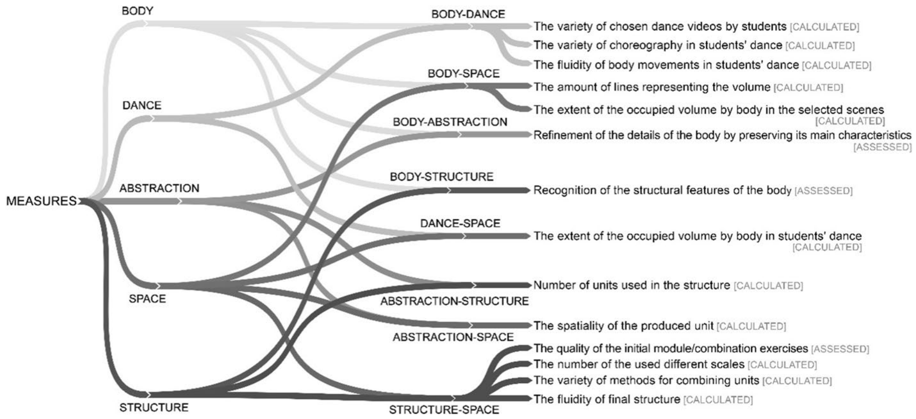

Fig. 2 Measures for the evaluation of the design process and final design

Fig. 3 The variety of choreography in students' dance (body-dance) and The fluidity of body movements in students' dance (body-dance)

For these measures, students' submissions were assessed by two judges blind to the research goals. Both are professors in the department of architecture (from different universities). One of them has published research articles and experienced thesis advisory regarding abstraction. The other focuses on body-space studies in their research and experienced thesis advisory in this field. The session, in which three measures were assessed, lasted about an hour and a half for both judges. The evaluation process was as follows:

Fig. 4 The extent of the occupied volume by the body in students' dance (dance-space)

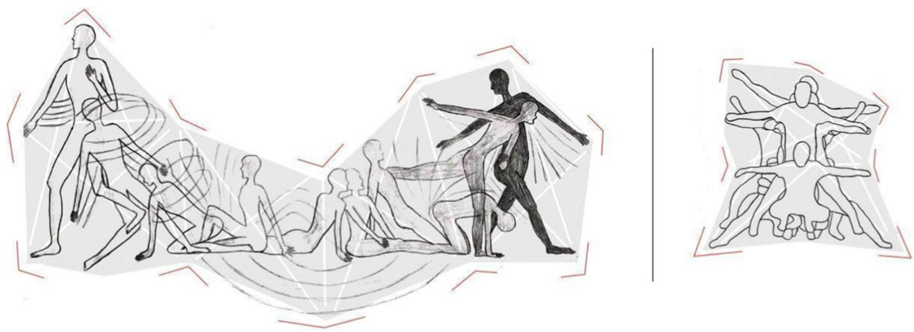

Fig. 5 The amount of lines representing the volume (body-space)

1. We introduced and explained the measures by showing some examples from student submissions. Judges asked questions for further clarification.
2. Student submissions were presented in random order (10 s for each study)
3. Researchers were given 15 s to score each measure of studies. However, it took 5 s for some of them and 30 s for others. Given time was changed to 5–30 s to avoid the pressure on the judges.
4. At the end of the session, researchers read scores aloud by showing the student submissions again. Thus, judges were able to check their assessments and revise some scores.

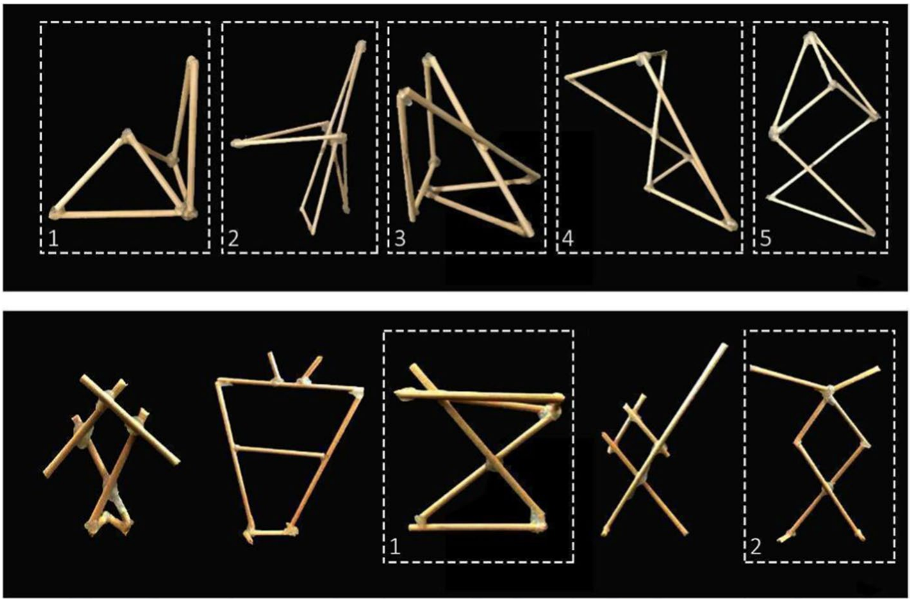

Fig. 6 Number of units used in the structure (abstraction-structure)

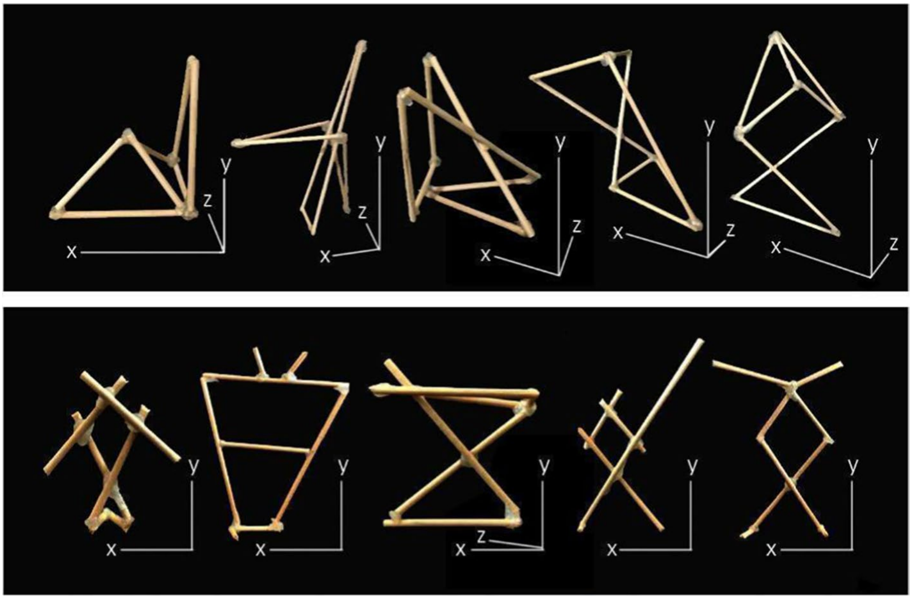

Fig. 7 The spatiality of the produced unit (abstraction-space)

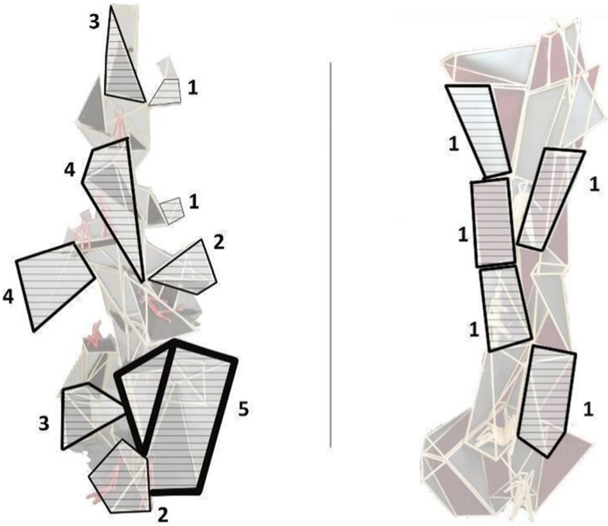

Fig. 8 The number of the used different scales (structure-space)

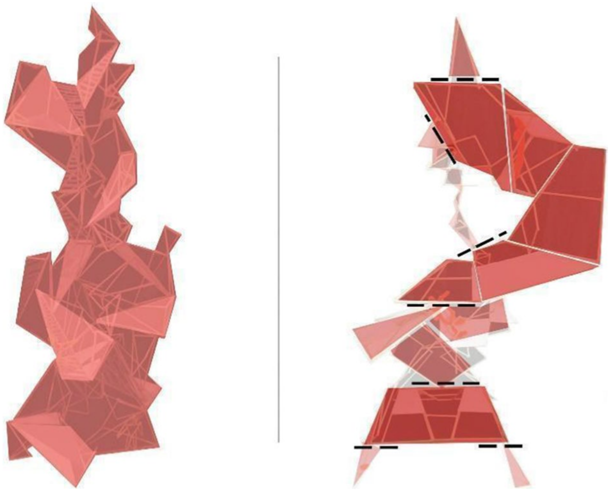

Fig. 9 The fluidity of final structure (structure-space)

Inter-rater agreement among judges was computed using Pearson's coefficient of correlation, as presented in Table 2. A significant correlation was found for all measures.

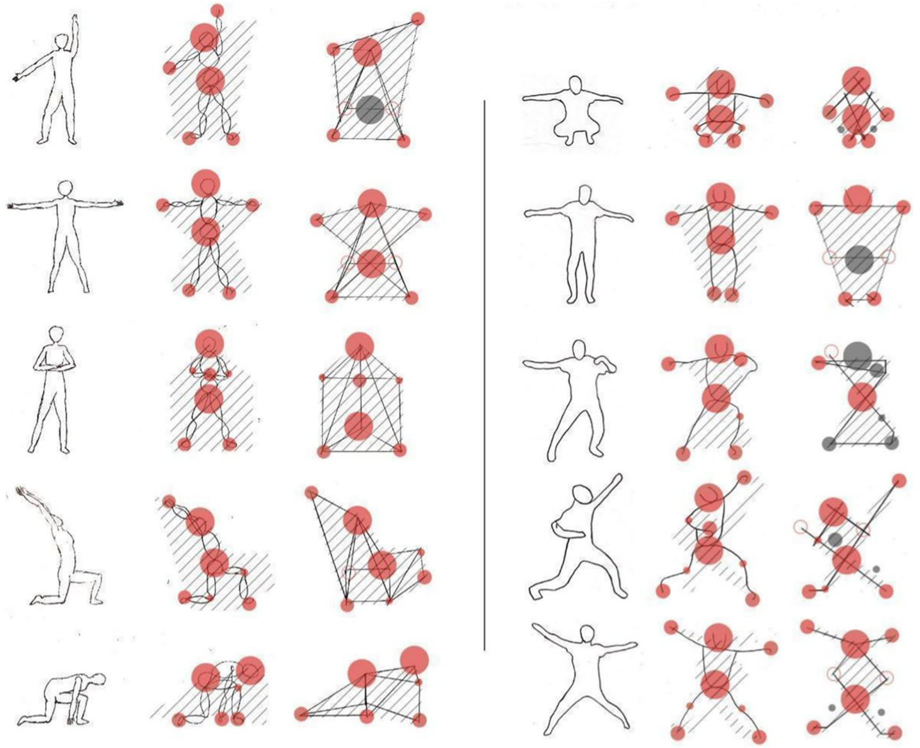

Fig. 10 The extent of the occupied volume by the body in the selected scenes (body-space) & Refinement of the details of the body by preserving its main characteristics (body-abstraction) & Recognition of the structural features of the body (body-structure)

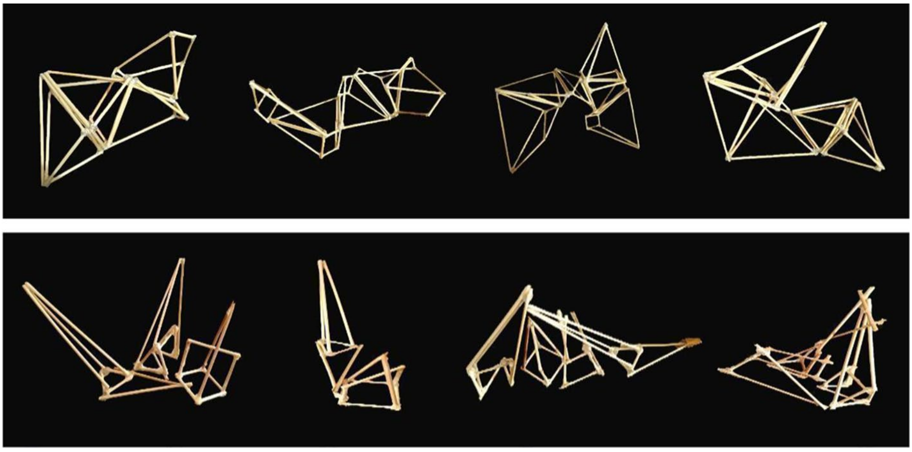

Fig. 11 The quality of the initial module/combination exercises (structure-space)

Table 2 Inter-rater agreement for judges

		Intraclass correlation	95% Confidence interval		*F* test with true value 0			
			Lower bound	Upper bound	Value	df1	df2	Sig
Recognition of the structural features of the body	Single measures	,494a	0.255	.676	2.951	50	50	.000
	Average measures	,661c	0.406	.807	2.951	50	50	.000
Refinement of the details of the body by preserving its main characteristics	Single measures	,564a	0.344	.725	3.588	50	50	.000
	Average measures	,721c	0.512	.841	3.588	50	50	.000
The quality of the initial module/combination exercises	Single measures	,506a	0.270	.685	3.049	50	50	.000
	Average measures	,672c	0.425	.813	3.049	50	50	.000

Table 3 Descriptive statistics

	N	Minimum	Maximum	Mean	Std. deviation	Skewness		Kurtosis	
						Statistic	Std. error	Statistic	Std. error
Body-Dance	51	1.00	4.00	2.7712	.92734	−0.245	0.333	−1.056	0.656
Body-Space	51	1.00	5.00	3.1961	1.12285	−0.327	0.333	−0.695	0.656
Body-Abstraction	51	1.00	5.00	2.8137	.95373	0.219	0.333	−0.631	0.656
Body-Structure	51	1.00	5.00	2.8922	.85623	−0.098	0.333	−0.064	0.656
Dance-Space	51	1.00	5.00	3.4118	1.31418	−0.488	0.333	− 0.850	0.656
Abstraction-Structure	51	2.00	5.00	2.9216	0.93473	0.925	0.333	0.172	0.656
Abstraction-Space	51	1.00	5.00	4.2941	.87850	− 1.546	0.333	3.089	0.656
Space-Structure	51	1.25	4.75	2.7745	.76812	.512	0.333	−0.082	0.656

Findings

To examine the role of the practices about body and abstraction in the design process, we used the normality test, Pearson correlation test and multiple linear regression analysis. The calculations and scores of each participant for each measure were utilised in the analysis. SPSS 22.0 software was used for the analysis of the study.

Normality test

Descriptive statistics were used to understand whether there was any normality problem in the data (Table 3). According to Kline (2015), to decide whether data is normally distributed, kurtosis and skewness values should be used to determine whether there is any distribution problem in the raw data. From this perspective, skewness should be between -3 and + 3, and kurtosis should be between -10 and + 10. Since the skewness and kurtosis values of all the variables in the table are within these ranges, the data are normally distributed.

Correlation analysis of measures

Pearson correlation coefficient was calculated to understand the strength and direction of the relationship between the final score and other variables. Correlation values are grouped as follows: 0.000–0.0190 very weak; 0.200–0.390 weak; 0.400–0.590 moderate; 0.600–0.790 strong; 0.800–1 very strong. According to Table 4, there is a positive and significant relationship between the final score and the variety of chosen dance videos ($r = 0.364$ $p < 0.01$), the variety of choreography ($r = 0.555$ $p < 0.01$), the fluidity of body movements ($r = 0.481$ $p < 0.01$), the amount of lines representing the volume ($r = 0.639$ $p < 0.01$), the extent of the occupied volume by body in the selected scenes ($r = 0.592$

Table 4 Correlations of final score with other measures

		The variety of chosen dance videos	The variety of choreography	The fluidity of body movements	The extent of the occupied volume by body in students' dance	The extent of the occupied volume by body in the selected scenes	The amount of lines representing the volume	Refinement of the details of the body by preserving its main characteristics	Recognition of the structural features of the body	The spatiality of the produced unit	Number of units used in the structure	The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
Final Score	Pearson Correlation	,364**	,555**	,481**	,641**	,592**	,639**	,396**	,417**	.120	.134	,634**	,528**	,377**	,623**
	Sig. (2-tailed)	0.009	0.000	0.000	0.000	0.000	0.000	0.004	0.002	0.403	0.348	0.000	0.000	0.006	0.000

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 5 Correlations of the variety of dance videos with other measures

		The variety of choreography	The fluidity of body movements	The extent of the occupied volume by body in students' dance	The extent of the occupied volume by body in the selected scenes	The amount of lines representing the volume	Refinement of the details of the body by preserving its main characteristics	Recognition of the structural features of the body	The spatiality of the produced unit	Number of units used in the structure	The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
The variety of chosen dance videos	Pearson Correlation	0.173	0.267	0.236	,292*	0.169	0.071	0.007	−0.177	.037	.215	0.076	0.175	0.105
	Sig. (2-tailed)	0.224	0.058	0.095	0.037	0.236	0.621	0.960	0.214	0.799	0.130	0.594	0.220	0.464

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 6 Correlations of the variety of choreography with other measures

		The fluidity of body movements	The extent of the occupied volume by body in students' dance	The extent of the occupied volume by body in the selected scenes	The amount of lines representing the volume	Refinement of the details of the body by preserving its main characteristics	Recognition of the structural features of the body	The spatiality of the produced unit	Number of units used in the structure	The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
The variety of choreography	Pearson Correlation	,657**	,644**	,658**	,542**	,383**	,346*	.102	.273	,362**	.246	,443**	,387**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.005	0.013	0.477	0.052	0.009	0.082	0.001	0.005

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

$p < 0.01$), refinement of the details of the body (r = 0.396 $p < 0.01$), recognition of the structural features of the body (r = 0.471 $p < 0.01$), the extent of the occupied volume by body in students' dance (r = 0.641 $p < 0.01$), the quality of the initial module/combination exercises (r = 0.634 $p < 0.01$), the number of the used different scales (r = 0.528 $p < 0.01$), the variety of methods for combining units (r = 0.377 $p < 0.01$), the fluidity of final structure (r = 0.623 $p < 0.01$).

Considering the Pearson correlation coefficient values in Table 5, there is a positive and significant relationship between the variety of chosen dance videos and the extent of the occupied volume by the body in the selected scenes (r = 0.292 $p < 0.05$).

Table 6 demonstrates a positive and significant relationship between the variety of choreography and the fluidity of body movements (r = 0.657 $p < 0.01$), the extent of the occupied volume by the body in students' dance (r = 0.644 $p < 0.01$), the extent of the occupied volume by body in the selected scenes (r = 0.364 $p < 0.01$), the amount of lines representing the volume (r = 0.658 $p < 0.01$), refinement of the details of the body (r = 0.383 $p < 0.01$), recognition of the structural features of the body (r = 0.346 $p < 0.05$), the quality of the initial module/combination exercises (r = 0.362 $p < 0.01$), the variety of methods for combining units (r = 0.443 $p < 0.01$), the fluidity of final structure (r = 0.387 $p < 0.01$).

The correlation analysis of the fluidity of body movements with other measures reveal a positive and significant relationship with the extent of the occupied volume by the body in students' dance (r = 0.577 $p < 0.01$), the extent of the occupied volume by the body in the selected scenes (r = 0.500 $p < 0.01$), the amount of lines representing the volume (r = 0.440 $p < 0.01$), refinement of the details of the body (r = 0.407 $p < 0.01$), recognition of the structural features of the body (r = 0.279 $p < 0.05$), number of units used in the structure (r = 0.286 $p < 0.05$), the quality of the initial module/combination exercises (r = 0.407 $p < 0.01$), the fluidity of final structure (r = 0.356 $p < 0.05$) (Table 7).

Table 8 shows a positive and significant relationship between the extent of the occupied volume by the body in students' dance and the extent of the occupied volume by the body in the selected scenes (r = 0.650 $p < 0.01$), the amount of lines representing the volume (r = 0.480 $p < 0.01$), refinement of the details of the body (r = 0.493 $p < 0.01$), recognition of the structural features of the body (r = 0.493 $p < 0.01$), number of units used in the structure (r = 0.320 $p < 0.05$), the quality of the initial module/combination exercises (r = 0.556 $p < 0.01$), the number of the used different scales (r = 0.407 $p < 0.01$), the variety of methods for combining units (r = 0.449 $p < 0.01$), the fluidity of final structure (r = 0.473 $p < 0.01$).

According to Table 9, there is a positive and significant relationship between the extent of the occupied volume by the body in the selected scenes and the amount of lines representing the volume (r = 0.493 $p < 0.01$), refinement of the details of the body (r = 0.471 $p < 0.01$), recognition of the structural features of the body (r = 0.465 $p < 0.01$), number of units used in the structure (r = 0.280 $p < 0.05$), the quality of the initial module/combination exercises (r = 0.472 $p < 0.01$), the number of the used different scales (r = 0.331 $p < 0.05$), the variety of methods for combining units (r = 0.514 $p < 0.01$), the fluidity of final structure (r = 0.531 $p < 0.01$).

Considering the Pearson correlation coefficient values in Table 10, there is a positive and significant relationship between the amount of lines representing the volume and recognition of the structural features of the body (r = 0.336 $p < 0.05$), the spatiality of the produced unit (r = 0.494 $p < 0.01$), the quality of the initial module/combination exercises (r = 0.436 $p < 0.01$), the number of the used different scales (r = 0.403 $p < 0.01$), the variety

Table 7 Correlations of the fluidity of body movements with other measures

		The extent of the occupied volume by body in students' dance	The extent of the occupied volume by body in the selected scenes	The amount of lines representing the volume	Refinement of the details of the body by preserving its main characteristics	Recognition of the structural features of the body	The spatiality of the produced unit	Number of units used in the structure	The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
The fluidity of body movements	Pearson correlation	,577**	,500**	,440**	,407**	,279*	.140	,286*	,407**	.146	.186	,356*
	Sig. (2-tailed)	0.000	0.000	0.001	0.003	0.048	0.326	0.042	0.003	0.307	0.191	0.010

*. Correlation is significant at the 0.05 level (2-tailed)

**. Correlation is significant at the 0.01 level (2-tailed)

Table 8 Correlations of the extent of the occupied volume by body in students' dance with other measures

		The extent of the occupied volume by body in the selected scenes	The amount of lines representing the volume	Refinement of the details of the body by preserving its main characteristics	Recognition of the structural features of the body	The spatiality of the produced unit	Number of units used in the structure	The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
The extent of the occupied volume by body in students' dance	Pearson correlation	,650**	,480**	,493**	,493**	.084	,320*	,556**	,407**	,449**	,473**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.560	0.022	0.000	0.003	0.001	0.000

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 9 Correlations of the extent of the occupied volume by body in the selected scenes with other measures

		The amount of lines representing the volume	Refinement of the details of the body by preserving its main characteristics	Recognition of the structural features of the body	The spatiality of the produced unit	Number of units used in the structure	The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
The extent of the occupied volume by body in the selected scenes	Pearson correlation	,493**	,471**	,465**	.103	,280*	,472**	,331*	,514**	,531**
	Sig. (2-tailed)	0.000	0.000	0.001	0.473	0.047	0.000	0.018	0.000	0.000

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 10 Correlations of the amount of lines representing the volume with other measures

		Refinement of the details of the body by preserving its main characteristics	Recognition of the structural features of the body	The spatiality of the produced unit	Number of units used in the structure	The quality of the initial module/ combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
The amount of lines representing the volume	Pearson correlation	0.215	,336*	,494**	.258	,436**	,403**	,416**	,440**
	Sig. (2-tailed)	0.130	0.016	0.000	0.068	0.001	0.003	0.002	0.001

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 11 Correlations of refinement of the details of the body by preserving its main characteristics with other measures

		Recognition of the structural features of the body	The spatiality of the produced unit	Number of units used in the structure	The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
Refinement of the details of the body by preserving its main characteristics	Pearson correlation	,801**	.019	,320*	,350*	.238	,433**	,342*
	Sig. (2-tailed)	0.000	0.895	0.022	0.012	0.092	0.002	0.014

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 12 Correlations of recognition of the structural features of the body with other measures

		The spatiality of the produced unit	Number of units used in the structure	The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
Recognition of the structural features of the body	Pearson correlation	0.163	0.239	,442**	0.267	,316*	0.263
	Sig. (2-tailed)	0.254	0.091	0.001	0.058	0.024	0.062

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 13 Correlations of the spatiality of the produced unit with other measures

		Number of units used in the structure	The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
The spatiality of the produced unit	Pearson correlation	0.150	−0.022	0.037	−0.012	0.243
	Sig. (2-tailed)	0.292	0.881	0.798	0.933	0.086

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 14 Correlations of number of units used in the structure with other measures

		The quality of the initial module/combination exercises	The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
Number of units used in the structure	Pearson correlation	0.103	,338*	,429**	0.241
	Sig. (2-tailed)	0.473	0.015	0.002	0.089

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

of methods for combining units ($r = 0.416$ $p < 0.01$), the fluidity of final structure ($r = 0.440$ $p < 0.01$).

Table 11 demonstrates a positive and significant relationship between the refinement of the details of the body and recognition of the structural features of the body ($r = 0.801$ $p < 0.01$), number of units used in the structure ($r = 0.320$ $p < 0.05$), the quality of the initial module/combination exercises ($r = 0.350$ $p < 0.05$), the variety of methods for combining units ($r = 0.433$ $p < 0.01$), the fluidity of final structure ($r = 0.342$ $p < 0.05$).

Table 12 shows a positive and significant relationship between recognition of the structural features of the body and the variety of methods for combining units ($r = 0.442$ $p < 0.01$), the variety of methods for combining units ($r = 0.316$ $p < 0.05$).

According to Table 13, there is not a statistically significant relationship between the spatiality of the produced unit and the remaining measures.

In Table 14, there is a positive and significant relationship between the Number of units used in the structure and the number of the used different scales ($r = 0.338$ $p < 0.05$), the variety of methods for combining units ($r = 0.429$ $p < 0.01$).

Table 15 demonstrates a positive and significant relationship between the quality of the initial module/combination exercises and the number of the used different scales ($r = 0.326$ $p < 0.05$), the fluidity of the final structure ($r = 0.390$ $p < 0.01$).

According to Table 16, there is a positive and significant relationship between the number of the used different scales and the variety of methods for combining units ($r = 0.566$ $p < 0.01$), the fluidity of the final structure ($r = 0.523$ $p < 0.01$).

The correlation analysis of the variety of methods for combining units (Table 17) reveals a positive and significant relationship with the fluidity of final structure ($r = 0.475$ $p < 0.01$).

Regression analysis

Multiple linear regression analysis was conducted to investigate whether Body-Dance, Body-Space, Body-Abstraction, Body-Structure, Dance-Space, Abstraction-Structure, Abstraction-Space, and Structure-Space significantly predicted the final scores. First, VIF values are examined to check for multicollinearity problems. Since these values are less than 5, the independent variables are not predictors of each other. Regression results showed that the model explained 64% of the variance and that the model was a significant predictor of the final score ($F = 11.937$ $p < 0.001$). It was also seen that Abstraction-Structure ($\beta = -3.908$, $t = -2.177$, $p < 0.05$) and Structure-Space ($\beta = 10.832$, $t = 3.632$, $p < 0.01$) contributed significantly to the model (see, Table18).

Table 15 Correlations of the quality of the initial module/combination exercises with other measures

		The number of the used different scales	The variety of methods for combining units	The fluidity of final structure
The quality of the initial module/combination exercises	Pearson correlation	,326*	0.240	,390**
	Sig. (2-tailed)	0.020	0.090	0.005

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 16 Correlations of the number of the used different scales with other measures

		The variety of methods for combining units	The fluidity of final structure
The number of the used different scales	Pearson correlation	,566**	,523**
	Sig. (2-tailed)	0.000	0.000

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 17 Correlations of the variety of methods for combining units with the fluidity in the unit combinations

		The fluidity of final structure
The variety of methods for combining units	Pearson correlation	,475**
	Sig. (2-tailed)	0.000

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 18 Multiple linear regression analysis results

	β	Std. Error	t	P	VIF
(Constant)	18.314	10.491	1.746	0.088	
Body-dance	4.203	2.583	1.627	0.111	2.526
Body-space	3.702	2.537	1.459	0.152	3.572
Body-abstraction	−0.621	2.941	−0.211	0.834	3.463
Body-structure	1.538	3.267	0.471	0.640	3.444
Dance-space	1.309	1.840	0.711	0.481	2.575
Abstraction-structure	−3.908	1.795	−2.177	0.035*	1.239
Abstraction-space	−.262	1.970	−.133	0.895	1.319
Structure-space	10.832	2.982	3.632	0.001**	2.310

$R^2 = .636$ $F = 11.937$; $p < .001$

*$p < 0.05$; **$p < 0.01$

[a]Dependent Variable: Final Score

[b]Predictors: (Constant), Structure-Space, Abstraction-Space, Abstraction-Structure, Body-Structure, Body-Dance, Dance-Space, [c]Body-Abstraction, Body-Space

Discussion

Relationship of body, dance, abstraction, space and structure with the final design

The findings demonstrate that all space-related measures are strongly associated with the final score. Practices with spatial priority heavily affect the final design. For this reason, researchers and educators need to elaborate further on how students can interact with the space throughout the design process.

The initial module/combination exercise is the last stage before students design the final structure. Here, students test the spatial and structural potentials of various modules and combinations by combining the units. For this reason, students are expected to be successful in the final design if they manage to explore qualified modules and combinations. Further, students did such exercises without learning the final task. This phase helped them explore their units' potential, in a spatial and structural sense, beyond the limitations of the final design concerns. Therefore, adding some exercise stages in various phases may lead students to open their minds to alternative possibilities for design solutions.

All measures related to dance and space have a moderate or strong association with the final score, except for the variety of dance videos. Since the design process is mainly built via subjective value judgments, we expected to observe a positive contribution to students' success when they used their choreography and body as a source. This finding confirmed our expectations. By embodying the different dance experiences, students can better understand the volumetric potentials of the body in space.

We expected that the variety of chosen dance videos and methods for combining units would help students to discover many perspectives. We also predicted that these encounters with body, space and structure might affect the success of the final design. Although this expectation was correct, the correlation value of variety is weak, while the correlation value of fluidity is strong or moderate. This may indicate that the increase in variety makes it hard to address the design problem and produce solutions. On the other hand, fluidity corresponds to perceiving the work without discontinuity. Although seeing more alternatives may provide a more comprehensive perception of the bodily movements and the potential of units, there is a need to find ways to incorporate various inputs in the final design coherently.

The amount of lines representing the volume related to space and the extent of the occupied volume strongly correlate with the final score. The amount of volumetric lines is related to students' awareness regarding the transition between various body movements and the volume generated by them. Students should not only focus on the volumes produced by the body but also consciously recognise the implication of these volumes for the space. Such understanding can lead students to be more aware of the diverse movement of the body in the design of the final structure. Therefore, students can design the final structure by combining the units allowing different body experiences through various spatial configurations. On the other hand, the extent of the occupied volume is related to exploring more possibilities in space. Students can make discoveries and understand the role of the body in space better when the volumetric potentials increase. For this reason, the extent of volume and its awareness should be a critical focus of the research about the body, abstraction, and space in the design process.

The measures related to abstraction have weak or no correlation with final success. While structural unit specifications are uncorrelated with the final score, combination exercises with these units have a strong correlation value. Rather than the unit's quantity, variety and spatiality, design students need to focus on these specifications for the spaces created by these units. In such studies, the body and its abstraction have a crucial role. Rather than focusing on only the unit in the process, students may discuss the spaces and structures that can be produced through the body on a large scale.

Understanding the body with its generated volume may lead students to more successful design solutions than focusing on the concrete components of the space (i.e., structure). This suggestion is supported since the extent of the occupied volume by the body has a strong correlation with the final score, while there is no correlation with the spatiality of the produced unit (as a volumetric reference of the unit). In addition, the refinement of the body has a weak level correlation, while structural features of the body have a moderate level correlation. When the abstraction process is considered in architectural design, it can be more helpful to approach the essence with the priority of structural aspects beyond a drawing.

According to our multiple linear regression analysis, 1 point (on a scale of 1–5) increase in the Abstraction-Structure parameter corresponds to 3.90 points (on a scale of 1–100) decrease in the final score. This demonstrates the negative impact of the increasing number of abstracted units on the success of the final design, even though it can potentially trigger more various spatial and structural configurations. One reason may be that students fail to manage the increasing complexity of the various combined units while designing the final structure. Another potential reason may be that units resulting from abstract bodies may confuse students as they try to place bodies in structures established with body-referenced units. Therefore, the body becomes a part of the structure and the volume between structures.

For Structure-Space parameters, 1 point (on a scale of 1–5) increase corresponds to 10.83 point (on a scale of 1–100) increase in the final score. These parameters are related to the stage closest to the final structure's design. Also, they are directly about the quality of the space configuration and structural solution. For this reason, it is expected to see their positive impact on students' success in the final design.

Interrelations between measures in the design process

The variety of choreography has a high correlation with measures related to perception of volume. Thus, the discovery of alternatives in dance choreography and the students' various experiences with bodily movements may increase the comprehension of occupied volume by the body. It is evident that the variety of choreography is highly impactful on the fluidity of the body in students' dance, but this effect decreases with the fluidity of the final structure. Because fluidity should be designed with the integration of the units produced through the abstraction of the body movement. In other words, the fluidity of the final structure can only be arranged by the careful combination of the abstracted bodies. This is another challenge for the students pushing them to imagine the fluidity of several bodies instead of the awareness of their own bodies.

The fluidity of body movements (due to their volumetric aspects) widens the awareness of the volume related to space. This means that the more fluid movements, the easier to understand the volume between the bodies recorded at different moments (as it becomes easier to combine those bodies). When the fluidity of movements decreases, students experience difficulties connecting bodily movements in mind and seeing the volume produced by the body. We can say that the fluidity of body movements may affect the student's understanding of the relationship between corporeality and volume regarding the space.

When the movements become more fluid, the occupied volume can expand as the concern of experiencing discontinuity disappears. Therefore, holistic design solutions can be developed where alternative spaces are merged. This may increase the quality of combination exercises. Also, the students who are able to experience their body movements without gaps may more efficiently manage the abstraction of their body movements.

Expanding the occupied volume during the dance can help students succeed in initial combination exercises. Still, this impact tends to decrease when it comes to the final design of the structure. This may happen because students are instructed with specific design parameters for the final structure. Students may struggle to address these specific parameters comparing to an exercise independent from final concerns. Also, it can be expected to see a strong association between the extent of the occupied volume in dance and drawing. This demonstrates that students who covered greater spaces were also aware of their bodily movement and successfully reflected this in the drawings of selected scenes.

Although the occupied volume has a potential effect on the abstraction of the body movement, it has no association with the spatiality of the units produced at the end of the abstraction process. The reason can be related to the challenge of transforming the 2D drawing into a 3D model because students abstract the body movements in 2D paper even though the bodily movement is about the third dimension. The tools students are provided with can prevent them from reflecting the spatial potential of bodily movements.

Refinement of the details of the body has a strong correlation with body-abstraction and body-structure measures. The abstraction process tends to help students understand structural reflections of their bodies on produced units. The students who are more aware of the structural potentials of bodily movements may explore various ways of combining the units. Therefore, students who designed units with higher structural potential to be combined may be more successful both in the initial combination stage and the final design of the structure. Even though there is no direct association, the variety of units may increase the number of different scales and combination methods, potentially indirectly increasing students' success in designing the final structure. There is a need for further research to understand how abstraction practices can contribute to the design of space and structure.

Conclusion

This study has aimed to evaluate how embodied experience and abstraction affect the architectural design process and outcome through statistical analysis. We observed that students' overall success is primarily dependent on how they manage to adapt the gained knowledge related to bodily movement and abstraction when instructed with final design requirements. In this sense, increasing awareness and the extent of the volume through bodily experience positively impacted the final design. Also, the measures related to space and structure mainly advanced students' success in the final design. The initial exercises, which focused on experiments with various combinations of units and modules before the final design, improved students' capacity to organise units for holistic structure design. However, the association of the abstraction process with the final design remained limited. Furthermore, utilising an increasing number of units produced through abstracting bodily movements in the design weakened students' ability to deliver sophisticated spatial and structural design.

The study's contribution is the systematic and statistical evaluation of the relationship between body, movement, abstraction and architectural design by constructing a set of measures from various stages of the design studio. This is only a glimpse of understanding the complex interaction between embodied experience, abstraction process and architectural design. For further research, it is critical to develop design processes allowing the analysis of the direct implications of the abstraction process on the design of space and structure. Also, more investigation is needed to further elaborate on the positive role of the volume through bodily movements in the design process. We hope our research will provide a basis for an upcoming discourse. We call for contributions from other researchers towards further analytical investigations regarding the body, dance, abstraction, space and structure. Such contributions will provide a more precise understanding of various elements related to corporeality, abstraction and architectural design.

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Data and material availability SPSS (Statistical Package for the Social Sciences) program was used for data analysis. Photoshop and Coggle was used for the figures of the article.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethical approval All participants' data were anonymised or anonymous from the beginning since no signifiers were used. The participants agreed to undertake the study based on the informed consent statement. They gave consent for the data to be used for this research. Images and tables are produced by the authors.

References

Becks-Malorny, U. (2003). *Wassily Kandinsky, 1866–1944: The journey to abstraction*. Barnes & Noble Books.

Birringer, J. (2004). Dance and interactivity. *Dance Research Journal, 36*(1), 88–111.

Boucharenc, C. (2006). Research on basic design education: An international survey. *International Journal of Technology and Design Education, 16*(1), 1–30. https://doi.org/10.1007/s10798-005-2110-8

Boucharenc, C. (2008). *Design for a contemporary world: A textbook on fundamental principles*. NUS Press.

Bradley, K. K. (2009). *Rudolf Laban*. Routledge.

Brandstetter, G. (1998). Defigurative choreography: From Marcel Duchamp to William Forsythe. *TDR/The Drama Review, 42*(4), 37–55.

Caner Yüksel, Ç., & Dinç Uyaroğlu, İ. (2021). Experiential learning in basic design studio: Body, space and the design process. *International Journal of Art & Design Education, 40*(3), 508–525.

Carman, T. (2008). *Merleau-Ponty*. Routledge.

Copeland, R. (2004). *Merce Cunningham: The modernizing of modern dance*. Routledge.

Cunningham, M. (1952). Space time and dance. *Trans/Formations, 1*(3), 150–151.

Erkenez, S., & Ciravoğlu, A. (2020). On possibilities of transforming space emerging from theories on body. *Megaron, 15*(3), 399–411.

Ersoy, Z. (2011). 'Building Dancing': Dance within the Context of Architectural Design Pedagogy. *International Journal of Art & Design Education, 30*(1), 123–132.

Feuerstein, M. F. (2002). Body and building inside the Bauhaus's darker side: On Oskar Schlemmer. In R. Tavernor & G. Dodds (Eds.), *Body and building: Essays on the changing relation of body and architecture* (pp. 226–237). The MIT Press.

Fischer, H., & Rainbird, S. (2006). Introduction. In H. Fischer & S. Rainbird (Eds.), *Kandinsky: The path to abstraction* (pp. 12–15). Tate Publishing.

Forsythe, W. (1995). *Programme eidos: Telos*. Intendanz Ballett Frankfurt.

Forsythe, W. (2011). Choreographic objects. In S. Spier (Ed.), *William forsythe and the practice of choreography: It starts from any point* (pp. 90–92). Routledge.

Forsythe, W., & Kaiser, P. (1999). Dance geometry: William Forsythe in dialogue with Paul Kaiser. *Performance Research, 4*(2), 64–71.

Funkenstein, S. L. (2007). Engendering abstraction: Wassily Kandinsky, Gret Palucca, and "dance curves." *Modernism/Modernity, 14*(3), 389–406.

Funkenstein, S. L. (2012). Picturing Palucca at the Bauhaus. In S. Manning & L. Ruprecht (Eds.), *New German dance studies* (pp. 45–62). University of Illinois Press.

Griffero, T. (2014). *Atmospheres: Aesthetics of emotional spaces*. Ashgate Publishing.

Hatıpoğlu, S., Şensoy, G., Kamaoğlu, M., & İnceoğlu, M. (2022). Initial practices for abstraction of body and space in design education. *Online Journal of Art and Design, 10*(2), 282–298.

Hodgson, J., & Preston-Dunlop, V. (1990). *Rudolf Laban: An introduction to his work & influence*. Northcote House.

Holl, S. (2000). *Parallax*. Princeton Architectural Press and Birkhäuser.

Huschka, S. (2010). Media-bodies: Choreography as intermedial thinking through in the work of William Forsythe. *Dance Research Journal, 42*(1), 61–72.

Huxley, M. (2017). The dance of the future: Wassily Kandinsky's vision, 1908–1928. *Dance Chronicle, 40*(3), 259–286.

Kandinsky, W. (1947). In H. Dearstyne & H. Rebay, Trans.; H. Rebay (Eds.), *Point and Line to Plane*. Solomon R. Guggenheim Foundation.

Kandinsky, W. (1926). Tanzkurven: Zu den Tänzen der Palucca. *Das Kunstblatt, 10*(3), 117–121.

Kandinsky, W. (2002). Program of the institute of artistic culture (1920). *Experiment, 8*(1), 143–155.

Kline, R. B. (2015). *Principles and practice of structural equation modeling* (4th ed.). The Guilford Press.

Laban, R. (1966). *Choreutics*. Macdonald & Evans.

Langer, M. M. (1989). *Merleau-Ponty's phenomenology of perception: A guide and commentary*. Palgrave Macmillan.

Lawson, B. (2005). *How designers think: The design process demystified* (4th ed.). Architectural Press.

Levy, A., & Bechtel, W. (2013). Abstraction and the organization of mechanisms. *Philosophy of Science, 80*(2), 241–261.

Maletic, V. (1987). *Body-space-expression: The development of Rudolf Laban's movement and dance concepts*. De Gruyter Mouton.

Matthews, E. (2002). *The philosophy of Merleau-Ponty*. McGill-Queen's University Press.

Mattingly, K. (1999). Deconstructivists Frank Gehry and William Forsythe: De-signs of the times. *Dance Research Journal, 31*(1), 20–28.

Merleau-Ponty, M. (1964). The Film and the New Psychology. In *Sense and non-Sense* (pp. 48–59). Northwestern University Press. (1945)

Merleau-Ponty, M. (2012). *Phenomenology of perception* (D. A. Landes, Trans.). Routledge.

Morgan, D. (1992). The idea of abstraction in German theories of the ornament from Kant to Kandinsky. *The Journal of Aesthetics and Art Criticism, 50*(3), 231–242.

Morgan, D. (1994). The rise and fall of abstraction in eighteenth-century art theory. *Eighteenth-Century Studies, 27*(3), 449–478.

Morris, D. (2014). Body. In R. Diprose & J. Reynolds (Eds.), *Merleau-Ponty: Key concepts* (pp. 111–120). Routledge.

Noland, C. (2013). Inheriting the Avant-Garde: Merce Cunningham, Marcel Duchamp, and the "legacy plan." *Dance Research Journal, 45*(2), 85–121.

O'Neill, M. E. (2001). Corporeal experience: A haptic way of knowing. *Journal of Architectural Education (1984), 55*(1), 3–12.

Pallasmaa, J. (2012).*The eyes of the skin: Architecture and the senses* (3 ed.). John Wiley & Sons.

Russell, L. J. (1930). Science and abstraction. *Journal of Philosophical Studies, 5*(17), 84–93.

Schiller, G. E. (2003). *The kinesfield: A study of movement-based interactive and choreographic art*. University of Plymouth.

Schiller, G. E. (2008). From the kinesphere to the kinesfield: Three choreographic interactive artworks. *Leonardo, 41*(5), 431–453.

Schlemmer, O. (1961). Man and Art Figure (A. S. Wensinger, Trans.). In W. Gropius & A. S. Wensinger (Eds.), *The theater of the Bauhaus* (pp. 17–48). Wesleyan University Press.
Siegmund, G. (2011). The space of memory: William Forsythe's Ballets. In S. Spier (Ed.), *William Forsythe and the practice of choreography: It starts from any point* (pp. 128–138). Routledge.
Sinnamon, C., & Miller, E. (2022). Architectural concept design process impacted by body and movement. *International Journal of Technology and Design Education, 32*(2), 1079–1102. https://doi.org/10.1007/s10798-020-09636-4
Smith, S. M., & Blankenship, S. E. (1991). Incubation and the persistence of fixation in problem solving. *The American Journal of Psychology, 104*(1), 61–87. https://doi.org/10.2307/1422851
Snowber, C. (2012). Dance as a way of knowing. *New Directions for Adult and Continuing Education, 2012*(134), 53–60.
Spier, S. (2011). Choreographic thinking and amateur bodies. In S. Spier (Ed.), *William Forsythe and the practice of choreography: It starts from any point* (pp. 139–150). Routledge.
Sutil, N. S. (2014). Mathematics in motion: A comparative analysis of the stage works of Schlemmer and Kandinsky at the Bauhaus. *Dance Research, 32*(1), 23–42.
Trimingham, M. (2004). Oskar Schlemmer's research practice at the Dessau Bauhaus. *Theatre Research International, 29*(2), 128–142.
Tschumi, B. (1996). *Architecture and disjunction*. The MIT Press.
Valéry, P. (1983). Philosophy of the dance. In R. Copeland & M. Cohen (Eds.), *What is dance?* (pp. 55–65). Oxford University Press.
Vroman, L., Naveda, L., Leman, M., & Lagrange, T. (2011). Generating tacit knowledge through motion: A vision on the matter of space. *Art, Design & Communication in Higher Education, 10*(2), 255–270.
Wong, W. (1993). *Principles of form and design*. John Wiley & Sons.
Wong, Y. L., & Siu, K. W. M. (2012). A model of creative design process for fostering creativity of students in design education. *International Journal of Technology and Design Education, 22*(4), 437–450. https://doi.org/10.1007/s10798-011-9162-8
Wrathall, M. A. (2005). Motives, reasons, and causes. In T. Carman & M. B. N. Hansen (Eds.), *The cambridge companion to Merleau-Ponty* (pp. 111–128). Cambridge University Press.
Zimmer, R. (2003). Abstraction in art with implications for perception. *Philosophical Transactions: Biological Sciences, 358*(1435), 1285–1291.